# Medium- and Heavy-Duty EV Charging Infrastructure Sufficiency to Support A More Ambitious Advanced Clean Fleets Rule

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Meeting the infrastructure needs to support the deployment of medium- and heavy-duty (MHD) electric vehicles (EVs) is technically and economically feasible and happening in a growing EV market today. Substantial funds and coordination exist for MHD EV charging infrastructure from the state legislature, the California Public Utility Commission's (CPUC) approved utility programs, the California Energy Commission (CEC) programs, the federal Infrastructure Investment and Jobs Act (IIJA), the Low Carbon Fuel Standard (LCFS), and the private sector. Although much work remains, the California Air Resources Board (CARB) can confidently adopt a strengthened Advanced Clean Fleets (ACF) rule, knowing that agencies, industry, and other stakeholders are engaged in a comprehensive set of programs to meet the needs of MHD EVs now, in the short-term and the years ahead.

As Chair Randolph said at the Ride and Drive event in Fontana on June 6, 2022, "[T]he future is here, and now is the time to put in your order."

## How MHD EV Charging Occurs

The majority (61%) of California trucks are Class 2b-3.[1] These include commercial pick-up trucks, delivery vehicles, and passenger vans. Most of these will charge at a "home base" overnight, such as a home garage or depot location. When there is a need for additional charging during the day, these vehicles can return to their home base or 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.[2] Given current EV technology, these vehicles can meet all their charging needs with overnight depot charging. Class 4-8 and Class 7-8 tractors with daily routes up to 200 miles will primarily charge at private depots overnight (home base or nearby contract off-site charging stations), although some may require higher-power DCFCs at their depots.

Class 4-8 and Class 7-8 tractors with daily routes longer than 200 miles will typically charge at depots and may need supplemental access to DCFCs along their routes.[3] However, less than 40% of all Class 7-8 tractors have daily routes longer than 200 miles.[4] Moreover, once the megawatt charging standard (MCS) is adopted and deployed,[5] Class 7-8 tractors capable of traveling 500 miles fully loaded will be able to recharge in 30 minutes – within the federally required 30-minute rest break every driver must take every 5-hours (a driver can travel about 300- 350 miles in 5-hours). Tesla is currently taking orders for their Class 8 Electric semi -truck offering 300 and 500-

[1] https://ww2.arb.ca.gov/sites/default/files/2021-09/210909acfpres_ADA.pdf
[2] https://ww2.arb.ca.gov/sites/default/files/2020-02/200212presentation_ADA_1.pdf
[3] 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
[4] https://ww2.arb.ca.gov/sites/default/files/2020-02/200212presentation_ADA_1.pdf
[5] Charged EVs | CharIN officially launches Megawatt Charging System for commercial EVs - Charged EVs

mile range versions[6] and production is expected in 2023[7]. At the rapid pace that battery advancement is progressing, additional OEMs are likely to have new longer-range versions in the not too distant future as well.

## Charging Infrastructure Planning

The CEC is the lead agency for planning and managing the development of charging infrastructure. In April 2022, CEC released the Draft Zero-Emission Vehicle Infrastructure Plan (ZIP) report. This report comprehensively describes the progress to date and plans to ensure sufficient charging infrastructure is in place where needed.[8]

We now know the number of electric vehicles that need to be supported by Electric Vehicle Service Equipment (EVSE or chargers) and how many chargers of what power, where, and in what year we need them. CARB has modeled the forecast number of MHD vehicles through 2050 and estimates we'll have 180,000 ZEVs on the road by 2030. While this will be updated periodically, it's the essential beginning of charging infrastructure planning.

The CEC has produced the first biennial Electric Vehicle Charging Infrastructure Assessment Report (AB 2127).[9] Using sophisticated modeling tools, the report estimates that 157,000 chargers are needed for MHD EVs by 2030. An updated report is expected in 2023. The underlying data from these reports are available to public and private stakeholders, including utilities, cities and counties, EVSPs, and state agencies, to guide them in knowing where and when to install charging infrastructure to best meet anticipated demand and fill geographic and volumetric gaps. Additionally, utilities will be able to use this data to learn where to upgrade their distribution grids ahead of coming demand.

