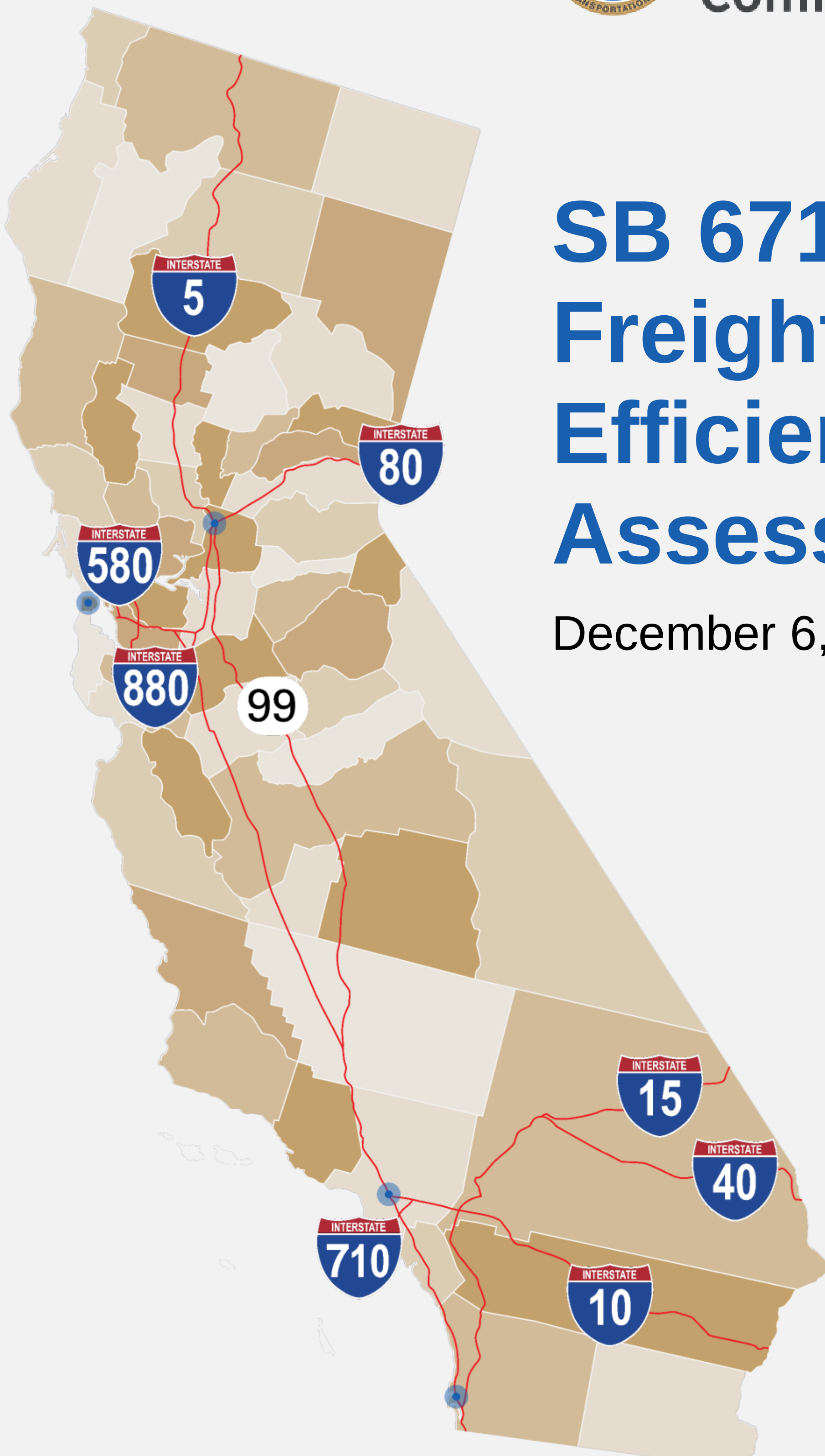
California Transportation Commission



SB 671 Clean Freight Corridor Efficiency Assessment

December 6, 2023

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Letter from the Chair

Dear Members of the Legislature:

We are pleased to submit the Senate Bill 671 Clean Freight Corridor Efficiency Assessment to the Legislature. Senate Bill 671 (Gonzalez, Chapter 769, 2021) requires the California Transportation Commission (Commission) prepare a Clean Freight Corridor Efficiency Assessment (Assessment) to identify specified freight corridors, the infrastructure needed to support the deployment of zero-emission medium and heavy-duty vehicles, and barriers and potential solutions to their deployment. This Assessment fulfills these requirements.

Since December 2021, the Commission has worked in partnership with the California Air Resources Board, the California Energy Commission, the California Public Utilities Commission, the California Department of Transportation, and the Governor's Office of Business and Economic Development to develop the Assessment. Fourteen public workgroup meetings have been held to collaborate with state, regional, and local governments as well as non-governmental organizations representing the freight industry, trucking associations, climate, equity, and other advocacy groups, warehouse workers, fleet owners, ports, utility companies and energy companies.

The Assessment provides a recommended path forward for the Legislature by identifying an initial viable network of zero-emission charging and hydrogen fueling stations needed to support fleets as they increasingly transition to zero-emission medium-duty and heavy-duty vehicles within the deadlines established by the California Air Resources Board's Advanced Clean Trucks and Advanced Clean Fleets regulations. The Assessment includes recommended next steps necessary to implement the construction of these stations, such as establishing a central delivery team to lead work, and recommendations that address time and cost concerns. The Commission is honored to play a role in California's transition to zero-emission freight and is committed to offering ongoing support for the transition to zero-emissions.

Sincerely,

LEE ANN EAGER
Chair, California Transportation Commission

Overview of

Requirements Senate Bill 671

Clean Freight Corridor Efficiency Assessment

Assessment Goal

“To identify corridors, or segments of corridors, and infrastructure needed to support the deployment of zero emission medium duty and heavy duty vehicles.”

There are the seven areas required by the Legislation:

1. Freight Corridors, or segments, that would be priority candidates for the deployment of zero emission medium duty and heavy duty vehicles.
2. The top five freight corridors, or segments, with the heaviest freight volume and near source exposure to diesel exhaust and other contaminants.
3. Projects that would achieve the goals of the Assessment, including potential project sponsors and funding opportunities.
4. Barriers and potential solutions to achieving the goals of the Assessment and the deployment of zero emission freight vehicles.
5. The impact on roads and bridges due to the increased weight of zero emission vehicles.
6. Methods to avoid displacement of residents and businesses on the freight corridor when considering projects.
7. Benefits from the deployment of zero emission vehicles.

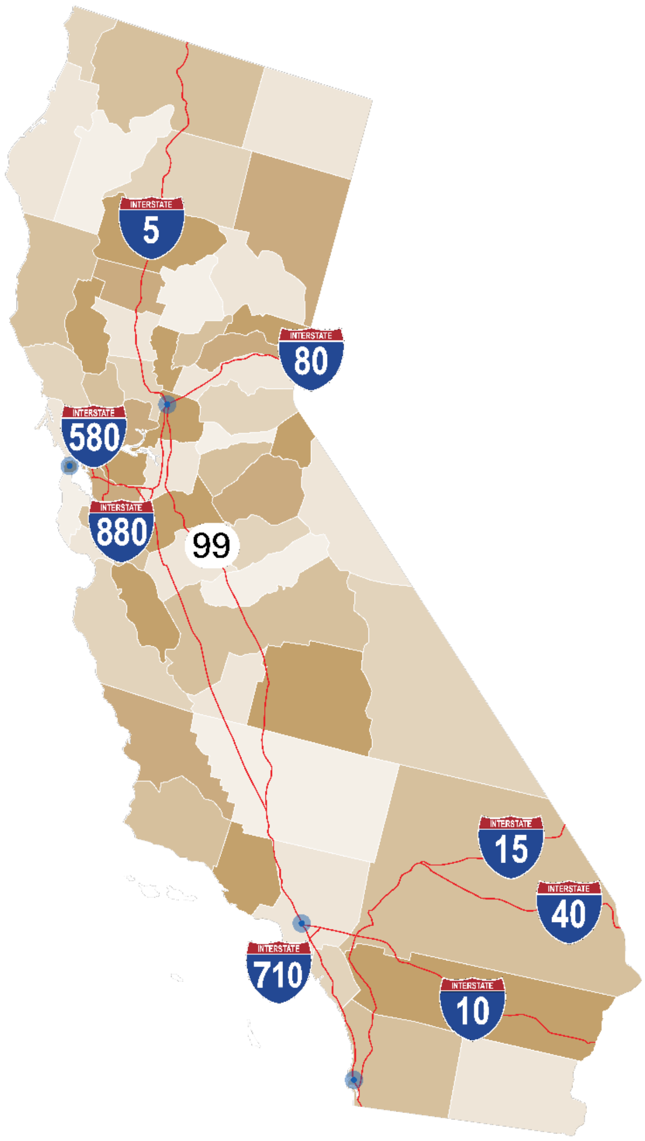
Executive Summary

California’s freight network is vital to the State's economy. The State’s ports of entry are a preeminent gateway for international supply chains, delivering goods and economic benefits to both the State and national economies. Agricultural goods make up a substantial portion of California’s freight, with the Central Valley alone producing one quarter of the nation's food, including 40 percent of its fruits, nuts, and other table foods. While the economic benefits from the State’s robust freight sector are significant, emissions generated by diesel fuel consumption cause health and environmental challenges, particularly for communities located near major freight corridors and freight facilities. Although these negative impacts may affect all residents, it is the most vulnerable that are most acutely impacted within communities. Diesel exhaust creates greenhouse gas emissions, contributing to climate change impacts in the form of increased wildfires, flooding, drought, severe storm damage, and other weather events.

Modernizing California’s freight transport system in a manner that reduces pollution is essential to improve public health and meet California’s environmental imperatives. In September 2020, Governor Gavin Newsom signed Executive Order N-79-20, which set ambitious targets for decarbonization of the transportation sector. As part of that order, Governor Newsom declared a goal for California to reach 100 percent zero-emission medium- and heavy-duty vehicles by 2045 for all operations where feasible, and 100 percent zero-emission drayage trucks by 2035. On April 28, 2023, the California Air Resources Board approved the Advanced Clean Fleets regulation to phase in a transition toward zero-emission medium-and-heavy duty vehicles to meet these goals.

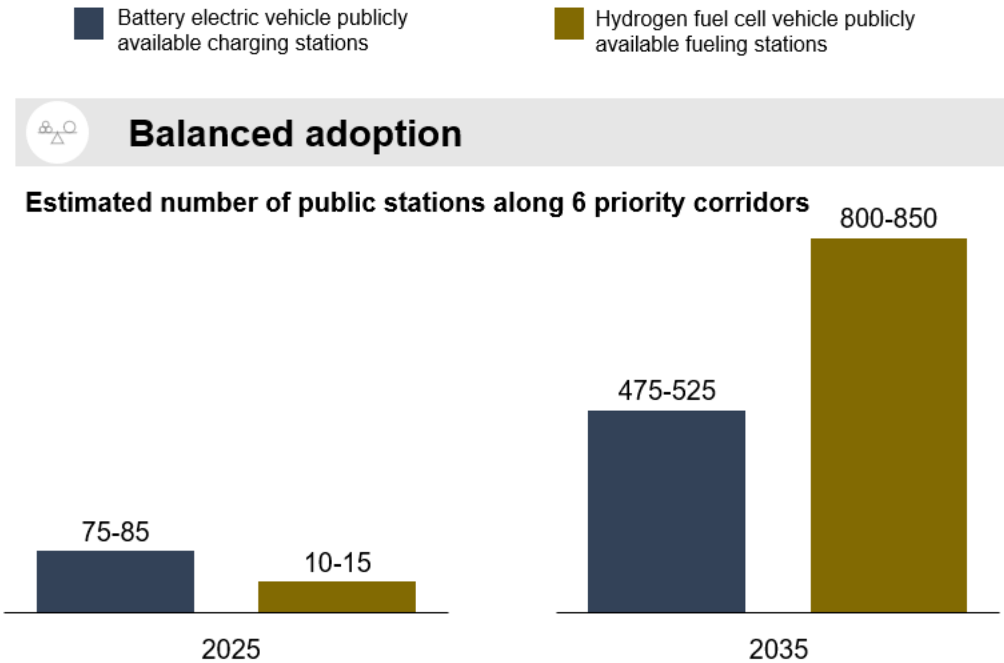
A key challenge in the transition toward zero-emission medium-and-heavy duty vehicles is the need for zero-emission infrastructure to support them, namely battery-electric and/or hydrogen fueling stations. California’s network of zero-emission charging infrastructure for medium-and-heavy duty vehicles needs to be significantly expanded in the coming years. This requires coordination across multiple levels of government and the private sector.

To identity the charging infrastructure needed to bring the State’s zero-emission goals for medium-and-heavy duty vehicles to fruition, in 2021, the Legislature passed, and Governor Newsom signed into law, Senate Bill 671 (Gonzalez, Chapter 769, Statutes of 2021). This legislation requires the Commission to collaborate with relevant state agencies and stakeholders to develop a Clean Freight Corridor Efficiency Assessment. The goal of the Assessment is to identify the freight corridors, or segments of freight corridors, and infrastructure needed to support the deployment of zero-emission medium- and heavy-duty vehicles.



The Commission's Assessment outlines a path forward for California to plan and implement zero-emission freight infrastructure by identifying the initial infrastructure needed to support zero-emission goods movement and identifying next steps California can take to begin building the necessary infrastructure in a timely manner. The Assessment identifies 34 Priority Freight Corridors for deployment by 2040, developed through an extensive stakeholder engagement process. Among these 34 Priority Freight Corridors, the Assessment recommends an initial focus on the "Top 6" corridors. The corridors were identified using a data driven methodology that considers corridors with the heaviest freight volume and near-source exposure to diesel exhaust and other contaminants. The map to the left shows the locations of the Top 6 corridors identified:

The Assessment identifies the number of zero-emission charging and zero-emission hydrogen fueling stations needed to support medium-duty and heavy-duty vehicles in 2025 and 2035 along the "Top 6" corridors—referred to as the initial viable network. The Assessment considers three potential scenarios for the initial viable network depending on the type of charging station: one for accelerated adoption of battery electric stations, one for balanced adoption of battery electric and hydrogen stations, and one for accelerated adoption of hydrogen stations. The initial viable network findings for public stations are listed below. (Public means the stations are publicly accessible – i.e., open to the public, whether or not they are publicly or privately financed and operated).



The potential costs, excluding grid upgrades, to build the initial viable network infrastructure are estimated to be $505 million to $950 million by 2025 and an additional $10 billion to $15 billion by 2035. Together with private funding, it is possible there are sufficient funds available to build out the public stations required for the initial viable network in 2025, but after that year additional investment is needed. The Assessment recommends allocating available public funds, where feasible, to support the implementation of the 2035 initial viable network cost.

The Assessment identifies three key barriers to building the initial viable network. First, the current station development process may take 6 to 8 years per station, which is too long to meet the needs for the initial viable network in 2025 and make it challenging to build the 2035 initial viable network. Second, the transition to zero-emission medium-and-heavy duty vehicles along the initial viable network may negatively impact fleet owners as they may face large, upfront costs and the need to modify their operations. Third, the transition will require the coordination of many different stakeholder groups across the state such as local permitting agencies, utility companies, Regional Transportation Planning Agencies and Metropolitan Planning Organizations, ports, the California Public Utilities Commission, the California Energy Commission, private entities like start-up companies, community-based organizations and advocates, public communities, impacted communities, and established corporations like beneficial cargo owners and fleets. The Assessment identifies solutions to each of these barriers. To expedite the timeline for building the infrastructure needed along the initial viable network, the Assessment recommends several ways to shorten the station development timeline, including through legislation authorizing a Categorical Exemption from the California Environmental Quality Act for medium-and-heavy duty charging stations as well as a statutory permit approval deadline for them. To support fleet owners during the transition, the Assessment recommends several actions, including the creation of a new limited-term (five-year) zero-emission truck incentive program to assist fleets with purchasing zero-emission trucks, as well as a new truck buy-back program. To facilitate coordination among the many agencies and stakeholders needed for the transition, the Assessment recommends the Administration create a central delivery team, functioning as a part of, or in coordination with the Governor’s recently created Executive Order N-8-23 Strike Team on infrastructure. The key barriers and solutions are summarized below and additional details on each is included in Chapter 4 of this report.