In October 2021, Governor Newsom signed SB 671 requiring the California Transportation Commission, CARB, and CEC to develop a Clean Freight Corridor Efficiency Assessment to identify freight corridors and the infrastructure needed to support zero-emission MHD vehicles by December 1, 2023.[10] The assessment's findings and recommendations will be incorporated into the California Transportation Plan. Subsequently, the California Freight Mobility Plan will describe the infrastructure, projects, and operations needed to develop the freight corridors identified in the assessment. In coordination with this effort, the California Statewide Truck Parking Study, led by Caltrans, aims to understand where MHD vehicles park and prioritize freight corridors for zero-emission vehicle (ZEV) charging and fueling infrastructure.[11]

## Paying for Charging Infrastructure

The combined funds available from multiple sources today are sufficient to address the charging needs for MHD EVs for several years and establish mechanisms to continue providing funding well into the future. The following are a few program highlights.

Utility funding

[6] Tesla Semi Order Books Are Open - CleanTechnica
[7] Tesla's Elon Musk predicts that 2023 will see massive "wave of new products" (teslarati.com)
[8] Draft Zero-Emission Vehicle Infrastructure Plan (ZIP) (ca.gov)
[9] https://www.energy.ca.gov/programs-and-topics/programs/electric-vehicle-charging-infrastructure-assessment-ab-2127
[10] Senate Bill 671 (Gonzalez, Chapter 769, Statutes of 2021)
https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202120220SB671
[11] Draft Zero-Emission Vehicle Infrastructure Plan (ZIP) (ca.gov)

"The CPUC has authorized more than $1.8 billion in ratepayer dollars on TE (transportation electrification) to date. This amount does not include the significant utility-side investment we expect to result from the new EV Infrastructure Rules under AB 841 and other necessary utility-side upgrades, and the significant investment from Low Carbon Fuel Standard revenue. Of the $1.8 billion that the CPUC has authorized, the IOUs have spent approximately $316 million to date, or approximately 17.5 percent. This means that there is a significant level of funding still available."[12] The $1.8 billion above includes more than $700 million dedicated to EVSE for MHD EVs and is just the first tranche. The IOUs may request approval for more from the CPUC as needed.

Public Funding

The ZEV Package approved by the California Budget Act of 2021 includes $623 million over three years for MHD ZEV infrastructure:[13]

- $250 million for infrastructure for 1,125 drayage trucks
- $25 million for drayage and infrastructure pilot
- $90 million for infrastructure for 1,000 transit buses
- $50 million for infrastructure for 1,000 school buses
- $208 million for other MDHD infrastructure

The Governor's proposed budget for fiscal year 2022-23 includes a second ZEV Package with over one billion dollars in new spending for MHD ZEVs and infrastructure:[14]

- $250 million for drayage truck infrastructure
- $140 million for transit bus infrastructure
- $500 million for clean trucks, buses, and off-road equipment
- $150 million for ZEV infrastructure at ports

Through 2023, the CEC's Clean Transportation Program offers almost $130 million for MHD ZEVs and EVSE and $82 million for light-duty EVs and EVSE infrastructure. The program also provides about $2.5 million per year for workforce development.[15]

The CEC recently initiated a major new program entitled the "Energy Infrastructure Incentives for Zero-Emission Commercial Vehicles" or the "EnergIIZE Commercial Vehicles" program.[16] It is designed to help MHD ZEV fleet and truck owners plan and fund fueling infrastructure needs. It is being initially funded with $50 million this year but can access $276 million through 2026. It is intended to extend for many years in the future with additional annual contributions. Demonstrating the high demand for charging infrastructure among EV fleet owners, EnergIIZE' s, first Fast Track funding allocation of $16.24M was fully subscribed within seconds of opening.[17]

[12] https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M453/K952/453952700.PDF
[13] Draft Zero-Emission Vehicle Infrastructure Plan (ZIP) (ca.gov)
[14] Ibid
[15] https://www.energy.ca.gov/publications/2021/2021-2023-investment-plan-update-clean-transportation-program
[16] EnergIIZE
[17] https://calstart.org/16m-for-commercial-zero-emission-vehicle-infrastructure-awarded-in-seconds-june-24-2022/

CARB's LCFS program was recently enhanced with its Fast-Charging Infrastructure (FCI) Program to incentivize DCFC deployments at public locations.[18]

Private Funding

Daimler Trucks of North America, NextEra Energy, and Blackrock recently signed an MOU making an initial commitment of $650 million to build the nation's first national public network of chargers for MHD EVs beginning in 2023.[19] They will begin in California and the west coast along the I-5 corridor, expand to the east coast I-95 corridor, the "Texas Triangle," and then expand nationwide.