Key Barriers	Key Solutions
Time and sequencing of corridor station development	Streamline clean freight infrastructure development process
Economic viability of ZEV transition for fleet owners	Support fleet owners with the costs of transition
Complex ecosystem of potential stations and stakeholders	Create a central delivery team and a corridor-first approach

While the implementation of zero-emission medium-duty and heavy-duty vehicles along the initial viable network comes with many costs and challenges, it also results in significant benefits and savings. The Assessment estimates that transitioning the “Top 6” corridors to zero-emissions will reduce diesel emissions of carbon dioxide, total organic gases, oxides of nitrogen, particulate matter 2.5 microns or less in size by approximately 23 percent in 2030, and by 53 percent in 2040, resulting in a potential reduction of 1,720 premature deaths related to emissions through 2040. Moreover, with full implementation of the California Air Resources Board’s Advanced Clean Fleets regulation (meaning beyond the Assessment’s initial viable network), the state will experience a savings of around $18.6 billion in statewide health spending from criteria emission reductions (pollution) through 2040.

The Assessment estimates the impact of zero-emission trucks on roads and bridges to be over $100 million per year in increased road and bridge maintenance costs. It identifies existing and in-development materials created by state agencies that should be leveraged to avoid displacement of residents and businesses during the implementation of the initial viable network. Further, it identifies two capacity and power source considerations that project sponsors should evaluate when determining whether microgrids may be necessary for station development. Finally, as a step toward implementing the initial viable network, the Assessment identifies agencies and entities that may sponsor projects as well as a list of projects which is included in Appendix 3.

Part 1: Identifying and defining clean freight corridors

Chapter Summary

Identifying corridors that are a priority for freight allows California policymakers to prioritize investments in zero-emission station development. It provides a place to start short-term and long-term infrastructure planning. The California Transportation Commission (Commission) took a goods movement-based approach to identifying and defining freight corridors in California. The Commission considered data from a variety of data sources and stakeholder groups, including the Army Corps of Engineers, Engineer Research and Development Center, Lawrence Berkley National Laboratories, the University of California - Davis, the California Department of Transportation (Caltrans), and the Federal Highway Administration, to understand goods movement in California.

To support the transition of medium-duty and heavy-duty trucks to clean energy, the Assessment first identifies 34 "Priority Freight Corridors" necessary to support the efficient movement of goods across the state, as developed by members of the SB 671 workgroup. To identify the "Top 6" corridors needed to support an initial viable network, the Commission reviewed emissions, truck volume, commodity flows, trip types, and the potential powertrain mix of truck traffic on California highways between 2022 and 2050. This approach ensures the outcomes of the Assessment appropriately estimate the infrastructure needs for California's current and future freight-related industries and economy.

The "Top 6" corridors represent over 50 percent of average daily truck vehicle miles traveled by medium-duty and heavy-duty trucks across California. The implementation of zero-emission infrastructure along these "Top 6" corridors will allow California to reduce tailpipe carbon dioxide, total organic gases, oxides of nitrogen, and particulate matters 10 and 2.5 by approximately 23 percent in 2030, and by 53 percent in 2040.

"Top 6" Corridors

1. **I-5** from California's Southern border with Mexico to its Northern border with Oregon
2. **I-15** from San Diego to California's Southeast border with Nevada
3. **SR-99** from Red Bluff to Bakersfield
4. **I-10/I-710** from the San Pedro Bay Ports to Los Angeles to California's Southeast border with Arizona
5. **I-40** from its intersection with I-15 to California's Southeast border with Arizona
6. **I-80/I-580 and I-880** from the Port of Oakland to San Francisco to California's northeast border with Nevada

1.1 Identifying the 34 “Priority Freight Corridors”

California represents the fourth largest economy in the world. A significant segment of that economy is driven by the movement of goods across the state’s vital freight corridors. To support the transition of medium-duty and heavy-duty trucks to clean energy, the Assessment identifies 34 “Priority Freight Corridors” necessary to support the efficient movement of goods across the state. For the 34 Priority Freight Corridors, the Commission focused on the importance of freight needs as identified by members of the SB 671 workgroup. A major goal of developing the Assessment was to make it useful for stakeholders responsible for implementation of recent air quality regulations, such as fleets, ports, Regional Transportation Planning Agencies, Metropolitan Planning Organizations, and alternative energy companies. Allowing SB 671 workgroup members to contribute to the process of identifying the 34 Priority Freight Corridors helped ensure the Assessment included their perspectives regarding freight need or areas of expertise throughout the state.

The 34 Priority Freight Corridors were identified using the following evaluation criteria:

1. The corridor is a critical freight route.
2. The corridor is located near existing electric infrastructure or hydrogen supply where feasible.
3. The corridor is located near similar efforts to expand electric or hydrogen infrastructure.
4. The corridor is identified as important by the California Energy Commission’s Medium-Duty and Heavy-Duty Electric Vehicle Infrastructure Load, Operations and Deployment Tool (HEVI-LOAD).
5. The corridor is in an area disproportionately burdened by air pollution.
6. The corridor is a route suitable for the short-haul use case (for electric vehicles); for this purpose, the short-haul use case means trips where trucks can complete a shorter route and return to a base to charge at a depot once a day.
7. The corridor is a logical starting point for the build out of a charging network or a logical co-location hub for both light-duty and heavy-duty hydrogen fuel cell electric vehicles.
8. The corridor is a corridor where projects could be built relatively quickly.
9. The corridor is a corridor where land is available to build zero-emission infrastructure.

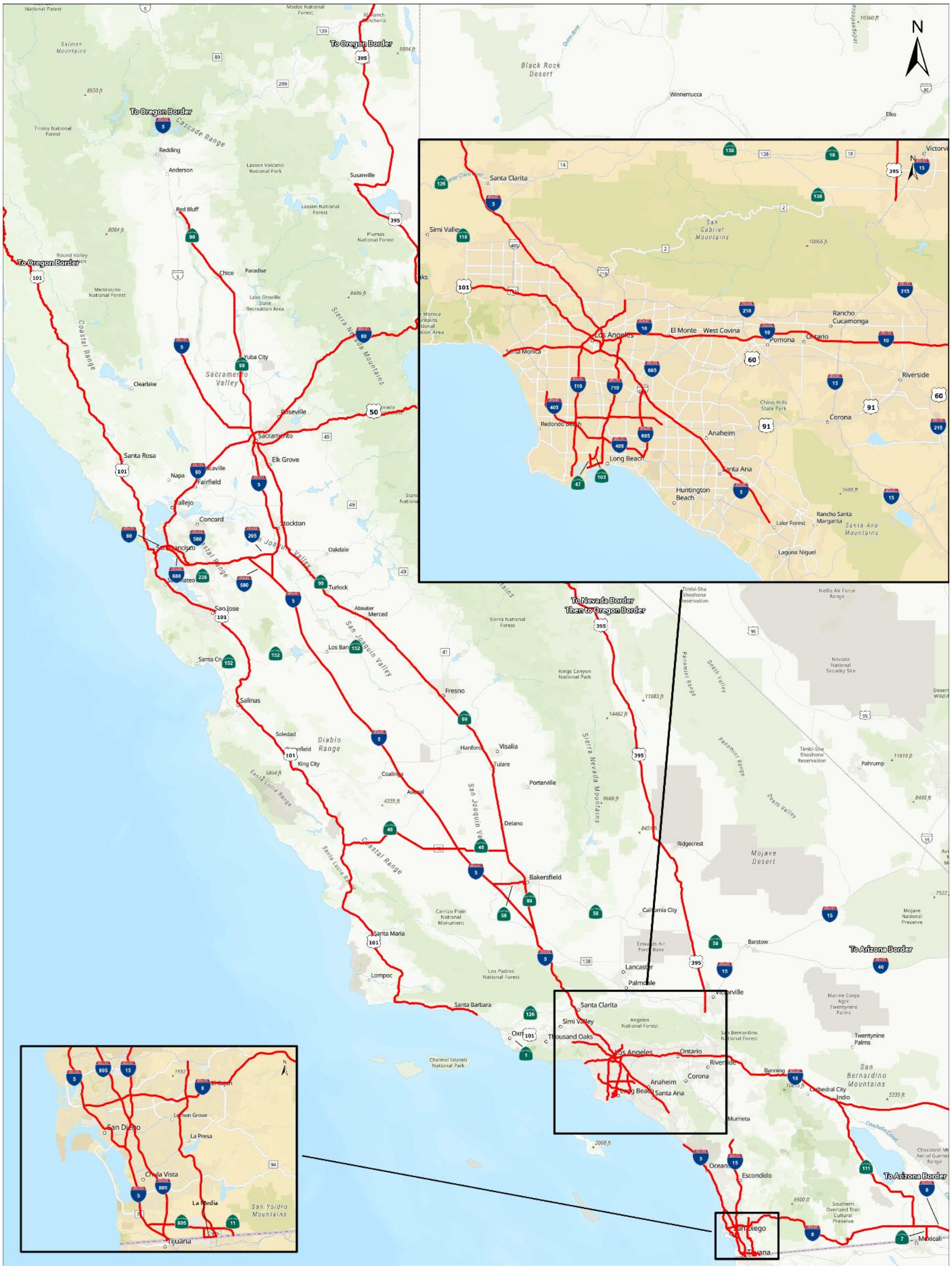
These criteria were expected to be met, where feasible, and the workgroup members who submitted corridors for consideration provided an explanation to justify why the corridor should be considered important for this Assessment.

In addition to considering the criteria, SB 671 workgroup members nominated corridors for consideration based on the following three questions:

1. What Corridor or Corridor Segment do you recommend (please provide your top three priority corridors)?
2. Describe why the Assessment should focus on this corridor?
3. What potential projects could be implemented along this corridor?

The resulting maps were presented to the SB 671 workgroup who confirmed 34 nominated corridors as "Priority Freight Corridors." These corridors represent important freight routes and align well with the Caltrans Strategic Interregional Corridors and Alternative Fuel Corridors, which mean they have been identified as important freight routes in other studies. They represent the next phase of corridors, after the "Top 6" corridors described in the next section, the state should invest in and support to create a statewide system of zero-emission freight infrastructure. Exhibit 1 shows a map and list of the 34 "Priority Freight Corridors".

Exhibit 1: Map & List of 34 "Priority Freight Corridors"



The table below lists the 34 Priority Freight Corridors.

Interstates	State Routes	United States Routes
5, 8, 10, 15, 40, 80, 110 205, 210, 215, 405, 580 605, 710, 805, 880	7, 11, 46, 47, 50, 58, 60, 91, 99, 103, 111, 118, 126, 152, 238, 905	101, 395

1.2 Identifying the “Top 6” corridors for the initial viable network

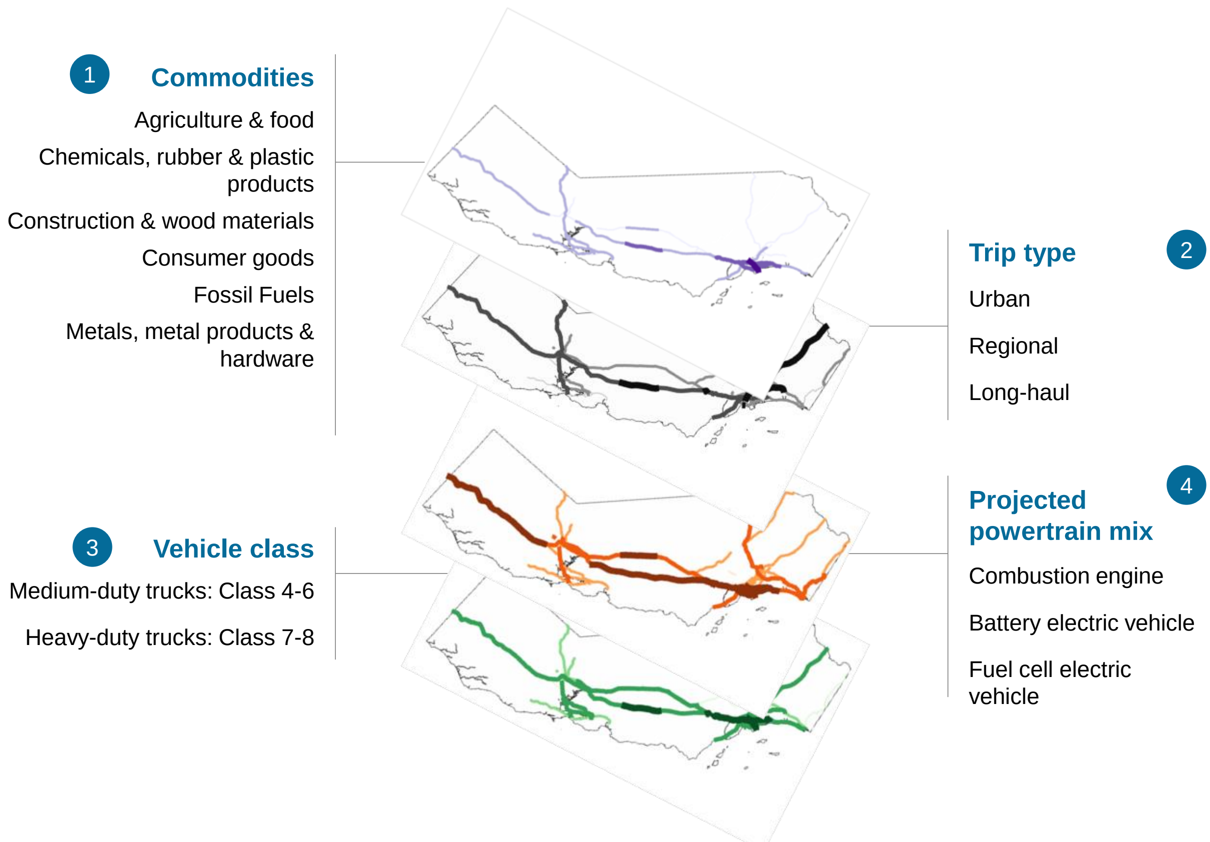
The Assessment employed a four-step approach to further narrow the list of 34 “Priority Freight Corridors” to a final “Top 6” corridors. Focusing on the “Top 6” corridors provides a concrete and achievable first step for the state through the establishment of an initial viable network. The Commission used a data driven methodology to identify the “Top 6” corridors, consistent with the SB 671 requirement to identify “the top five freight corridors, or segments of freight corridors, with the heaviest freight volume and near-source exposure to diesel exhaust and other contaminants.” The Commission identified six top corridors rather than five, because based on the analysis performed, all six of these corridors are of primary importance to California’s freight system and clean air goals and are also needed to establish an initial viable network.

1. Goods movement and commodity flows across commodity type, expected trip type, vehicle class, and projected powertrain adoption were estimated. The term “powertrain” refers to the type of energy used in the truck, such as battery electric or hydrogen fuel cell.
2. The “Top 6” freight corridors were defined as corridors greater than 50 miles in length, with the highest concentration of goods movement and highest average daily truck vehicle miles traveled.
3. Corridors over 50 miles in length were ranked based on vehicle miles travelled determined using Freight Analysis Framework average daily truck vehicle miles travelled and median daily truck trips, and an analysis of additional datasets including truck traffic data from Caltrans and truck Global Positioning System data.
4. “Top 6” corridors were evaluated for emissions and near-source pollution exposure effects.

1.3 Estimating goods movement (Step 1)

The Commission started with goods movement data to preserve the freight-focused intent for the Assessment. The overlap of the highest vehicle miles traveled (VMT) for trucks, and the median of truck trips per day gave an initial perspective on the priority corridors to consider. Truck vehicle miles travelled measures the amount of travel for all trucks on a specific corridor over a specific time period, in this case a year. Exhibit 2 shows four categories of freight information the Commission collected and used to understand goods movement in California and project zero-emission infrastructure needs.

Exhibit 2: Categories Used to Assess Goods Movement in The State of California



The pattern of goods movement was assessed based on the categories in Exhibit 2. These categories are described below.

Commodities: The goods movement analysis found that agriculture and consumer goods in California flow to major population centers, while industrial commodities movement is concentrated around various manufacturing, production areas, and harbors throughout the State.

Trip type: The trip types evaluated were urban, regional, and long-haul. Urban trips are defined as trips in and around cities and urban centers usually for delivery of goods. For this work, cities and urban centers were qualitatively identified based on areas in maps of California that had more people and roads, and the terms “city” and “urban” were used interchangeably. Redding, for example, is a city surrounded by several forest areas with less people and roads. Regional trips are defined as trips in between larger California cities, such as San Francisco and Los Angeles, and neighboring states. Regional also includes short-haul trips such as drayage. Long-haul trips are defined as trips much longer in length, whether cross-country or several states away in proximity. In general, medium-duty trucks are more frequently used for urban or delivery trips and heavy-duty trucks are used for drayage, regional, and long-haul trips. Distances for trip types were largely determined by looking at information about typical truck behavior. In general, urban trips were defined as trips up to 30,000 annual truck miles traveled in length, regional up to 60,000 annual truck miles travelled and long haul up to 90,000 annual truck miles traveled or more. Annual urban trips are concentrated along population centers, while regional and long-haul truck traffic is more equally distributed across major interstates. Medium-duty trucks are concentrated on urban roads between large metropolitan areas, while heavy-duty trucks are mostly found on connecting interstates and some drayage routes.

Vehicle class: California Air Resources Board vehicle classifications were used for modeling purposes because the Assessment also utilized California Air Resources Board zero-emission projected truck estimates and vehicle miles traveled data. Vehicle estimates associated with the Advanced Clean Fleets regulation included some light-duty vehicle classifications, specifically, “LHD-1,” “LHD-2,” and bus vehicle classes. The California Air Resources Board’s Mobile Source Emissions Inventory modeling tool, known as EMFAC, describes these vehicle classifications as “light heavy-duty trucks” with weights between 8,508 and 14,000, which fall within the light-duty vehicle class category. The EMFAC guide lists vehicle class type 4 as the first public medium-duty truck vehicle class. After consulting with state agency partners, the decision was made not to include vehicle class types lower than vehicle class type 4 in the Assessment because SB 671 specifically requires identifying infrastructure for “freight” and “medium-duty and heavy-duty” vehicles. Focusing on medium-duty and heavy-duty vehicles ensures a clear differentiation from passenger vehicles and an assessment focused primarily on commercial vehicles carrying freight. More details on vehicle class types can be found in Appendix 2.

Projected powertrain mix: The projected power train vehicle inventory considered includes combustion engine (including diesel) vehicles, battery electric vehicles, and hydrogen fuel cell electric vehicles. By 2050, annual battery electric truck trips are projected to be concentrated on interstates, while hydrogen fuel cell electric truck trips, coinciding mostly with heavy-duty long haul vehicle trips, are projected to be concentrated on the highest average daily vehicle miles traveled corridors between major origin and destination points, such as along I-5.[1]

1.4 Defining freight corridors (Step 2)

To identify the “Top 6” corridors, the Assessment had to first delineate a consistent definition for freight corridors.

This Assessment defines freight corridors as routes with the highest concentration of truck volume with a minimum segment length of 50 miles.

A minimum length of 50 miles was chosen as the cutoff point in determining the “Top 6” corridors for this Assessment for several reasons:

- The goal of this Assessment is to take a freight-focused and corridor-based view of goods movement throughout the state and assess the resulting zero-emissions infrastructure needs. Although some of the shorter highways are important links or connectors, the priority for initial funding and development of infrastructure is to develop a connected statewide network that is useable as stations are developed.
- 50-mile spacing is consistent with plans for infrastructure outlined by the National Electric Vehicle Infrastructure Program.[2]
- Shorter length highways and connecting routes often surround key origin and destination points like warehousing facilities in cities, ports, and inland ports, which will need more localized charging infrastructure solutions than can be provided in a statewide study.
- 50 miles is significantly shorter than the range of most zero-emission trucks currently on the market.

Appendix 2 outlines calculations for the recommended 50 mile spacing of the initial viable network for battery electric vehicles in 2025.

I-5 and SR-99, while separate highways, operationally function as one corridor from a national goods movement perspective. Since this is the case, the major east-west roads that connect I-5 and SR-99, for example highway 41 and highway 58 are important to the corridor. Building zero-emission freight infrastructure on these east-west connectors will be necessary to provide for system resiliency.

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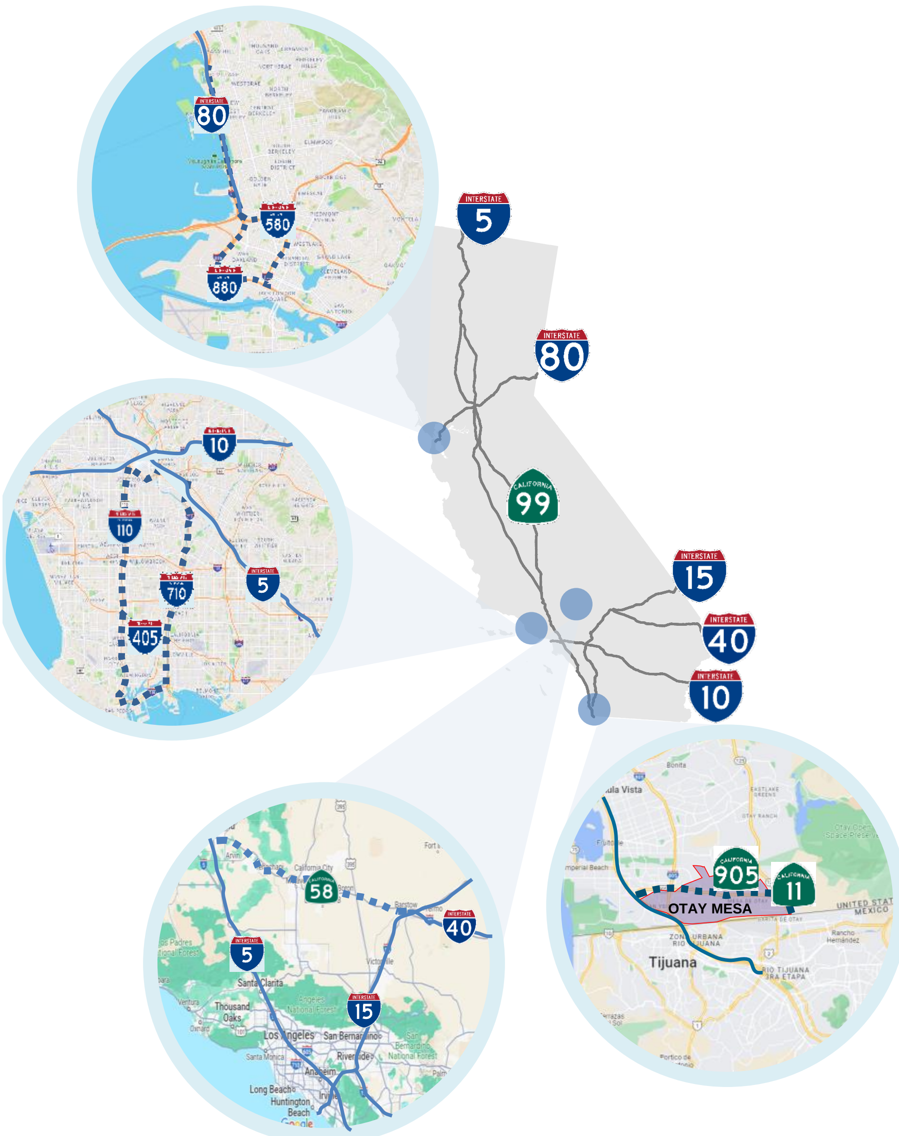
[1] Analysis of data from Highway Performance Monitoring System (Federal Highway Administration), Freight Analysis Framework (Bureau of Transportation Statistics).

[2] The National Electric Vehicle Infrastructure Program was established through the Infrastructure Investment and Jobs Act to create a nationwide network of publicly available, fast-charging battery electric vehicle chargers along state and federal highways with an initial focus on light-duty vehicles

Infrastructure that is placed within a radius of 5 miles of a “Top 6” corridor may support a parallel corridor if it is placed between the corridors. In the case of I-10 and SR 60, for example, infrastructure placed between the routes may support traffic travelling along either corridor.

The “Top 6” corridors also include smaller segments of highways that connect the longer corridors to key ports of entry as part of the corridor due to the segment’s importance to goods movement. For example, a segment of Interstate I-710 is considered part of the I-10 priority corridor, because I-710 connects I-10 to the San Pedro Bay ports. Small segments of I-580 and I-880 are also considered part of the I-80 priority corridor because I-580 and I-880 form a loop which connects I-80 to the Port of Oakland. Exhibit 3 provides a visualization of these links. Additional information about the key connecting segments to ports of entry can be found in Appendix 2.

Exhibit 3: Top 6 Corridors – Key Connecting Routes



PORT OF OAKLAND: The I-80 corridor includes the short segments of I-580 and I-880 that connect I-80 to the Port of Oakland.

SAN PEDRO BAY PORTS: The I-10 corridor includes the short segment of the I-710 that links the I-10 to the San Pedro Bay ports, the SR-47 that connects the Port of Los Angeles to I-710, and the segments of I-405 and Highway 1 that connect I-110 and I-710 near the San Pedro Bay Ports.

OTAY MESA: The I-5 corridor includes the short segments of SR-905 and SR-11 that connect I-5 to Otay Mesa and the US-Mexico border.

SR-58 (SR 99 and I-5 East/West Connectivity): I-40 also includes SR-58 extending to I-5 near Bakersfield.

Key connecting routes

Interstates 580 and 880

Interstate 580 is an east-west state highway which connects with Interstate 880, a north-south state highway, to form a loop which connects Interstate 80 to the Port of Oakland and nearby freight rail intermodal yards at the Oakland waterfront. The Oakland Seaport oversees 1,300 acres of maritime-related facilities serving a local market of over 14.5 million consumers, 34 million consumers within a seven-hour drive and 50% of the United States' population by rail. Three container terminals and two intermodal rail facilities serve the Oakland waterfront.

The Port of Oakland formalized its commitment to becoming a zero-emissions port in 2019 when it adopted the Seaport Air Quality 2020 and Beyond Plan: The Pathway to Zero Emissions. The Port Infrastructure Development Project will guide the Oakland Seaport in its transition from using fossil-fuels to using clean energy. At the heart of this effort is the use of clean electricity to fuel battery-electric mobile equipment and to provide power to berthed vessels. Port of Oakland tenants have until December 31, 2023, to create a cargo-handling equipment conversion plan. The plan will allow the Port to work collaboratively with its business partners to support an efficient and timely transition to zero emissions.[3]

Interstate 710

I-710 is a major north–south state highway in Los Angeles. I-710 is a heavily congested approximately 25-mile freeway that connects the Ports of Los Angeles and Long Beach to freight rail intermodal yards located near East Los Angeles and to the rest of the national interstate system via I-10. Located in one of the most dense, urban, and economically disadvantaged parts of Los Angeles County, I-710 is essential both to the communities that it traverses, and to the national freight distribution network. In recent years, ever increasing traffic from the ports has combined with local population growth and aging infrastructure to create challenges to meeting the state's safety, equity, environment, and economic prosperity goals on I-710.

The public health and climate challenges facing the equity-focused communities along the I-710 Corridor caused by the tens of thousands of diesel heavy-duty trucks travelling along the corridor has spurred regional agencies to invest significant levels of funding for zero-emission heavy-duty trucks, and their supporting infrastructure, to replace those diesel trucks. The Los Angeles County Metropolitan Transportation Authority has programmed $50 million in seed funding to leverage a $200 million zero-emission truck program for the I-710 corridor, while the Ports of LA and Long Beach have approved a Clean Truck Fund Rate that could generate approximately $90 million per year to subsidize the transition of heavy-duty drayage trucks that call on the ports to zero-emission technology.

The Los Angeles region is planning an extensive zero-emission charging and fueling network to support the deployment of zero-emission trucks. For example, the Los Angeles Cleantech Incubator created an investment blueprint for heavy-duty charging depots adjacent to the busy I-710 freight corridor that can support battery electric trucks serving the San Pedro Bay Ports. Following a selection framework that incorporated grid infrastructure, drayage duty cycles, and community priorities, the Los Angeles Cleantech Incubator identified priority locations for public and private heavy-duty charging infrastructure and associated cost structures. Los Angeles County Metropolitan Transportation Authority is working

[3] More information on the Port of Oakland and its zero emission policy plans is available on the Port's website at: https://www.oaklandseaport.com/

closely with the Los Angeles Cleantech Incubator and is building upon this blueprint and other feasibility studies conducted by the Ports and other partners to advance the deployment of zero emission truck infrastructure in the I-710 Corridor.

Otay Mesa

Otay Mesa is a community located just north of the United States-Mexico border in the City of San Diego and is a key commercial crossing for goods movement between the US and Mexico. The Otay Mesa Port of Entry connects the City of San Diego and incoming and out-going trade across the United States border with Tijuana and western Baja California, Mexico. The Otay Mesa border crossing connects with SR-905, and the Otay Mesa East border crossing connects with SR 11, providing key links to I-805 and I-5.