Volvo Trucks will construct a charging network throughout California for MHD EVs. Volvo is joining forces with Volvo Financial Services, Volvo Technology of America, Shell Recharge Solutions, TEC Equipment, Affinity Truck Center, and Western Truck Center to bring the network to life. Supported in part by a $2 million CEC grant, the project is slated to get underway in 2022 and all five of the initial EV charging stations in the network are expected to be operational by the end of 2023.[20]

WattEV is a new trucking-as-a-service [21]company in the process of building four large hub locations in Bakersfield (in part with CEC grant funding and expected to be completed in 2022), San Bernadino, Port of Long Beach, and Gardena. They intend to subsequently build a hub in Sacramento and two between there and Bakersfield. Their longer-term ambition is to provide a national network of 12,000 trucks in a truck-as-a-service model and the necessary hubs and charging infrastructure by 2030. While they will operate their own trucks for customers, they will make their chargers available for public MHD EV charging. At the Bakersfield facility, they are installing 16 megawatt charging system (MCS) connectors and 64 240 kW CCS connectors largely powered by locally installed solar generation and supported with on-site battery storage.[22]

Penske Truck Leasing recently purchased 750 GM Brightdrop electric delivery vans for lease or rent. To support these vehicles, Penske and Shell Recharge Solutions North America announced a new joint initiative to support light-duty electric vehicle (EV) charging at Penske locations. Art Vallely, president of Penske Truck Leasing, stated, "We continue to invest in growing our electric fleet and charging infrastructure to provide more options to customers seeking sustainable fleet solutions." Penske's EV Test Fleet currently includes vehicles such as the Freightliner eCascadia (Class 8), Freightliner eM2 (Class 6 and 7), Volvo VNR tractor (Class 8), International® eMV™ (Class 6 and 7), Ford E-Transit (Class 2), and FUSO eCanter (Class 4).[23] Penske Truck Leasing operates more than 372,000 vehicles and serves customers from more than 1,300 locations in North America, South America, Europe, Australia, and Asia.

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,

[18] https://ww2.arb.ca.gov/resources/documents/lcfs-zev-infrastructure-crediting
[19] Daimler Truck North America, NextEra Energy Resources and BlackRock Renewable Power Announce Plans To Accelerate Public Charging Infrastructure For Commercial Vehicles Across The U.S. | Daimler
[20] Volvo Trucks to construct charging network throughout California (electrek.co)
[21] "Trucking as a service" (Taas) is a new business model in which for a predictable monthly fee, customers have access to the electric vehicles, its charging infrastructure, and all servicing, maintenance, insurance, and training requirements from the Taas company.
[22] Charged EVs | WattEV aims to operate 12,000 electric Trucks-as-a-Service and a charging network to support them by 2030 - Charged EVs
[23] Penske Electric Trucks and Vehicles - Penske Truck Leasing

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.[24]

The South Coast Air Quality Management District's (SCAQMD) Warehouse Indirect Source Rule will incentivize warehouse owners to install EV chargers to support electric delivery trucks at their locations.[25] This will impact the warehouse operations within nearly half the state's population.

For other charging infrastructure costs not otherwise covered, most often, they can be included in financing programs such as the lease used to acquire the electric truck. Nearly all of the legacy OEMs, ZEV OEMs, and major truck leasing/rental companies now offer these financing packages. Some also offer truck-as-a-service programs where the upfront capital is paid for, and all the truck user pays is some form of a per-mile cost. Because the total cost of ownership (TCO) of most MHD EVs is or will be lower than for the diesel vehicle alternative by 2025, the owners can still realize cash savings on day one.

## National Charging Infrastructure to Support Long-haul Operations

Many of the efforts referenced above such as:

- Daimler's partnership to build out a national charging network for MHD vehicles,
- Volvo's MHD charging network project in California,
- Federal support from the $7.5 billion from the IIJA program,
- WattEVs national plans,
- Penske's installation of EVSE at many of its locations to support leasing its ZEVs and
- NATSO's Partnership with ChargePoint for chargers at truck stops,

will contribute to a robust national network of chargers.