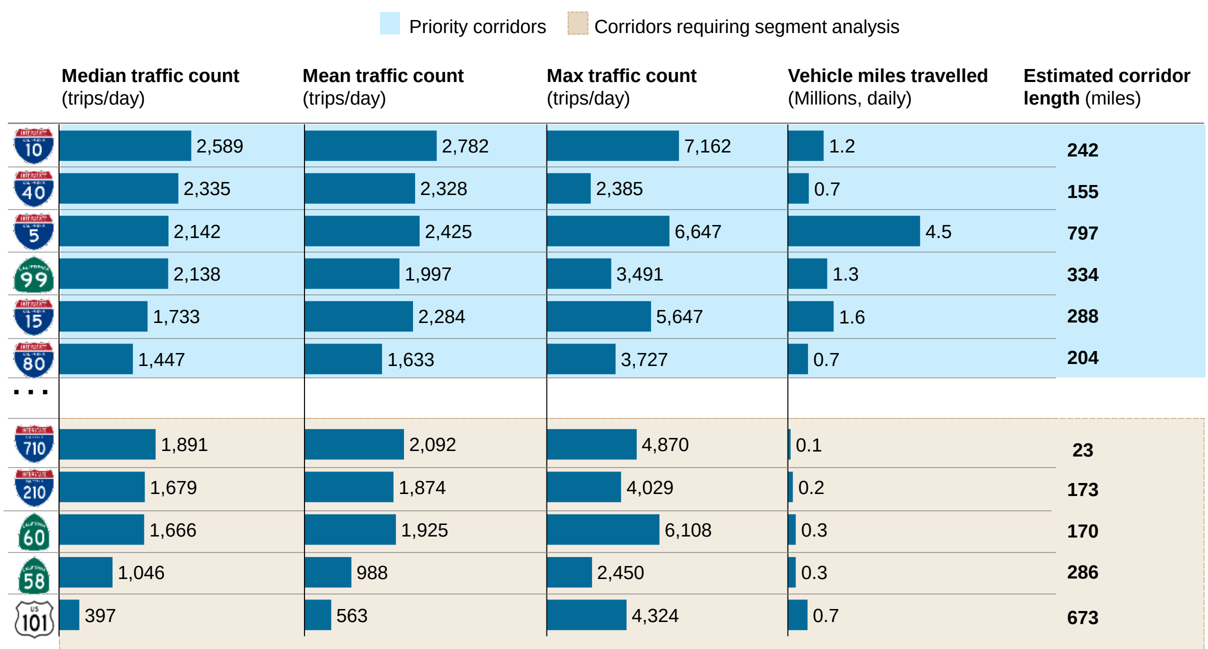
Zero-emission infrastructure is needed along the United States and Mexico border at ports of entry like Otay Mesa East, where many trucks cross the border. The 2023 memo, "Zero Emission Freight Transition at the California and Baja California Border[4] notes over 1.4 million northbound trucks moved through the region's three commercial land ports of entry in 2021, with an assumed equal number of southbound trips. In 2021, the region's land ports of entry handled $71.8 billion in goods, with the Otay Mesa Port of Entry being the second-busiest truck crossing along the United States–Mexico border. Additional information can be found in Appendix 2.

[4] The "Zero Emission Freight Transition at the California and Baja California Border" memo is available online at: https://www.sdapcd.org/content/dam/sdapcd/documents/capp/meetings/int--border/04-19-23/Zero%20Emission%20Freight%20Transition%20at%20the%20California0410.pdf

1.5 Ranking corridors and determining the natural cut-off (Step 3)

In addition to the Freight Analysis Framework version 5 data that was used, the Commission also reviewed truck counts from Caltrans and truck Global Positioning System data. This data, along with the Freight Analysis Framework version 5 data, was used to rank the corridors and then to determine the natural break points of freight corridors. The Freight Analysis Framework version 5 data was given more weight than the other datasets when ranking corridors because it was the primary source for the commodity flow data used in Step 1. The final “Top 6” corridors ranked highly in terms of goods movement and had the highest daily truck volume on segments 50 miles long or more. An excerpt of this analysis is included as Exhibit 4.

Exhibit 4: Truck Traffic Assessment of California Corridors



The vehicle miles travelled was doubled in the graphic above to account for two-way directionality.

1.6 Evaluating "Top 6" corridors for emissions and near-source exposure impact (Step 4)

One of the primary goals of the Assessment is to identify corridors which move freight throughout the state and are also responsible for significant emissions and near-source pollution exposure. For Step 4, the Assessment assumes a direct correlation between truck volume and truck emissions. Thus, after identifying the "Top 6" corridors with the highest truck traffic volume as discussed in the previous section, the next step in the approach was to overlay this data with industrial activity, emissions, and near-source pollution data and research.

The purpose of this step was to estimate the impact of addressing emissions from heavy-duty and medium-duty trucks by investing in zero-emissions infrastructure along these corridors and to confirm that the "Top 6" corridors align with Senate Bill 535 Priority Population data that demonstrates an existing need for improved air quality. See Appendix 2 for the emissions estimation approach. Senate Bill 535 (De Leon, Chapter 830, 2012) authorized the California Environmental Protection Agency and the California Air Resources Board to identify disadvantaged communities based on geographic, socioeconomic, public health, and environmental hazard criteria. The California Environmental Office of Health Hazard Assessment's mapping tool called "CalEnviroScreen" displays Senate Bill 535 communities. This information was used to show the proximity of the "Top 6" corridors to Disadvantaged Communities. Exhibit 5 highlights that the "Top 6" corridors are near many communities that have been identified as Senate 535 disadvantaged communities.

Exhibit 5: Air Quality Impact of Transitioning to Zero-Emission Freight Along "Top 6" Corridors

"Top 6" Corridors

Based on the methodology outlined in this section, the Assessment has identified the following "Top 6" corridors for emissions and truck volume:

Exhibit 6: "Top 6" freight corridors identified

Priority corridors identified
Ordered by truck volume – 2022 projected

- I-5 from California's Southern border with Mexico to its Northern border with Oregon
- I-15 from San Diego to California's Southeast border with Nevada
- Route 99 from Red Bluff to Bakersfield
- I-10/I-710 from the San Pedro Bay Ports to Los Angeles to California's Southeast border with Arizona
- I-40 from its intersection with I-15 to California's Southeast border with Arizona
- I-80/I-580 and I-880 from the Port of Oakland to San Francisco to California's northeast border with Nevada

Freight Analysis Framework version 5 data, 2022 projection

Part 2: Estimating clean freight infrastructure needs

Chapter Summary

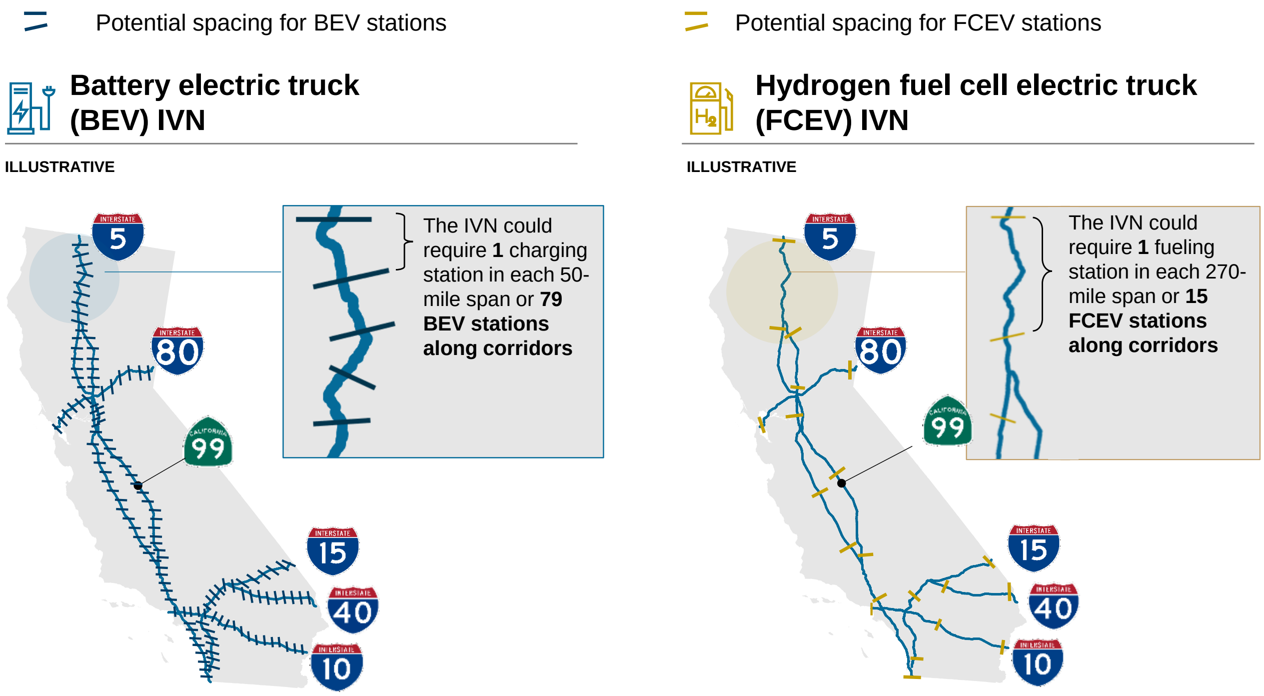
To prioritize zero-emission infrastructure along the most pollution burdened corridors, and to support publicly accessible infrastructure where there is a greater need for charging infrastructure, the Assessment focuses on the need to develop a network of publicly accessible charging and hydrogen fueling infrastructure along the “Top 6” corridors.

Focusing on the “Top 6” corridors as the initial viable network provides a concrete and achievable next step for the state. An initial viable network of zero-emission infrastructure for freight will support the implementation of the California Air Resources Board’s Advanced Clean Trucks and Advanced Clean Fleets regulations. A map of the initial viable network is shown in Exhibit 7.

Infrastructure needs for the initial viable network were estimated using the following approach:

1. Estimated statewide electrical and hydrogen fuel demand across three potential scenarios of zero-emission truck adoption: 1) Accelerated Battery Electric Vehicle Adoption, 2) Balanced Adoption, and 3) Accelerated Hydrogen Fuel Cell Adoption.
2. For the initial viable network, allocated a portion of statewide electrical and hydrogen fuel demand to each of the “Top 6” corridors.
3. Assessed the number of charging and fueling stations required along “Top 6” corridors based on charging and fueling archetypes.
4. Estimated the capital investment required to construct the public and private charging and fueling stations to meet fuel demand along the corridors. More detail is in Appendix 2.

Exhibit 7: Initial Viable Network



Three potential scenarios of infrastructure needs were assessed due to the uncertainty surrounding which type of technologies are likely to be adopted by fleets in the future (more details in the section which follows). This creates a range of potential needs that can help policy makers plan.

The assessment recommends policy makers focus first on the initial viable network of publicly available zero-emission stations needed along the “Top 6” corridors. This prioritizes emissions reductions and public health, while balancing the state’s growing freight sector ensuring the Assessment is a useful tool for policymakers manageable zero emission infrastructure needs.

2.1 Defining potential scenarios for zero-emission truck adoption

The Assessment studied four years that are benchmarks in the Advanced Clean Fleets regulation – 2025, 2030, 2035, and 2040.

For each year, three potential scenarios were created to gauge zero-emission truck demand and estimated infrastructure needs: accelerated battery electric adoption, balanced adoption (given likely fleet owner powertrain choice), and accelerated hydrogen fuel cell adoption.

Input from the workgroup, including private companies and state agencies such as the California Energy Commission and the California Air Resource Board, was used to shape the estimated powertrain adoption in each scenario. The estimated powertrain adoption is the estimated percentage split between battery electric trucks and hydrogen fuel cell electric trucks used in each scenario.

The Assessment considered the estimated cost of vehicle ownership, and how well different technology choices fit different truck use cases to estimate how many trucks would be battery electric and how many trucks would be hydrogen per scenario. California Air Resources Board vehicle estimates disaggregated by vehicle class type were used to associate different truck vehicle class types with typical use cases and cost. Exhibit 8 summarizes the key scenario assumptions.

Exhibit 8: Key scenario assumptions

Key assumptions behind the three scenarios

	Accelerated battery electric adoption	Balanced adoption	Accelerated hydrogen fuel cell adoption
Cost of ownership	**Battery electric trucks become more cost effective over time** accelerating incorporation into commercial fleets	**Balanced adoption of zero-emissions technologies** over time	**Fuel cell trucks become more cost effective over time** accelerating incorporation into commercial fleets
Technology choice and use case	**BEV trucks and charging become the optimal solution for all or most use cases** including drayage, delivery, and long haul	**No predominantly used technology across use cases**	**FCEV trucks and fueling become the optimal solution for all or most use cases** including drayage, delivery, and long haul

2.2 Assessing clean freight infrastructure needs

Once the three scenarios were developed, the infrastructure needed to support the battery electric and hydrogen medium-duty and heavy-duty truck fleets were estimated for each scenario. Developing scenarios for zero-emission freight infrastructure needs requires estimates of the following factors:

- Total number of zero-emission medium-duty and heavy-duty vehicles on the road (assumptions are held constant across all three scenarios).
- Annual medium-duty and heavy-duty annual average statewide vehicle miles traveled by vehicle class type (assumptions are held constant across all three scenarios).
- Fuel efficiency of battery electric and hydrogen trucks (assumptions are held constant across all three scenarios).
- Mix of power train adoptions. For example, what percent of the total trucks will be battery electric? What percent will be hydrogen? The three scenarios are:
  - Accelerated battery electric adoption: Tests a higher and faster adoption of battery electric trucks.
  - Accelerated hydrogen fuel cell adoption: Tests a higher and faster adoption of hydrogen fuel cell trucks.
    - Related to hydrogen, there are many safety measures that are either in place in existing standards and codes or that are being developed currently. The United States Department of Energy oversees hydrogen safety work. There is a Hydrogen Safety Panel, with a mission to, “enable the safe and timely transition to hydrogen and fuel cell technologies by sharing the benefit of extensive experience and providing suggestions and recommendations pertaining to handling and use of hydrogen.” The Hydrogen Safety Panel website includes “hydrogen tools” which are related to safety and are funded by the United States Department of Energy and maintained by the Pacific Northwest National Laboratory. The Department of Energy also has a “safety, codes and standards” webpage, which lists all of the existing and in-process standards and codes related to hydrogen safety. Among the standards the list covers are leak detection and response practices, the safe transfer of hydrogen, and the safe distribution of hydrogen. Experts and community members are encouraged to participate in the development of safety standards for hydrogen.
  - Balanced adoption: Tests adoption driven by information about decisions fleets have made in the past about what types of zero-emission trucks to purchase, as well as the likely total cost of ownership parity with combustion engines (based on information about truck sales and a study from the McKinsey Center for Future Mobility, called, “Why the Economics of Electrification

Make This Decarbonization Transition Different),” and the resulting powertrain choice by vehicle class and primary trip type, given expected commodity growth resulting trip types.

- Characteristics of battery electric charging stations, such as the number of public versus private stations, charging efficiency, capacity factors, and utilization (assumptions around these characteristics are held constant across all three scenarios).
- Characteristics of hydrogen fuel stations, such as the split of public versus private ownership, annual fuel capacity per station, and utilization (assumptions are held constant across all three scenarios).
- Maximum distance between charging stations and hydrogen fuel stations to form an initial viable network (assumptions are held constant across all three scenarios but differ based on the rate and mix of zero-emission truck power train adoption included in each scenario).

Exhibits 9 and 10 illustrate the overall approach for modelling energy demand for zero-emission truck charging and fueling and the resulting infrastructure necessary. For detailed information, please see Appendix 2.

Exhibit 9: Approach for Estimating Energy Required

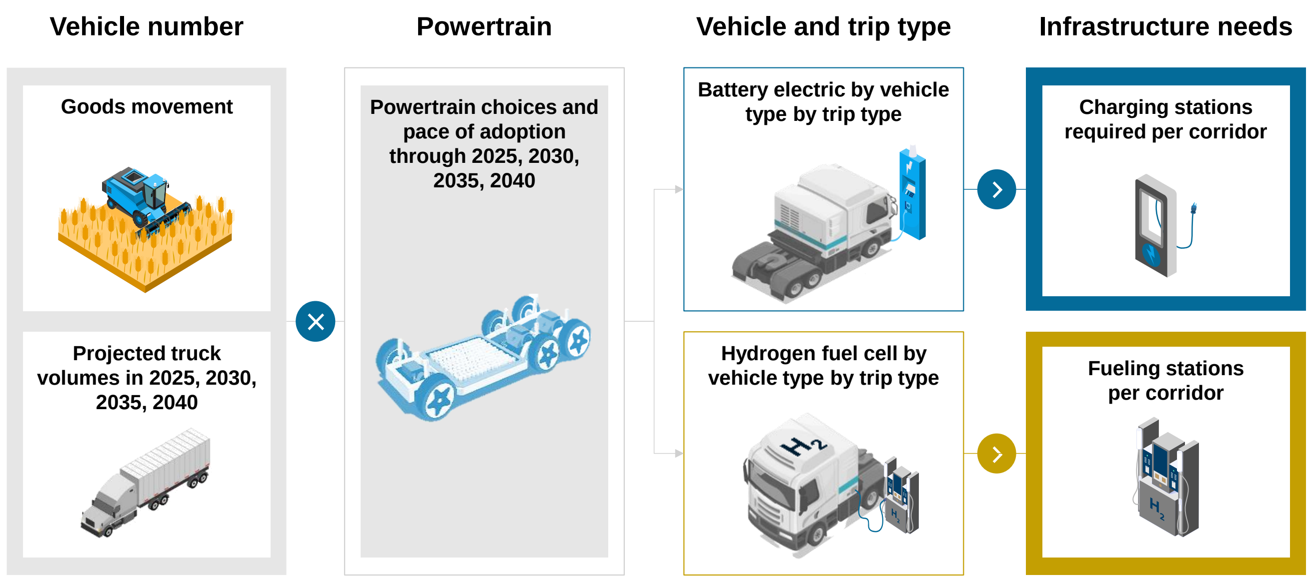
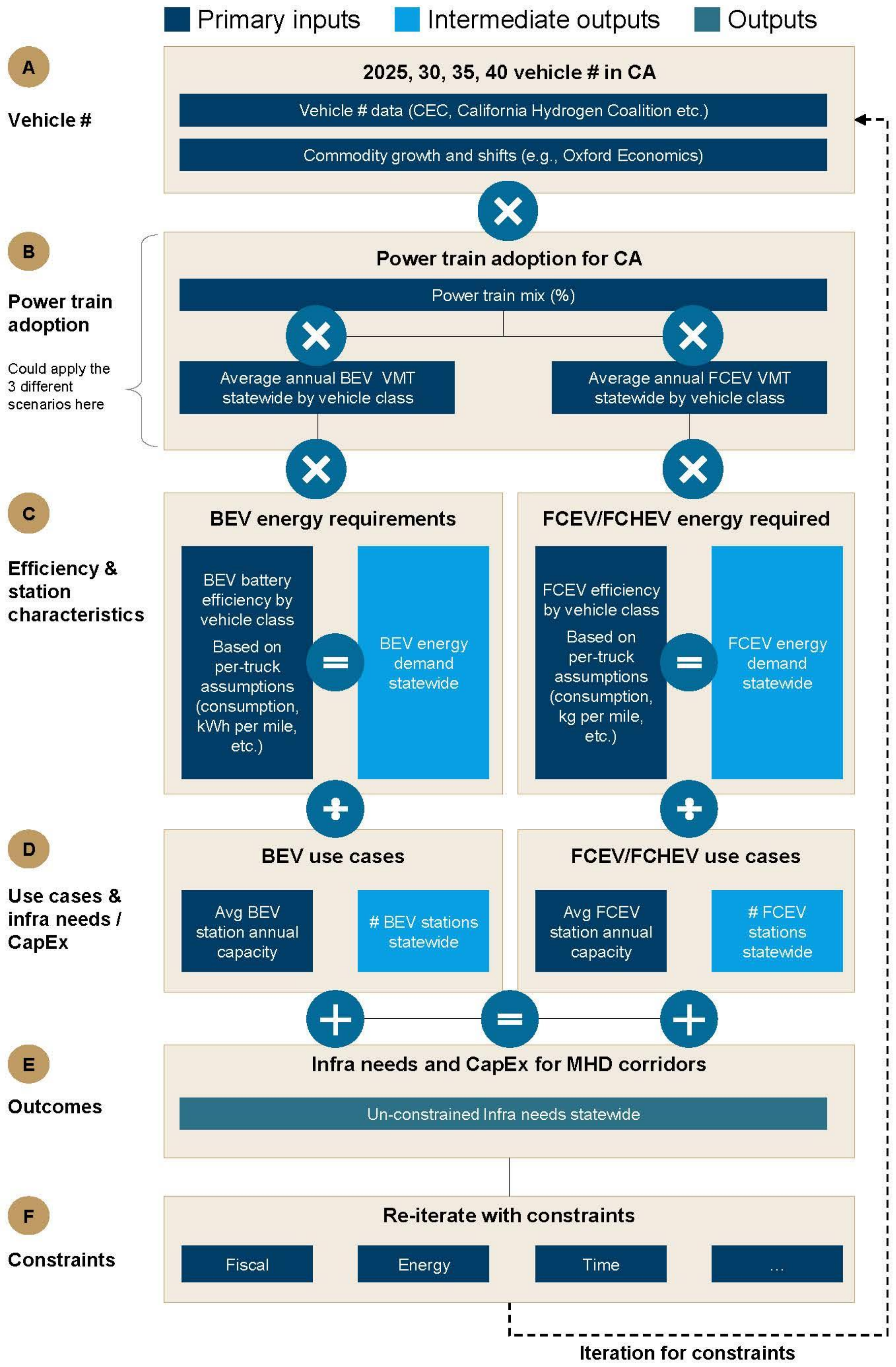


Exhibit 10: Detailed Infrastructure Modelling Logic


Primary inputs
Intermediate outputs
Outputs
A
Vehicle #
2025, 30, 35, 40 vehicle # in CA
Vehicle # data (CEC, California Hydrogen Coalition etc.)
Commodity growth and shifts (e.g., Oxford Economics)
B
Power train adoption
Could apply the 3 different scenarios here
Power train adoption for CA
Power train mix (%)
Average annual BEV VMT statewide by vehicle class
Average annual FCEV VMT statewide by vehicle class
C
Efficiency & station characteristics
BEV energy requirements
BEV battery efficiency by vehicle class
Based on per-truck assumptions (consumption, kWh per mile, etc.)
BEV energy demand statewide
FCEV/FCHEV energy required
FCEV efficiency by vehicle class
Based on per-truck assumptions (consumption, kg per mile, etc.)
FCEV energy demand statewide
D
Use cases & infra needs / CapEx
BEV use cases
Avg BEV station annual capacity
BEV stations statewide
FCEV/FCHEV use cases
Avg FCEV station annual capacity
FCEV stations statewide
E
Outcomes
Infra needs and CapEx for MHD corridors
Un-constrained Infra needs statewide
F
Constraints
Re-iterate with constraints
Fiscal
Energy
Time
...
Iteration for constraints

2.3 Projects satisfying initial infrastructure needs

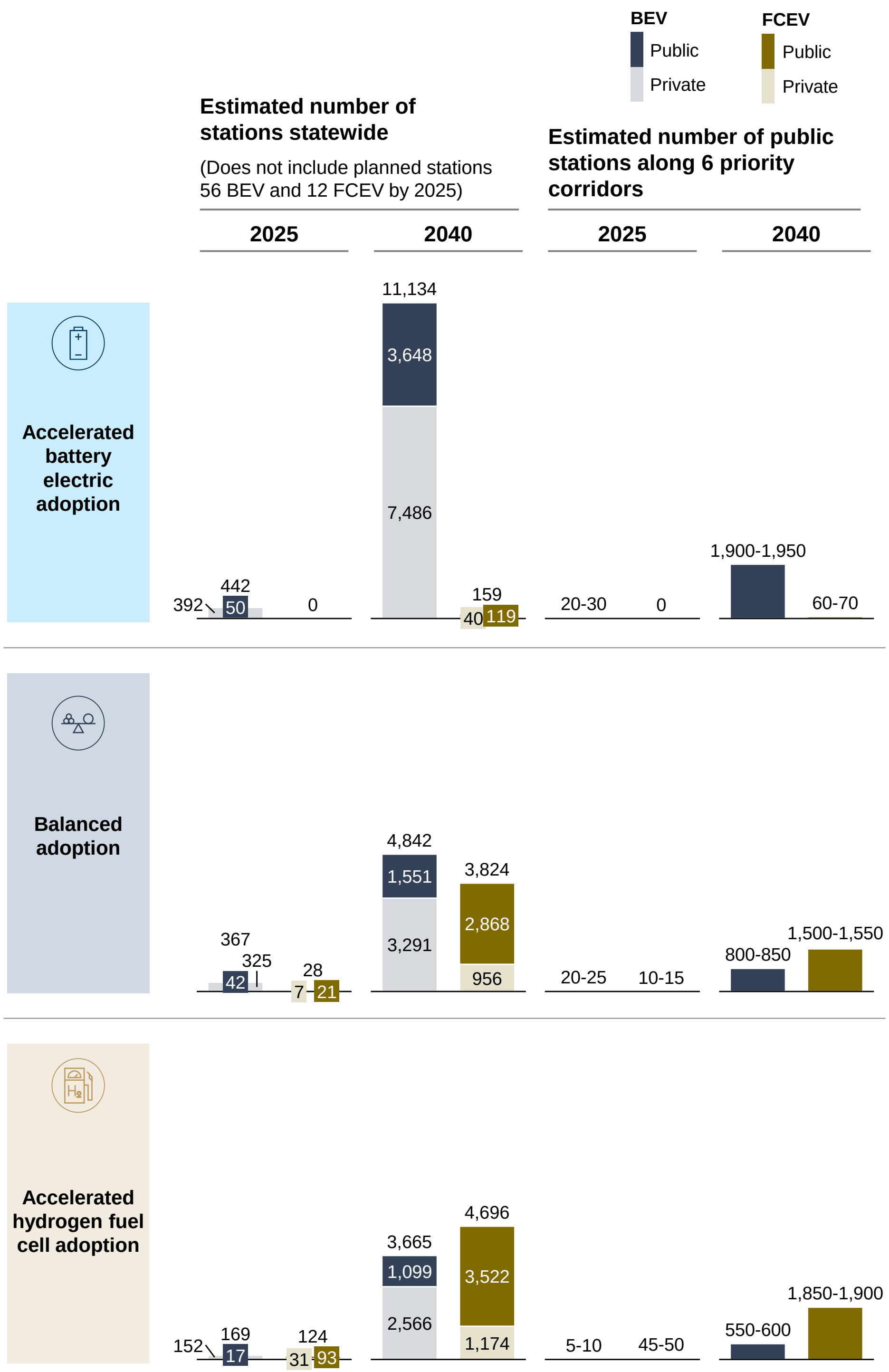
There is value in focusing on the number of electric charging and hydrogen fueling stations required to ensure a network dense enough to encourage early adoption by the 2025 and 2035 benchmark years.

To support zero-emission truck adoption, the state, federal, and local governments can potentially play a greater role in the development of publicly available charging and hydrogen fueling stations to ensure an initial viable network of public infrastructure. For example, in the past, traditional fuel companies like Chevron and Shell built publicly available truck stops and gas stations to realize a return on investment. Today, for zero-emission freight infrastructure, a fleet owner may see a clear need to install a charging or hydrogen fueling station on their property to allow their zero-emission trucks to charge or re-fuel, but a fleet owner may not build a publicly available zero-emission truck station because their primary concern is the financial stability of their fleet. Also, the return on investment for a publicly available station is uncertain. Existing companies interested in building zero-emission infrastructure are truck stops converting some of their existing locations to zero-emissions and companies who are interested in offering an all-inclusive truck and station service model to customers, known as “truck-as-a-service.” However, to date, there are not many companies like this in California. Despite these limitations, publicly available truck stops are essential for independent owner/operators who do not have the ability to charge or re-fuel at a private depot and for long-haul trucks that depend on publicly accessible stations to complete their routes. Until the market is more developed, the state can play a key role in encouraging the development of publicly accessible zero-emission infrastructure.

Please note that the initial viable network is meant to provide a flexible roadmap for zero-emissions truck transition for the state of California and represents the initial infrastructure required to support this transition. It is not intended to suggest that battery electric and fuel cell adoption will necessarily progress in any particular scenario but rather, give the state the ability to plan for a range of options available on the market.

Exhibit 11 shows the estimated stations needed in 2025 and 2040.

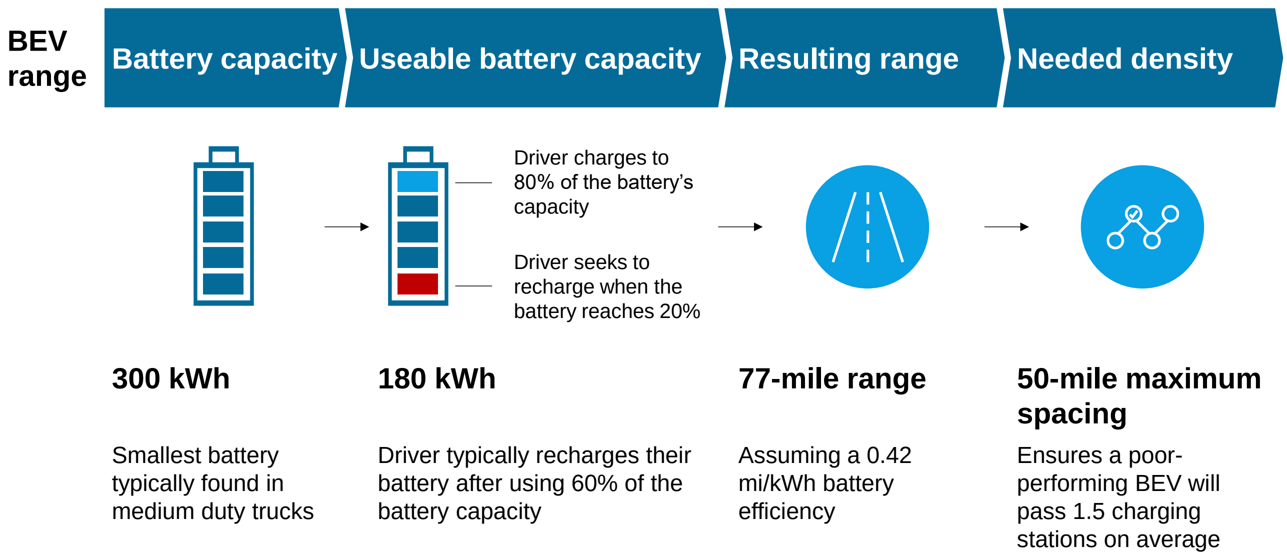
Exhibit 11: Results of the zero-emission infrastructure needs assessment (state-wide and for "Top 6" corridors)



To build the initial viable network, the Assessment recommends zero-emission truck stations be developed first along the "Top 6" freight corridors.