Additional examples of major travel center/truck stop operators starting to plan for electrification and implementing EVSE projects include:

- GM partnering with EVgo to install up to 2,000 chargers at up to 500 DC fast-charging stations across the country at Pilot Flying J travel centers. Pilot Flying J has a comprehensive network of 772 travel centers nationwide, many of which also support commercial trucks. While the number of chargers at each station will vary, all will be 350-kw CCS-format, with the bulk installed from 2023 to 2025. Several of these will be installed in pull-through lanes that could accommodate larger MHD vehicles.[26]
- Travel Centers of America (TA), the nation's largest publicly traded full-service travel center network, has created a new Business unit, eTA, to Advance Sustainable fueling Energy Efforts, including electrification. According to Jon Pertchik, CEO of TA, "This is a pivotal moment in our company's 50-year history, and we believe that the actions we are taking today will support the next 50 years of profitable growth at TA." TA secured a $4 million grant from the CEC to participate in an innovative industry test project for MHD EVs. TA and its partners will design, develop and deploy an integrated distributed energy resource to power energy storage and EV charging solutions.[27]

[24] https://www.natsoaltfuels.com/EVCharging.php
[25] r2305.pdf (aqmd.gov)
[26] GM and Pilot plan a 350-kw coast-to-coast charging network (greencarreports.com)
[27] https://www.ta-petro.com/newsroom/travelcenters-of-america-enhances-commitment--to-sustainability-and-alternative-energy

- Love's Travel Stops and Electrify America are collaborating to bring public ultra-fast EV charging stations to seven locations in six U.S. states.[28]

Transportation fueling companies, concerned about declining fossil fuel revenues as transportation shifts to ZEVs, can gain an early adopter advantage if they move quickly. They very much want to capture this new business, as evidenced by their advocacy with the DOT: "NATSO by and large supports efforts to expand the use of alternative fuels for transportation and thinks its members' locations could play a vital role in establishing alternative fuel corridors. However, NATSO strongly opposes the installation of alternative-fueling stations at rest areas and thinks states should work with existing exit-based businesses to install them at private businesses."[29]

There are also significant multi-state programs to support infrastructure development.

Seventeen states with the District of Columbia and supported by northerly neighbor Quebec working under a memorandum of understanding (MOU) just announced the completion of their "Multi-State Medium- and Heavy-Duty Zero-Emission Vehicle Action Plan" that identifies barriers and proposes solutions to support widespread electrification of medium and HD vehicles. The U.S. jurisdictions in the initiative collectively represent 43 percent of the population, nearly half of the economy, and 36 percent of the nation's medium- and heavy-duty vehicles.[30]

Several Midwest states, including Illinois, Indiana, Minnesota, Michigan, and Wisconsin, signed a Regional Electric Vehicle Midwest MOU to promote HD ZEV infrastructure, manufacturing, and other supportive policies.[31]

The DOT's Federal Highway Administration (FHWA) recently announced the latest round of Alternative Fuel Corridor designations. Under the new National Electric Vehicle Infrastructure (NEVI) Formula Program established by President Biden's Bipartisan Infrastructure Law, funding will be directed to designated EV Alternative Fuel Corridors to serve as the backbone for the national EV charging network.[32]

Relatively few MHD EV charger locations are initially needed to provide an effective national network. For example, Tesla initially developed its national charging network by installing stations roughly 150 miles apart to maximize coverage and enable coast-to-coast travel. Then, as the number of vehicles and demand increased, Tesla increased the number of charger ports at existing stations and filled the network with more and larger stations to handle the volume while increasing power to enable faster charging.

## Charging Infrastructure Funding for Small Fleets

Small and independent fleets are eligible for infrastructure funding support from most programs above, including the CPUC-approved programs, public utility programs, CEC programs, and financing from OEMs and leasing /rental companies. As more public DCFC chargers for MHD EVs become available, these fleets can utilize them to meet some or all of their needs. Charging

[28] **https://www.loves.com/en/news/2020/august/electrify-america-announces-collaboration-with-loves-travel-stops**
[29] **https://wwww.natso.com/topics/dot-to-establish-electric-vehicle-charging-corridors**
[30] 17 States, D.C., and Quebec Release Action Plan to Rapidly Advance Electric Truck and Bus Adoption (nescaum.org)
[31] https://www.regulations.gov/comment/EPA-HQ-OAR-2019-0055-1186
[32] Charged EVs | Alternative Fuel Corridor designations facilitate charging network build-out in all 50 states - Charged EVs

hubs such as those under construction by WattEV provide 350 kW and MCS chargers and the parking space to allow these vehicles to be charged.