The 50-mile maximum station spacing and the assumed BEV specifications in Exhibit 12 are not intended to characterize the capabilities of the diverse set of BEVs that we anticipate operating along these corridors. The initial viable network needs to be able to support all the vehicles that we might reasonably expect to be operating. Several manufacturers are developing and/or have deployed battery electric Class 8 tractors with the specifications and demonstrated ability to meet long-haul and regional freight duty cycles.[1]

Exhibit 12: Approach to Establish Initial Viable Network for Battery Electric Vehicles

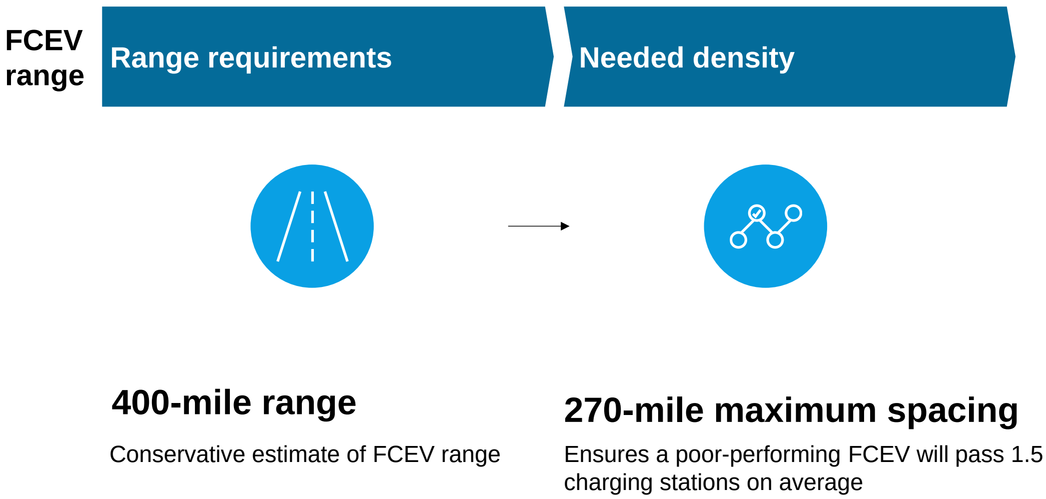


Most Hydrogen Fuel Cell Electric vehicles have a range of 400 miles or more. Hydrogen is similar to diesel in that it allows drivers to cover approximately the same distance and it takes about the same time to re-fuel as it does with diesel. Using 270 miles as the distance between hydrogen stations makes sure that even if trucks do not have a full hydrogen fuel cell, they will likely pass a place where they can re-fuel. Using a 270-mile maximum station spacing, the initial viable network for fuel cell electric vehicles would require 15 hydrogen fueling stations in total along the "Top 6" corridors. Exhibit 13

[1] The North American Council for Freight Efficiency (NACFE) recently completed its Run On Less event which showcases and independently validates the capabilities of various medium and heavy-duty vehicles operating in a variety of commercial settings and applications. The results of this event which include the performance of Class 8 tractors, can be found here: https://results-2023.runonless.com/. It will be important to update zero-emission station estimates as more information becomes available.

summarizes the approach to estimating the spacing needs for Fuel Cell Electric Vehicles; additional information on the methodology is detailed in Appendix 2

Exhibit 13: Approach to Establish the Initial Viable Network for Fuel Cell Electric Vehicles



By investing in an initial viable network, there could be enough stations along these corridors to provide a sufficient network to spur further adoption of zero-emission trucks.

According to the California Energy Commission's [EnergIIZE Monitoring Dashboard], which tracks existing and funded zero-emission charging and fueling stations in California, there are 40 battery electric vehicle charging stations and 3 hydrogen fuel cell electric vehicle fueling stations designed for freight within one mile of the 34 Priority Freight Corridors or one of the "Top 6" corridors as of July 6, 2023. Many of the existing or funded stations are clustered in metropolitan areas, so the placement of additional stations should be carefully considered to create the initial viable network. In addition to stations along the "Top 6" freight corridors, stations near the United States/Mexico border, maritime ports, and where the "Top 6" corridors and the 34 Priority Freight Corridors cross into neighboring states are essential.

The stations within the initial viable network could be underutilized in the short-term since zero-emission truck adoption could take some time. However, an initial viable network is required to facilitate widespread adoption of battery electric trucks and hydrogen fuel cell electric trucks statewide by overcoming fleet-owners' "range anxiety"—the fear of running out of charge or fuel because of travelling on roads that lack sufficient charging or fueling stations.

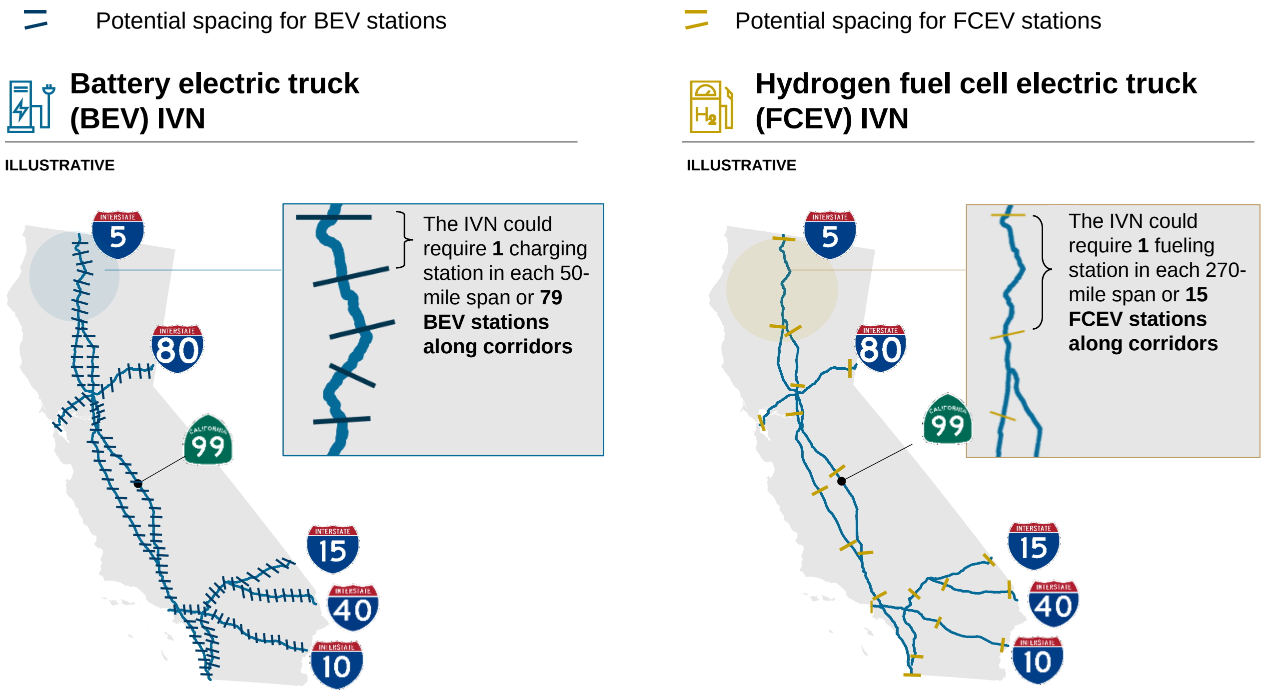
The correct estimation of utilization averages directly affects the number of stations needed to meet demand. This report assumes an average utilization of public stations of around 20 percent. Lower utilization would increase the number of stations needed. Factors that affect this utilization average include the number of stations needed to meet peak demand and drivers' tolerance of queues. Station economics and the value of driver time must be balanced with these factors. As more medium and heavy-duty stations are installed, monitoring utilization over time will provide more insight into this issue.

Shared Depot Facilities

Publicly accessible infrastructure near the Top 6 corridors, and the critical publicly accessible infrastructure needed in the first few years of the transition may not be located within a highway right-of-way. These areas include fleet depots, warehouses, ports, and other logistics hubs. As multiple fleets and independent owner-operators will be able to use a shared depot facility, these sites could be considered publicly accessible. A significant portion of medium-duty and heavy-duty trucks may rely on the shared depot model to serve as a central fueling hub, or hub-and spoke model, and may also rely on opportunity charging infrastructure along their routes. Contracting with a third-party fueling provider can sometimes be more cost effective for fleets than developing their own zero-emission depot. If fleets can save money on infrastructure, it will allow them to invest more in zero-emission trucks.

Exhibit 14 shows the number and spacing of both battery electric and hydrogen fuel cell stations along the initial viable network.

Exhibit 14: Initial Viable Network Along "Top 6" Freight Corridors



2.4 Future project selection and other project types

In the future, additional work can be done by a central delivery team engaging with stakeholders to refine specific station locations throughout the entire state. To this end, the Assessment identifies the location of existing infrastructure, such as electric grid infrastructure, existing funded and planned zero-emission infrastructure projects, truck parking, logistics depots, and warehouses, to see where existing infrastructure can support the development of the initial viable network of zero-emission truck charging and hydrogen fueling infrastructure. An example map is provided in Exhibit 15.

Exhibit 15a: Map of Existing Infrastructure and Truck GPS Data

Map Legend:

Existing or funded and planned zero-emission infrastructure for medium-duty and heavy-duty vehicles

Average Annual Truck Trips per Day based on truck GPS data

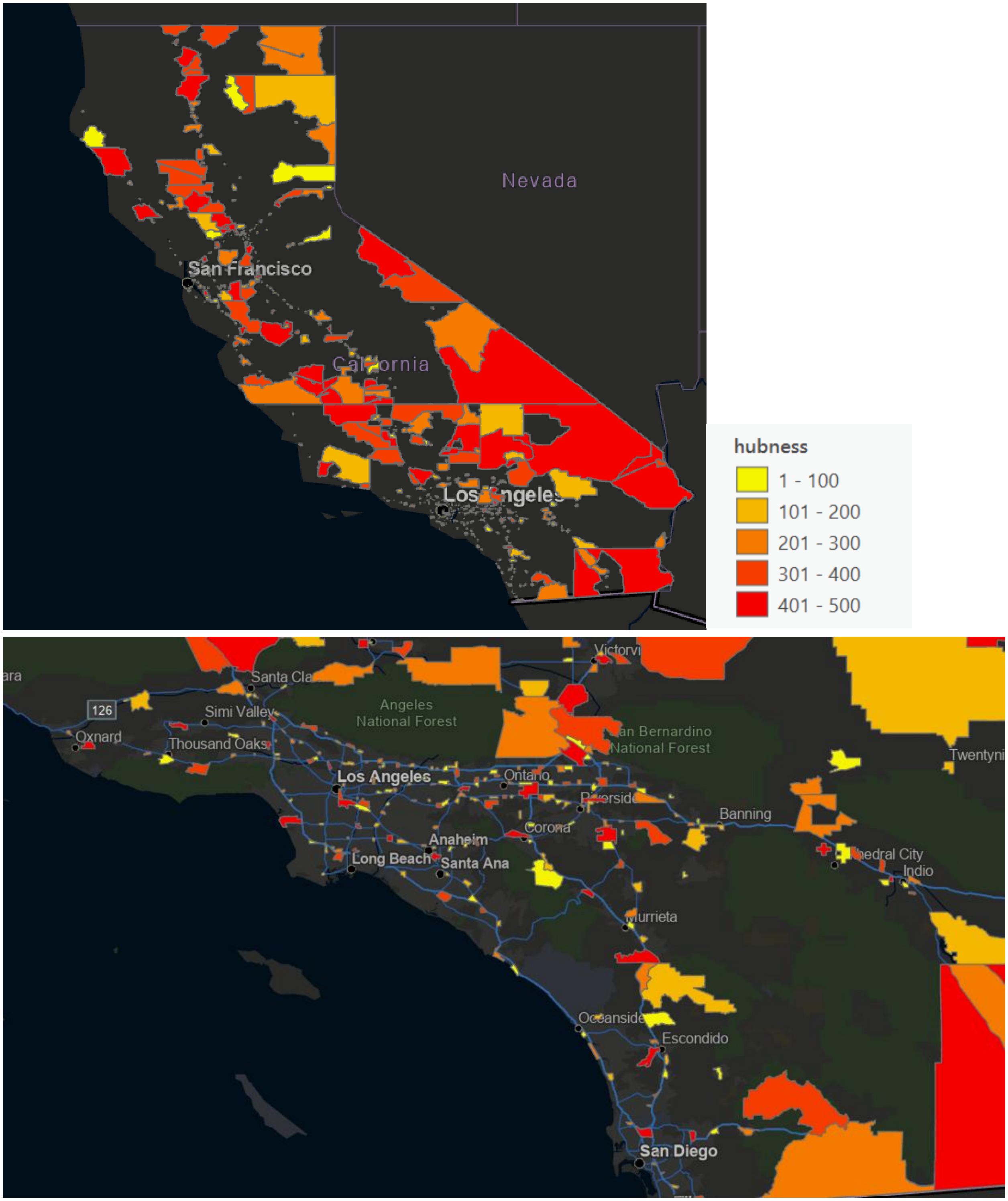
- 500-1000
- 1000-1500
- 1500-2500
- 2500-5000
- 5000 - 3126667

The Assessment includes an overview of projects that could help achieve the goals of the Assessment and potential project sponsors. This overview can be found in Appendix 2. In general, there are several types of projects that will help achieve the goals of the Assessment. There are a significant number (approximately 50) of projects that have been funded but not yet built. Truck stop companies that plan to add zero-emission infrastructure to existing stations will provide infrastructure to several locations already identified as critical to trucks. Some state funding programs provide a platform for companies ready and interested in building zero-emission infrastructure to apply for funding. For some state grants, private companies must partner with public companies to receive state funds, so public/private partnerships are important.

In addition to building zero-emission charging and hydrogen fueling stations, it is important for the state to incentivize the production of hydrogen and to support more availability of affordable hydrogen in the market. This is especially important in the early years of the transition when customer demand is still developing. Hydrogen is an important option for freight because of its similarity to the characteristics of diesel, such as being light in weight and the ability to distribute hydrogen via trucks.

In addition, the Commission worked with the United States Army Corp of Engineers, Engineer Research and Development Center to develop a map showing optimal census tracts for zero-emission stations based on diesel stations and truck volume. These optimal tracts were given a “hubness” score based on which census tracts include the most truck volume, at least one diesel station, and proximity of highway to the diesel station. Heat maps like Exhibit 15B: Map of Hubness base on Truck GPS data will be important when the central delivery team works on implementing geographically specific station location plans.

Exhibit 15b: Map of Hubness based on Truck GPS data



Similarly, to encourage the availability of charging stations, the California Public Utilities Commission should continue to work with the Commission, the California Energy Commission, and other state agencies as needed to plan the infrastructure needs for the electric grid.

Senate Bill 671 requires the Assessment to consider other project types in addition to zero-emission infrastructure. These include 1) highway improvements needed to accommodate charging and hydrogen fueling infrastructure, including truck parking, 2) highway improvements on the corridor to increase safety and throughput, and 3) improvements to local or connector streets and roads to support the corridor.

Due to limited time, additional study of the topics listed above is necessary. It is recommended that the central delivery team, referenced later in the Assessment, consider these topics more once specific zero-emission station locations are identified. Specific highway improvements to accommodate charging and hydrogen fueling can only be identified once specific locations are identified.

The Assessment discusses these topics as outlined below.

- **Truck parking.** Existing truck parking locations identified by Caltrans were included in the maps used to develop the Assessment and identify potential locations for zero-emission infrastructure.
- **Increased maintenance and operations need resulting from heavier trucks.** A discussion of the need for increased maintenance on all roads due to heavier zero-emission trucks is included in Chapter 5.
- **Safety and throughput improvements on I-710 segment.** The discussion of the I-710 segment in Appendix 2 speaks to safety and throughput improvements along that corridor.
- **“Top 6” corridor connections**. The inclusion of connections within the “Top 6” freight corridors to key freight destinations includes local streets and roads.

One area this Assessment did not have the bandwidth to cover is tires for zero-emission medium-duty and heavy-duty trucks. Tires used on zero-emission trucks may differ from tires used on traditional internal combustion engine trucks. The potential benefits of including tire changing facilities at zero-emission station locations should be considered. Further study of tire dust emissions from tires used on zero-emission trucks may also be beneficial.

2.5 Potential project sponsors

The ideal project sponsor for zero-emission infrastructure projects should be an agency or organization that supports building zero emission charging infrastructure not only through financial co-investing, but also through project and operational leadership. Sponsors for public infrastructure may come from both the public and private sector.

Public sponsors that could lead station development projects locally include Regional Transportation Planning Agencies and/or Metropolitan Planning Organizations throughout the state. These entities could be strong candidates because they plan infrastructure projects at a regional level and could be best positioned to coordinate station sequencing across the top freight corridors which pass through their jurisdictions.

The private sector could bring significant capital to co-invest in development projects, as well as private sector best practices, to deliver the public network. Potential private sponsors for station development projects could include:

- Warehouse owners and operators
- Utilities (for electric grid update portion of projects)
- Truck stops and gas station companies which have already expressed interest in adding zero-emission freight charging to existing locations.
- Private charging station networks, which are developing zero-emission infrastructure independently.
- Zero-emission truck manufacturers, that have expressed intent to invest in zero-emission infrastructure.