Further, there are special programs targeted to help these fleets including:

- The EnergIIZE program has created a special funding program called "Funding Lane: EV Jump Start" specifically designed to provide funds for and assist these fleets in applying for grant funds for charging infrastructure.[33] This program is designed to assist small businesses, certified minority business enterprises, women-owned businesses, veterans, LGBT, tribal organizations, non-profit commercial fleets and for commercial fleet's recharging infrastructure when in a designated disadvantaged or low-income community.
- The HVIP Small e-fleets program.
    - The goal of the Innovative Small e-Fleet (ISEF) set-aside ($25 million within the Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP) for Fiscal Year 2021-22) is to implement innovative solutions to assist small fleets in making the transition to ZEVs, including, but not limited to, flexible leases, short-term rentals, truck-as-service (TAAS), assistance with infrastructure, individual owner planning assistance, increased available funding, and other mechanisms.[34]
    - Beginning August 31, 2022, privately-owned or non-profit trucking fleets with 20 or fewer trucks and annual revenue of less than $15 million can access flexible financing options for zero-emission trucks through this program.[35]

## Significant Savings from Low Electricity Costs

One of the biggest benefits of electric transportation is significant fuel cost savings. A key factor in producing those savings is that electric drivetrains are about 4-5 times more efficient than combustion engines.[36] LCFS credits can also cover a majority and sometimes all the electricity fuel costs.

According to CARB's total cost of ownership (TCO) analysis,[37] for a Class 8 day cab semi-truck with a lifetime mileage of 600,000 miles:

- The diesel fuel costs are $366,069 or $.61 per mile. Fuel cost is 56% of the total cost of ownership for the diesel semi.
- The electricity fuel costs are $234,326 or $.39 per mile.
- **This represents a 36% or $131,743 savings.**
- LCFS credits are $248,902 at $.22/kWh, covering 106% of the total cost.

**In CARB's example, when including the LCFS credits, electricity fuel savings produces a net benefit of $14,576 available to cover other operational expenses.**

The current high fossil fuel costs would greatly increase these savings and point out the risk of the wide and unpredictable volatility of fossil fuel costs. In contrast, electricity costs are much more stable and predictable.

[33] 5. V4 EV Jump Start Factsheet (energiize.org)
[34] Innovative Small e-Fleet (ISEF): Flexible Zero-Emission Trucking Funding for Small Fleets (pardot.com)
[35] Ibid
[36] 180124hdbevefficiency.pdf (ca.gov)
[37] Draft ACF Total Cost of Ownership Discussion Document (ca.gov); Note that savings from electricity costs and LCFS credits will vary based on the truck type, vocation and duty cycle.

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.[38] As an example of this, Los Angeles Department of Transportation is installing a solar and storage microgrid and EV charging to power 100+ electric buses in partnership with Proterra and Apparent. "By delivering clean solar energy generated and storage capacity, the project will reduce greenhouse gas emissions, lower LADOT's electricity costs, and also provide emergency back-up power that will enable the agency to continue to operate in an outage."[39]

## Charging Technology Standards, Options, and Progress

California has over 80,000 public and publicly accessible chargers for all EV vehicles, including over 7,000 DCFC.[40] And this does not include the many private chargers installed for MHD EVs, including for over 1,200 MHD electric public transit buses across the state and many other chargers paid for via investor-owned utility programs. This demonstrates that the utilities, EVSPs, and commercial electrical contractors have the processes, technology, and trained electricians to successfully install this type of infrastructure to meet the needs of MHD EVs today.

### Standards

The de facto charging standard used by nearly all light-duty and newer MHD EVs in the US is the combined charging system (CCS). (Tesla is the exception but will likely provide CCS adapters soon.) The CCS standard can fuel a vehicle using AC current, for example, from a home or employer garage or DC current from a DCFC at up to 350 kW. The megawatt charging system (MCS) standard will have the capability of going up to 3.7 mW (equal to 3,700 kW) to support charging for very large batteries such as might be in Class 8 semi-trucks with 500 miles of range.[41] This new standard could allow these trucks to recharge their batteries within 30 minutes. This has been developed as an international standard that will also support commercial heavy-duty industrial applications such as ships, locomotives, aircraft. After nearly four years of development, this standard was recently inaugurated by CharIN and demonstrated with an MCS charger and a Scania 100% electric truck at a major international meeting in Oslo.[42] Testing in commercial use has begun, and the final standard is expected to be published in 2024. The MCS standard will also be backward compatible with CCS chargers through an adapter. Demonstration MCS chargers have been installed by Tesla at their Nevada Gigafactory site and PepsiCo/Frito-Lay's major factory and delivery site in Modesto, California.