In addition, utilities are important project sponsors for electric distribution grid infrastructure. Even though electric utilities may not be the lead development entity on a charging or hydrogen refueling project, coordination with the local electric utility will be fundamental to achieving success. Coordination and early project scoping for electric distribution capacity and service support will be necessary to determine cost feasibility for any site. Electric utilities are integral partners in the infrastructure buildout. It should be noted that utility infrastructure will also be needed for hydrogen stations. Dispensing hydrogen is dependent on hydrogen compression performed by electric compressors, which use significant amounts of electricity at scale.

As demand for zero-emission freight infrastructure increases throughout the state through 2035 and beyond, the private sector may be interested in entering the market and co-developing zero-emission charging stations beyond the public initial viable network.

Part 3: Funding outlook

Chapter Summary

Funding for publicly accessible initial viable network projects should come from public and private sources. Some public funding already exists, but additional state, local, and federal funding is needed to support sustained station development, especially as demand for zero-emission infrastructure is expected to increase over time.

The total capital costs to build the initial viable network in 2025 is estimated to be between $505 million to $950 million (not including electric grid upgrade costs). Estimates identify more than $1 billion available through 2025 for zero-emission freight infrastructure.[1] Most of these funds are limited-term and set to expire in 2025. Together with private funding, it is possible there are sufficient funds available to build the public stations required for the 2025 initial viable network.

The total capital costs for a publicly available initial viable network in 2035 is estimated to be approximately $10 billion to $15 billion. It is recommended this funding need be shared between private and public funding sources to deliver the initial viable network by 2035. Public funds should come from all sources, including federal, state, and local.

Summary of funding needs:

- **2025 initial viable network –** existing public funds available with support from private investment
- **2035 initial viable network** - $10-$15 billion total will be needed from all fund sources.

Individual station cost estimates

The cost for building each hydrogen fuel cell electric vehicle station is estimated to be approximately $9 million to $13 million. The cost for building each battery electric vehicle station is estimated to be approximately $5 million to $9 million. A detailed breakdown of capital expenditure estimates is included in Exhibit 16.

[1] Source: California Transportation Commission internal work completed in collaboration with the California Air Resources Board and the California Energy Commission.

Exhibit 16: Breakdown of Total Estimated Capital Expenditure Costs

	Cost category	BEV cost estimate USD, millions	FCEV cost estimate USD, millions
Permitting and design costs	**PA&ED**	$1.6	$1.6
	Design & engineering	$0.3	$0.3
Construction costs	**Right of way**	$1-3	$1-3
	Hardware & installation	$0.9	$4.7
	Site construction (building, roof, periphery, signage)	$2-3	$2-3
Currently not included in adjustment	**Grid upgrades /capacity**	$2-7	N/A
Updated per station cost estimate		**~$5-9 million**	**~$8.6-12.6 million**
Updated total IVN (2025+) cost range		**~$375-765+million**	**~$130-190+million**

Key considerations

- Sites will vary in need for PA&ED and Right-of-way costs
- Grid upgrades are not currently included in site capex adjustment recommendation; associated costs are often incurred outside of TCEP and related programs
- Not all sites will need design & engineering; some existing sites have in-house capabilities (e.g., gas station companies)
- The private sector will typically contribute 40-50% of total project cost

BEV = battery electric vehicle, FCEV = fuel cell electric vehicle, IVN = initial viable network, USD = United States dollars, PA&ED = Planning and Environmental Documents phase, TCEP = Trade Corridor Enhancement Program

The $2 - $7 million in "grid upgrades/capacity" is based on estimates of zero-emission station costs that were submitted by SB 671 workgroup members. The actual cost of grid upgrades depends on each site and could be more or less than this estimate. Extensive study on the cost of grid upgrades was out of scope for this Assessment. The grid upgrade costs shown on this table were estimated from projects submitted to CTC as part of its SB 671 work. Costs shown here may not be wholly predictive of the cost of future upgrades, as sites with existing available grid capacity will be likely sites for initial electrification efforts.

Number of initial viable network stations needed

The initial viable network of stations needed in 2025 is estimated to be 15-20 publicly available hydrogen fuel cell stations and 75-85 public battery electric stations to support goods movement along the "Top 6" corridors.

The initial viable network of stations needed in 2035 is estimated to be approximately 800-850 public hydrogen fuel cell stations and 475-525 public battery electric stations.[1]

Total cost estimates

Given the per station cost estimates, the total capital costs to build the initial viable network in 2025 is estimated to be $505 million to $950 million.

The total capital costs for the recommended public initial viable network in 2035 is estimated to be approximately $10 billion to $15 billion in 2023 dollars.

These cost estimates include costs for hardware, installation, site readiness and construction, design, and permitting. for public infrastructure. It is also possible, that as technology improves and becomes more readily available, hardware and installation costs may decrease over time.

The costs represented here account for publicly available infrastructure.

These estimates do not include costs necessary to upgrade the electric grid, which were not studied extensively as part of this assessment. To serve new energy load for vehicle charging, utilities may need to make upgrades to components of the distribution system on the utility side of the meter such as transformers, primary and secondary circuits, and substations. These distribution upgrades may in turn trigger the need for additional transmission infrastructure. Estimates for these costs are being developed in other venues, such as through the California Public Utilities Commission's Freight Infrastructure Planning Process.

Timing of needed funding

Current station development timelines may take 6 to 8 years.[2] This timeline is described in further detail in the Barriers and Solutions section of this report.

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[1] The Commission developed 3 scenarios of stations needed, including 1) accelerated battery-electric adoption, 2) accelerated hydrogen fuel cell adoption, and 3) a balanced adoption scenario. The estimate of stations needed for the initial viable network is based on the balanced adoption scenario.

[2] Sites that are dependent on long lead time transmission infrastructure will have a longer development timeline.

California could have enough public and private funds available to fund the 2025 initial viable network, however, given the station development timeline, it is critical funding be awarded and available to use by 2025.

To build the number of stations needed by 2035, public and private investment is necessary through fiscal year (FY) 2031-32. This allows three years after FY 2031-32 to build stations prior to 2035.

Available public funding

Some zero-emission freight infrastructure funding has already been allocated to EnergIIZE[3] projects. The California Energy Commission's EnergIIZE program has provided funding to 111 existing or planned zero-emissions freight stations. Of these, approximately 40 electric vehicle charging stations and 3 hydrogen refueling stations are within 1 mile of the "Top 6" freight corridors[4]. These stations are currently clustered in dense urban areas and do not currently create statewide coverage. Close consideration should be given to the placement of new charging or fueling stations relative to existing stations to ensure they are providing appropriate coverage to create the initial viable network.

An analysis was conducted on existing state funding programs available over the next three years that can support zero-emission freight projects. Based on this analysis, there is more than $1 billion available between 2023 and 2025 that may be used for zero-emission freight infrastructure.[5] When identifying existing funding, the analysis focused on what is available through 2025, because that is the first near-term target year studied in the Assessment. The largest portion of the estimate of existing funds is from the California Energy Commission's Investment Plan, which covers fiscal years 2022-23 through 2025-26. The Investment Plan can be found in the California Energy Commission's 2022-23 Investment Plan Update for the Clean Transportation Program document. The analysis estimated the portion of these funds available for zero-emission infrastructure with input from the California Energy Commission. The Trade Corridor Enhancement Program funds and California Air Resources Board funds are also an estimate of the percent of funds available through 2025 for zero-emission freight infrastructure from existing programs that cover more than just zero-emission infrastructure.

Related to electric infrastructure, the CPUC has authorized just over $1 billion in investor-owned utility (IOU) ratepayer funds to provide behind-the-meter rebates for the medium-duty and heavy-duty vehicle sector. This includes $316.4 million in medium-duty and heavy-duty rebate funding for the CPUC Funding Cycle 1 program which will launch in 2025, as well as funding authorized in prior programs: $356.4 million for Southern California Edison's Charge Ready Transport program, $245.8 million for

3 More information about the EnergIIZE program is available at: https://www.energiize.org/.

4 Source: California Energy Commission Existing and Funded ZE truck stations. As of July 6, 2023

5 The funding available estimate includes an estimate of funds from the California Energy Commission Investment Plan, the California Air Resource Board Carl Moyer Program and Assembly Bill 617 Program, and the Commission's Trade Corridor Enhancement Program.

Pacific Gas and Electric's Electric Vehicle Fleet program, and $113.4 million for San Diego Gas and Electric's Power Your Drive for Fleets program.

Beyond 2025, it is reasonable to assume some level of funding will continue for zero-emission medium-duty and heavy-duty infrastructure from the California Energy Commission, California Air Resources Board, and Commission programs referenced above, where applicable.

These estimates do not include any estimate of federal Charging and Fueling Infrastructure Discretionary Grant Program funds.[6] This estimate also does not include the California Air Resources Board's Low Carbon Fuel Standard credits program that may be available for zero-emission stations, because this program provides reimbursement at a certain dollar per kilogram or kilowatt hour of station capacity, and it is not feasible to estimate in this study the amounts that will be awarded through it. Additionally, the National Electric Vehicle Infrastructure formula funds may be used for medium-duty and heavy-duty vehicles, and Caltrans will continue to evaluate opportunities to use National Electric Vehicle Infrastructure formula funds for this purpose.

This Assessment does not include a total estimate of electric grid infrastructure costs. The electric infrastructure cost per station is highly dependent on the station location, and since utilities are still determining upgrade needs in each region, it was not possible for this report to include an estimate of total electric infrastructure costs.

Although many programs include zero emissions infrastructure as an eligible project type, after state fiscal year 2025-26, additional public and private funding will be needed to build the statewide infrastructure required to support the transition to zero-emission trucks.

Conclusions

Initial Viable Network – 2025

- California may be able to fund the initial viable network needed in 2025 with existing public and private funds. This is based on the assumption that total costs for the 2025 initial viable network are between $505 million and $950 million, that there is over $1 billion in available public funding through 2025 that may be used, and that the private sector will share a portion of project costs.
- The cost estimate does not include costs associated with electric grid upgrades.

Initial Viable Network – 2035

- The total estimated cost to build the 2035 initial viable network is between $10 billion and $15 billion.
- Public and private investment from all sources will be needed to meet the 2035 infrastructure need.

[6] The Charging and Fueling Infrastructure Discretionary Grant Program provides up to $700 million nationwide for zero-emission infrastructure, although this is not specifically for freight infrastructure. More information on this federal grant can be found here: https://www.fhwa.dot.gov/environment/cfi/

Recommendation for public funding

- Allocate available public funds, where feasible, to support the build out of the 2035 initial viable network cost. The total cost of $10 to $15 billion will need to be shared between private and public funding and come from all available fund sources.

Part 4: Barriers and solutions

Chapter Summary

It may not be possible to build the initial viable network in time to support fleets complying with Advanced Clean Fleets deadlines unless the state and all stakeholders work together to shorten the current station development process.

Listening to and understanding the perspective of fleets and individual truck owner/operators is key to understanding how to support them.

Public incentives, federal funds, and private financing strategies such as loans and public-private partnerships are needed to help transition the financing of zero-emission stations to primarily private funds.

A central delivery team could provide a coordinated state vision, and work with stakeholders to hear their needs and work with them through some of the challenges discussed in this chapter.

Three key barriers and corresponding solutions were identified. These three barriers and solutions fall into three main categories: time, cost, and a complex ecosystem of stakeholders.

Exhibit 17: Key Barriers and Solutions to Clean Freight Infrastructure Development:

Key Barriers	Key Solutions
Time and sequencing of corridor station development	Streamline clean freight infrastructure development process
Economic viability of ZEV transition for fleet owners	Support fleet owners with the costs of transition
Complex ecosystem of potential stations and stakeholders	Create a central delivery team and a corridor-first approach

4.1 Barriers and solutions to achieving the transition to zero-emission freight

The SB 671 workgroup identified several challenges associated with the transition to zero-emission freight; the Assessment groups and consolidates them as shown in Exhibit 17. Each of the challenges associated with the transition will take time and a thoughtful approach to fully implement. The topics not included directly in this report include things like the potential for high vehicle insurance rates, the impact of longer routes on drivers who are paid on commission, the need to standardize station design, and the potential for high demand charges on the use of electricity at peak times.

Below is additional detail related to each main topic area addressed in the Assessment.

4.2 Barrier: Timing and sequencing of corridor station development

Process streamlining and simplification may be necessary to build the 2025 and 2035 initial viable network in a timely fashion. The current station development process ranges from 6 years to more than 8 years on average per station. This represents the aggregated timeline for permitting and pre-construction activities (3 years to more than 5 years), construction (2 years to more than 3 years), and grid upgrades. This station development timeframe presents unique challenges to building the number of stations needed in each of the Assessment's four study years (2025, 2030, 2035, and 2040), particularly in the Assessment's early milestone years.

Challenges identified throughout existing funding and permitting processes include:

- Minimal use and awareness of statutorily created streamlining opportunities by local municipalities.
- Varying local permitting requirements for California Environmental Quality Act approval.
- Limited ability to tier from Programmatic Environmental Impact Reports to expedite permitting processes across multiple site locations.
- Backlog of projects in approval and inspection processes.

According to the California Public Utilities Commission, significant electrical grid infrastructure upgrades could take up to 10 or more years. Additionally, timelines for zero-emission infrastructure are new and still developing. These timeframe assumptions are based on the best available knowledge of current infrastructure development timelines.

4.3 Solution: Streamline the clean freight infrastructure development process

To address the 2025 milestone need for charging infrastructure and ensure the roll-out of an incrementally useable and operational network of stations, the state should take the following steps to streamline the station development process.

Public funding programs and environmental requirements are based on state and federal law. Implementing the recommendations in their totality may require legislative or regulatory change. When implementing these recommendations, absent legislative or regulatory change, state agencies should align with state and federal law and streamline the clean freight infrastructure development process, where feasible.

Recommendations are intended to complement recent efforts to streamline infrastructure development enacted as part of the 2023-24 budget package.

Recommendations for streamlining zero-emission station development

- To shorten the station delivery timeframe, a central delivery team should be created to coordinate state and local stakeholders to implement the recommendations noted in this list. This central delivery team should function as part of or in coordination with the Executive Order N-8-23 Strike Team.
- The central delivery team should work to create a set of standardized station development model(s) (zoning and building permits) that can be replicated for each station across a priority corridor, based on affected local municipality guidelines.
- To complement recent efforts to improve California Environmental Quality Act timeframes, the Legislature should consider enacting a Categorical Exemption from CEQA for zero-emission freight charging and hydrogen fueling stations.
    - It is recommended that, where possible, zero-emission infrastructure encourage the re-routing of trucks away from communities, and that environmental and air quality stakeholders, impacted communities, and community-based organizations are involved in the development process, general planning process, and location planning process. A specific process related to this suggestion is included in the central delivery team recommendations.
    - The community should engage with the CEQA lead to determine the level of environmental document needed. If a project is challenged, a higher-level environmental document, such as an Initial Study or Environmental Impact Report, may be produced to address concerns.
- The Legislature should set a statutory default permit approval deadline for zero-emission freight charging and hydrogen fueling stations similar to AB 970 (McCarty, Chapter 710, Statutes of 2021) that allows a permit for a passenger battery electric vehicle charging station to be deemed complete

if it is not approved or otherwise commented on within a specified time period. In addition, existing law, SB 1291 (Archuleta, Chapter 373, Statutes of 2022), requires cities and counties to administratively approve an application to install electric vehicle charging stations and hydrogen-fueling stations through the issuance of a building permit or similar nondiscretionary permit if the location meets certain criteria. The provision of a default permit approval deadline for zero-emission freight charging and hydrogen fueling stations should be made permanent.