The CEC is leading the effort to select and promulgate other software and communications standards such as those that support Plug and Charge functionality, smart charging, vehicle to grid (V2G), and vehicle to load (V2L) towards making the charging infrastructure environment optimally interoperable, functional, and cost-efficient.

### Special Use Chargers

These products are examples of chargers that can be installed much faster and less expensively, can be in fixed locations or mobile, or can be installed in a remote location completely off-grid.

[38] https://www.evgo.com/press-release/evgo-balances-ev-fast-charging-with-14-battery-storage-systems-across-11-evgo-fast-charging-stations/
[39] https://www.proterra.com/press-release/ladot-ev-charging-system/
[40] Electric Vehicle Chargers in California
[41] https://www.charin.global/technology/mcs/
[42] Charged EVs | CharIN officially launches Megawatt Charging System for commercial EVs - Charged EVs

- Pre-built Containerized Depot Charging Solutions – Amply, offers a containerized deport charging solution ("INRUSH") with all the switch gear, inverters, charging transformers, and electrical connections pre-wired inside the container. Each container provides five chargers. Design, procurement, and installation costs for the container solution are expected to be roughly 50% less expensive than traditional infrastructure. The setup process takes about six months from start to finish—50% less time than traditional infrastructure."[43]
- Portable Charger – Nikola offers a portable charger in a trailer than can be purchased or rented. "Nikola's Mobile Charging Trailer (MCT) can help speed up access to EV operations. It can also allow the fleet owner to operate and grow their EV fleet before incurring a significant capital expense. Knowing how they want to operate their EVs will help them smoothly transition to a permanent recharging infrastructure plan."[44]
- Off-grid Containerized Fuel Cell generator charger – AFC Energy offers a containerized solution that can contain a fuel cell generator, fuel supply tank (with either Green hydrogen or ammonia), battery storage, and EV chargers. This solution can be used at a permanent or temporary site with a fixed or mobile configuration. This hydrogen-fueled EV recharger can be used for commercial and industrial vehicles and can provide rapid charging with 24/7 availability and zero emissions. Finally, it can enable charge points at any location – even with no grid connection or limited supply."[45]

## 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.[46] For more information on GO-Biz's programs to support EVs and charging infrastructure, go to: https://business.ca.gov/industries/zero-emission-vehicles/.
- Accelerating Permitting - 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.
- The California Building Standards Commission (CBSC) adopted MHD ZEV infrastructure requirements through its CALGreen Building codes to support the future addition of chargers for MHD vehicles at new warehouses, grocery stores, and retail buildings with off-street loading spaces.[47]

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[43] AMPLY Power Launches New Containerized EV Charging Infrastructure Solution, Anaheim Transportation Network Signed on as First Customer - AMPLY Power

[44] Nikola Energy: Clean Energy Solutions (nikolamotor.com)

[45] **https://chargedevs.com/features/extreme-e-tackles-tough-terrain-promotes-sustainable-racing/**

[46] https://business.ca.gov/industries/zero-emission-vehicles/zev-strategy/

[47] California Building Standards Commission. CALGreen. https://www.dgs.ca.gov/BSC/CALGreen.

- The CEC, CPUC, Utilities, EVSPs, and others are working on accelerating permitting and gaining interconnection approval from utilities and other processes. This is similar to the planning and procedure maturation process that successfully occurred to better support the more rapid approval for and installation of solar PV projects over the last 15 years.

## Designing, Installing, and Managing EVSE

Several aspects are involved in the full lifecycle of charging infrastructure design, installation, management, and electricity cost management. These include:

- Business and truck operational planning.
- Determining optimal EVSE type, location, and power planning
- Taking advantage of available financial incentives and financing options.
- 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 storage with MHD deployments to maximize use of clean energy, reduce costs and manage net charging demand.[48]

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

- Full service Electric Vehicle Service Provider (EVSP) firms.
- Many truck makers, dealers and truck leasing firms have their own EVSP divisions or have contracts with EVSE consulting services.
- 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, maximizing incentive programs, and providing the capital. They typically charge their customer a simple all-inclusive fee per kWh consumed by the EVs. [49]

Examples of firms offering services through one or more of the above ways include Amply, Enel X, AlphaStruxture, In-Charge Energy, Shell Recharge Solutions (formerly Greenlots) ChargePoint, Electrify America, ABB, Siemens, Black and Veatch, Burns & MacDonald, Schneider Electric, Volvo North American Trucks, Peterbilt, and many others.

## MHD EV Grid Integration

Integrating EVs 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:

[48] http://blogs.edf.org/energyexchange/files/2021/03/EDF-ChargingForward-FINAL.pdf
[49] https://chargedevs.com/newswire/montgomery-county-maryland-deploys-microgrid-to-support-electric-bus-charging/

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. [50]

## Grid Capacity

According to the CEC, "California's electric grid can accommodate near-term infrastructure goals, and longer-term goals can be achieved with planning, which is already underway. California's existing grid and approved investments in it will allow the state to handle millions of electric vehicles in the next few years. Ongoing planning will help prepare the grid for reliance and reliability in the longer term."[51]

At the statewide generation level

"The [CEC's] 2021 Integrated Energy Policy Report (IEPR) Energy Demand Forecast projected about 30,000 gigawatt-hours (GWh) in 2030 from charging battery-electric vehicles (including light-duty and MD/HD trucks, urban transit, and high-speed rail) in the "High" case. "Projections from the CEC's AB 2127 report, which considered a larger PEV fleet, estimate that light-, medium- and heavy-duty on-road vehicle charging will result in about 44,000 GWh by 2030. These totals are estimated to increase annual statewide energy usage by 11–15.5 percent in 2030 compared to observed energy usage in 2020." This would be an increase of less than 2% per year beginning in 2022.[52]

At the local Distribution Circuit level

As noted earlier, the CEC has prepared its first Electric Vehicle Infrastructure Assessment report which details the estimated number of chargers, type, location and year needed for MHD and light duty vehicles. As part of this process, it also utilizes the "EVSE Deployment and Grid Evaluation" (EDGE) tool that shows where any gaps in capacity may exist now or in the future at a granular level.[53] It then provides this data to the CPUC, CAISO and utilities. The utilities can then

[50] https://electrek.co/2021/03/25/cummins-to-power-first-vehicle-to-grid-school-buses-in-north-america/
[51] Draft Zero-Emission Vehicle Infrastructure Plan (ZIP) (ca.gov)
[52] Ibid.
[53] https://www.energy.ca.gov/programs-and-topics/programs/electric-vehicle-charging-infrastructure-assessment-ab-2127

incorporate these needs in their annual Integrated Resource Plans and general rate cases to upgrade their distributions grids ahead of demand growth to meet the needs of anticipated new chargers.

## Resiliency

One concern expressed by some stakeholders is how they can fuel their ZEVs in a power outage and how power outages can be minimized.

In its recently released SRIA report, CARB addresses this issue as follows: "Although some fleets may want backup generation on site, staff does not assume infrastructure costs for the use of on-site backup generation for a number of reasons. First, ZEVs would gradually enter the fleet over time and only a small portion of the fleet would be zero-emission. Second, power outages affect all fuel types as fuel pumps cannot work without electricity, so similar issues already exist today. Third, mobile fueling and other solutions are currently being developed and present a solution for fleets seeking additional reliability. Some backup generation options such as onsite power storage, present the opportunity to offset some or all of the costs to store energy during off-peak periods to reduce peak demand charges, or by reselling the electricity onto the grid during peak times using vehicle-to-grid technology."[54] [ ..and can also provide some back-up power in an outage].

In the last few years, utilities have initiated public safety power shutoffs to mitigate electric system caused wildfires under extreme fire risk conditions. However, they have been taking aggressive steps to reduce the frequency, duration, and number of customers affected. For example, since PG&E first started doing PSPSs three years ago, they have made significant improvements in communications with customers, seeking to give them advance notice, minimizing the area affected, minimizing the duration and is seeking to reduce risk in the first place. Some of the actions they have taken are:

- Continuing to upgrade the electric grid by hardening power lines to reduce wildfire risks including undergrounding some lines
- Installing sectionalizing devices to narrow the scope of PSPS so fewer customers are without power
- Piloting new technologies that detect threats to the electric grid and rapidly reduce or shut off power, thus reducing the need for larger PSPS
- Installing microgrids that use generators to keep the electricity on during PSPS.

Fleet owners who install on-site solar along with battery storage can not only lower their electricity costs but also provide resiliency for backup power in the event of a power outage.[55]

## Workforce

Substantial investments in electric vehicle infrastructure are a tremendous economic engine leading to a growing demand for the highly-skilled electrical construction workforce needed to build an adequate statewide network of charging stations. While EV charging infrastructure electrical work includes some emerging technology elements, EV infrastructure projects are primarily comprised of conventional electrical construction work skills. In California, most of those skills are held by C-10 electrical contractors and - most importantly - their electrical worker employees who are state certified general electricians. In fact, according to California law,

[54] Proposed Advanced Clean Fleets Regulation - Standard Regulatory Impact Assessment (ca.gov) Page 76
[55] https://www.evgo.com/press-release/evgo-balances-ev-fast-charging-with-14-battery-storage-systems-across-11-evgo-fast-charging-stations/

electrical work – including EV infrastructure projects - must be performed by those contractors and electricians[56].

How many electricians will it take to get the job done now and in the future? There are currently 30,471 California state certified general electricians.[57] They have most of the necessary skills required for EV infrastructure. Electricians are also gaining important additional EV charging infrastructure electrical technology skills through the Electrical Vehicle Infrastructure Training Program (EVITP). More than 2,300 California electricians[58] have advanced EVITP certified skills, with hundreds more graduating annually. There are also currently 7,937 registered electrical apprentices in the state.[59]

The governor's office and California state agencies have projected a need for approximately 250,000 additional charging stations, of all types, by 2025, and 1,250,000 by 2030. That will put a considerable number of state certified general electricians to work in the following categories:

- 250,000 Charging Station Installations by 2025. 455 EVITP electricians, 350 non-EVITP electricians, and 595 electrical apprentices would install 252,000 charging stations in three years. That's 1,400 electrical workers, out of a total of 38,408, or only 3.7% of the existing electrical workforce.
- 1,250,000 Charging Station Installations by 2030. 848 EVITP electricians, 652 non-EVITP electricians, and 1,109 electrical apprentices would install 1,252,992 charging stations in eight years. That's 2,609 electrical workers, out of a total of 38,408, or only 6.8% of the existing electrical workforce.

Therefore, the State has significantly more than sufficient electricians to install forecast charging needs through 2030 and beyond.

Nationally, as part of the Administration's Talent Pipeline Challenge, the IBEW pledged to train 10,000 of their members through the Electric Vehicle Infrastructure Training Program (EVITP) by this August. Philanthropies, including the Hewlett Foundation, committed a total of $250,000 to support women and workers of color training for the EVITP-certification – with an emphasis on geographic diversity.[60]

## Conclusion

Although the electrical infrastructure to meet the expected demand from large-scale MHD vehicle electrification is significant, similar successful expansions have successfully 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 from public and private sources. The CEC is making excellent progress in detailed planning for the number, power, location and timing of chargers and is selecting and implementing technical standards to make the charging experience interoperable, easy and reliable. It is working with the CPUC and utilities to identify local gaps

[56] Bill Text - AB-841 Energy: transportation electrification: energy efficiency programs: School Energy Efficiency Stimulus Program.
[57] Source: California Contractors State Licensing Board as of February 3, 2020
[58] Source: Electrical Vehicle Infrastructure Training Program as of July 18, 2022
[59] Source: California Department of Apprenticeship Standards as of February 21, 2020
[60] https://www.whitehouse.gov/briefing-room/statements-releases/2022/06/28/fact-sheet-biden-harris-administration-catalyzes-more-than-700-million-in-private-sector-commitments-to-make-ev-charging-more-affordable-and-accessible/

in electrical capacity so utilities can upgrade their grids in advance of anticipated need. Industry from legacy OEMs such as Daimler and Volvo, start-ups like WattEV, truck stop / travel center companies like Loves, Pilot Flying J and Travel Centers of America, national truck leasing/rental companies like Penske and others are all taking the initiative to begin installing EVSE for MHD vehicles both in California and nationally to support long-haul operations. New business models such as Charging-as-a-service can provide the capital and knowledge to install charging infrastructure systems with a cost-effective turnkey solution and only charge the fleets a known simple fee/ kWh for vehicle electricity used. 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—all with robust engagement from a wide range of experts and stakeholders. The increasingly positive total cost of ownership for MHD vehicles will further drive their adoption and help fund and demand the installation of needed EVSE.

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