- The central delivery team should take a corridor approach to combine and sequence station development where feasible. In other words, synchronize building stations along the selected top freight corridor until the whole corridor is complete prior to moving to the next corridor. The selection process should start first with the “Top 6” corridors and move next to the 34 Priority Freight Corridors. These decisions should be made in collaboration with stakeholders, because while this is an ideal goal, the timing of station development depends on market readiness within each corridor.
    - The initial viable network may be developed to allow smaller segments along the initial viable network to be useable by freight operators as sections of corridors and freight journeys are constructed (for example, given the prevalence of intra-California freight travel along the I-5 corridor, starting construction at the ports and working north or south along the corridor).
- The California Public Utilities Commission, the Commission, and other relevant state agencies should continue to collaborate on the Freight Infrastructure Planning process to proactively update electric infrastructure plans and to coordinate freight modeling efforts. In the short-term, the Freight Infrastructure Planning process will identify process alignment and reforms for infrastructure planning to support freight electrification. In the medium term, the Freight Infrastructure Planning process will identify potential locations for freight electrification to study grid needs. These studies may lead to infrastructure authorization in the long term. The state, and specifically a central delivery team, if one is identified, should continue to work to identify short-term solutions. As part of this effort, it is recommended that state agencies evaluate the procurement process for transformers and identify best practices among utilities that can help reduce bottlenecks. Transformer shortages are impacting projects across the country and can cause project delays up to 24 months. Shortening this process where feasible will help address delays in receiving transformers, switch gear, and other electrical equipment. Stakeholder workshops, and the potential for federal financial aid could be explored.

Exhibit 18 shows the current timeline for zero-emission freight infrastructure development and how the above recommendations could shorten that timeline.

Exhibit 18: Estimated Timing for Zero-Emission Infrastructure Development

Grid readiness could take 2-7+ years in parallel to this process

Current timeline	1-2 years	1-2 years	~1-2 years	2-3 years	6-8+ years
Station development phase	Project development, funding, and financing	Planning Approval and Environmental Documents	Design and Right-of-Way	Construction	
Strategic actions to consider	**A central delivery team works closely with stakeholders to help them understand funding processes**	**Pursue a Categorical Exemption** from the California Environmental Quality Act and **petition to expedite National Environmental Policy Act permitting** for SB 671 zero-emission station development **Allow for default approval of local permits when not processed in a timely manner**	**Create model station development process** (zoning and building permits) as appropriate with federal, state, regional, and local partners **Work with the California Public Utilities Commission to expedite electric grid upgrades**	**Take a corridor-approach to batch and sequence station buildout** (e.g., ensure top freight journeys within California are developed first, while also working with border states and countries to build out)	
Potential future timeline	~6 months to 1 year	~6 months to 1 year	~6 months to 1 year	1-2 years	2-5+ years

4.4 Barrier: Economic viability of the transition for fleet owners

The transition to zero-emission vehicles, and the corresponding infrastructure development required to sustain the transition, could negatively impact fleet owners due to the constraints of time and money.

Members of the SB 671 workgroup who represent fleets and individual truck owner/operators in California, along with fleet owners from Mexico, voice concern regarding the lack of public infrastructure available to power zero-emission trucks: the higher cost of zero-emission trucks; and the resale value of medium-duty and heavy-duty zero-emission trucks.

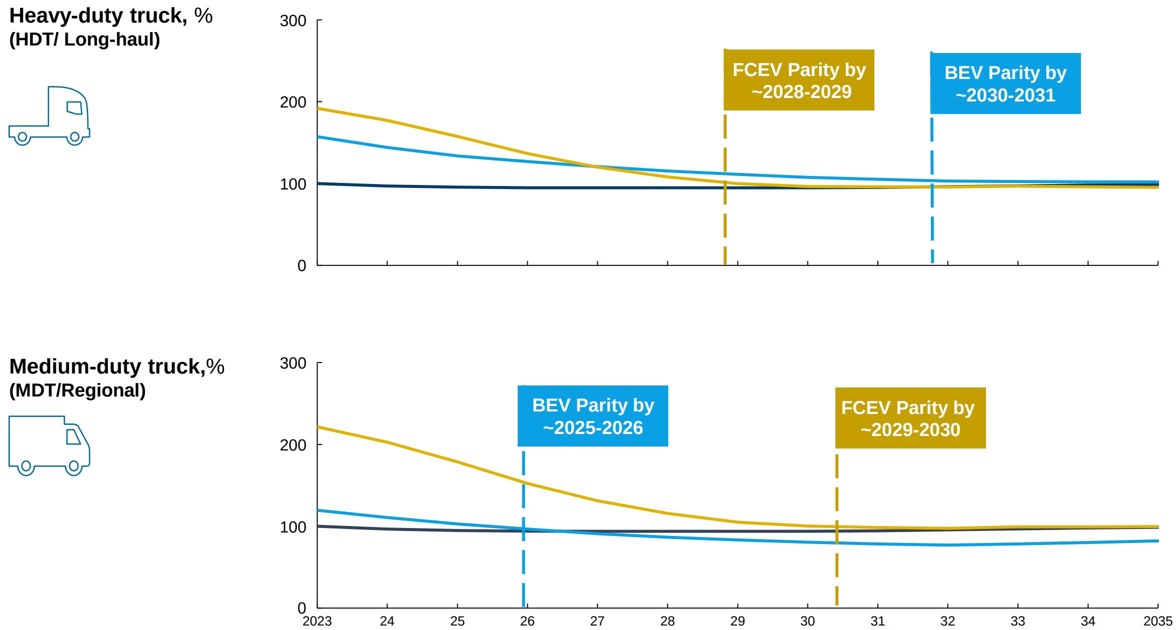
The Advanced Clean Trucks regulation mandates that manufacturers sell an increasing portion of truck sales in California as zero-emission, starting with the 2024 model year. The Advanced Clean Fleets regulation requires state and local governmental fleets, drayage trucks (diesel-fueled, heavy-duty trucks that transport cargo, such as containerized and bulk goods that primarily operate on and through ports and intermodal railyards), and federal and large commercial fleets to begin acquiring zero-emission medium- and heavy-duty vehicles and light-duty package delivery vehicles beginning in 2024. The Advanced Clean Fleets regulation additionally requires that all new California-certified medium- and heavy-duty vehicles be zero-emission vehicles starting in 2036. However, current demand for these trucks remains low. Large, upfront capital costs to buy zero-emission trucks may deter fleet owners from purchases, even though zero-emission vehicles may have lower overall operating costs in the long-term. The McKinsey Center for Future Mobility estimates that battery electric medium-duty trucks will reach cost parity in total cost of ownership by 2026, and battery electric heavy-duty trucks will reach cost parity in total cost of ownership by 2036. The McKinsey Center for Future Mobility also estimates that hydrogen fuel cell electric medium-duty trucks will reach cost parity in total cost of ownership by 2031, and hydrogen fuel cell electric heavy-duty trucks will reach cost parity in total cost of ownership by 2030.[7] Exhibit 19 summarizes these timelines for parity in total cost of ownership. The McKinsey Center for Future Mobility cost parity estimates include the estimated impact of the Inflation Reduction Act on cost parity.

Currently, limited data exists about the life-cycle costs of zero-emission trucks, and it will take a few years to build a body of evidence that can support estimates well. This uncertainty adds risk to the decisions fleets must make about transitioning their trucks to zero-emission. However, decisions regarding fleet conversion should be informed by existing cost parity research that shows that total cost of ownership for zero-emission trucks may be lower in future years than the total cost of ownership for a conventionally fueled truck.

The Advanced Clean Trucks regulation mandates that manufacturers sell an increasing portion of truck sales in California as zero-emission, starting with the 2024 model year. The Advanced Clean Fleets regulation requires state and local governmental fleets, drayage trucks (diesel-fueled, heavy-duty trucks that transport cargo, such as containerized and bulk goods that primarily operate on and through marine ports and intermodal railyards), and federal and large commercial fleets to begin acquiring zero-emitting medium- and heavy-duty vehicles and light-duty package delivery vehicles beginning in 2024. The Advanced Clean Fleets regulation additionally requires that all new California-certified medium- and heavy-duty vehicles be zero-emitting vehicles starting in 2036. However, current demand for these trucks remains low. Large, upfront capital costs to buy zero-emission trucks may deter fleet owners from purchases, even though zero-emission vehicles may have lower overall operating costs.

[7] McKinsey Center for Future Mobility, Commercial Fleet Electrification Model

Exhibit 19: Projected Total Cost Parity for Fleet Owners



In addition, freight fleet workforces will need to adapt to changes precipitated by the widespread adoption of zero-emission hardware and technology. Drivers may require training on fueling, charging, and handling zero-emission vehicles. Logistics workers will need to adjust for alternate driving ranges and charging or fueling schedules. Maintenance workers may require reskilling, upskilling, and in some cases both reskilling and upskilling to support high-tech drivetrain technologies.

4.5 Solution: Support fleet owners through the transition

Listening to and understanding the perspective of fleets and individual truck owner/operators is key to understanding how to support them. Especially in the next five to seven years of the transition to zero-emission freight, public incentives, private funds, and federal funds are needed to ensure a successful transition. At the same time the state plans and implements incentive programs, the state should also plan and implement transitional financing strategies such as loans, and public private partnership opportunities, because this type of support is needed to transition the market to primarily private funds over time.

Fleet owners and some individual truck owner/operators in Mexico are also required to transition to zero-emission vehicles if they do business in California. Incentives and long-term financing strategies are needed to support the transition to zero emissions medium- and heavy duty-trucks on the Mexico side of the border. This will require innovative financing strategies.

Below are recommended actions to support fleet owners as they transition to zero-emission freight.

Recommendations for supporting fleet and truck owners through the zero-emission vehicle transition

- The Legislature should create a new limited-term (five-year) zero-emission truck incentive program to assist fleets with purchasing zero-emission trucks. Program development should incorporate input from communities, and fleets of all sizes including those who will be impacted by regulations and should be flexible to ensure support in a way that is considerate of their needs. Although a new limited-term funding program is needed, there are existing programs that provide support for zero-emission trucks. Several examples are summarized below.
  - There are clean truck programs that assist fleets with purchasing zero-emission trucks, such as the San Pedro Bay Ports' ' Clean Truck Program[8]. These programs are helpful but are typically limited to a specific geographic area like a port where a charge can be levied on users.
  - The California Air Resources Board and the California Energy Commission are working on a new Zero-Emission Truck and Infrastructure Loan Pilot Project designed to combine financing for both heavy-duty zero-emission vehicles and charging or fueling infrastructure. A comprehensive loan package that combines vehicle and infrastructure financing can provide additional access to zero-emission financing and create a streamlined lending process for small businesses, with a focus on those in disadvantaged communities, that are transitioning to zero-emission vehicles. The California Air Resources Board and the California Energy Commission will each partner with the Treasurer's Office to build on successful relationships across agencies and with the California Pollution Control Financing Authority to implement the Truck Loan Assistance Program through their California Capital Access Program.
  - The Short-Haul Zero-Emission Truck Pilot Project is a result of collaboration between the California Air Resources Board, the Portside Steering Committee (the Portside Steering Committee is a group of people representing various interests in an Environmental Justice Community that encompasses parts of Barrio Logan, Logan Heights, Sherman Heights, and National City in San Diego), and the San Diego County Air Pollution Control District to incentivize the purchase or lease of zero-emission heavy-duty trucks that operate in the Portside Environmental Justice community. The program provides up to 90 percent or $250,000 of the eligible purchase cost (or up to 90 percent of the 3-year lease payment) for an eligible truck that

[8] Information about the Clean Truck Program can be found online here: https://www.portoflosangeles.org/environment/air-quality/clean-truck-program#:~:text=Port%20of%20Los%20Angeles%20Clean%20Truck%20Program%20Overview,to%20comply%20with%20State%20law.

has performed at least 52 trips a year in the community of Portside and does not require the participating business to scrap or sell the old vehicle. Currently $4 million in AB 617 (Garcia, Chapter 136, Statutes of 2017) incentive funding has been approved for distribution through this program.

  - Retrofitting traditional internal combustion engine trucks to zero-emission power trains should be explored as an option to reduce costs. This option may be less expensive than purchasing a new zero-emission truck.

- The California Air Resources Board could create a provision within the Low Carbon Fuel Standard program to support buildout and operation of fast charging and hydrogen fueling infrastructure for medium-duty and heavy-duty vehicles, similar to the existing capacity crediting provision in the Low Carbon Fuel Standard regulation.[9]

- State agencies, Regional Transportation Planning Agencies, Metropolitan Planning Organizations, and the Legislature, should consider how the state may support Mexico-based fleets, operating within California, in the transition to zero-emission freight. Mexico-based fleets, operating within California, do not currently have public incentives from the Mexican government to support the transition to zero-emission trucks and the infrastructure to support electricity or hydrogen does not currently exist. The following potential financing strategies and energy support strategies should be considered to support Mexico-based fleets and the zero-emission vehicle transition at the California border:

  - State agencies, Regional Transportation Planning Agencies, and Metropolitan Planning Organizations should apply for federal funding programs designed to support zero-emission trucks and infrastructure in border areas.

  - The Legislature should explore developing a state program that allows public funding to be spent in border regions for zero-emission freight pilot projects that provide benefits to California, where allowable by law.

  - State agencies should build on existing public private partnership programs within public organizations like the San Diego Association of Governments to implement zero emission charging and hydrogen fueling within the border region.

  - State agencies, Regional Transportation Planning Agencies, and Metropolitan Planning Organizations should partner with the North American Development Bank or similar organizations when possible. The North American Development Bank was created with the passage of the North American Free Trade Agreement and focuses on providing funding and technical assistance to border communities in the United States and Mexico.

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[9] Low Carbon Fuel Standard program information can be found online here: https://ww2.arb.ca.gov/sites/default/files/classic/fuels/lcfs/guidance/zev_infra_crediting_overview.pdf

  - State agencies should request Congress reinstate the federal Coordinated Border Infrastructure Program that allowed funds to be used for pilot projects that spanned both sides of the United States and Mexico border. Although Mexico is California's number one trading partner, most of these recommendations apply to the U.S. states that border California. These strategies should be employed at all California borders.

- The Legislature should authorize a vehicle buy-back program that would appropriate funds to a state agency that would work with truck sales companies to set aside funds to buy back used zero-emission trucks from fleets once they reach their useful life as a "new" vehicle. This could be added as a new component of existing or new truck incentive programs.

  - A buy-back program could be useful for drayage trucks. Currently, many drayage trucks are used trucks that were bought on the secondary market. Currently, there is no secondary market for zero-emission trucks. Creating a truck buy-back program could help create a secondary market, extend the life of existing zero-emission trucks, and provide more affordable trucks. The Advanced Clean Fleets regulation requires, in pertinent part, that existing drayage trucks cannot be used to conduct drayage operations once they exceed a specified minimum useful life period, defined as the later of either: thirteen (13) years from the model year that the engine and emissions control systems are first certified by the California Air Resources Board or the United States Environmental Protection Agency; or when the vehicle reaches 800,000 vehicle miles traveled or 18 years from the model year that the engine and emissions control systems are first certified by the California Air Resources Board or the United States Environmental Protection Agency, whichever is earlier. This is in Health and Safety Code 43021(a).

Over time, financing strategies that encourage the use of private funds and promote an independent privately funded system should be used. A lease is one example of this type of financing. The California Air Resources Board and California Energy Commission lease pilot programs referenced above are good examples of lease programs for both trucks and infrastructure. Private companies, such as Penske, are also considering lease programs for clients to purchase zero-emission trucks. In addition, North American Development Bank, which is referenced above, is an organization focused on providing leases for zero-emission infrastructure.

4.6 Barrier: Complex stakeholder ecosystem

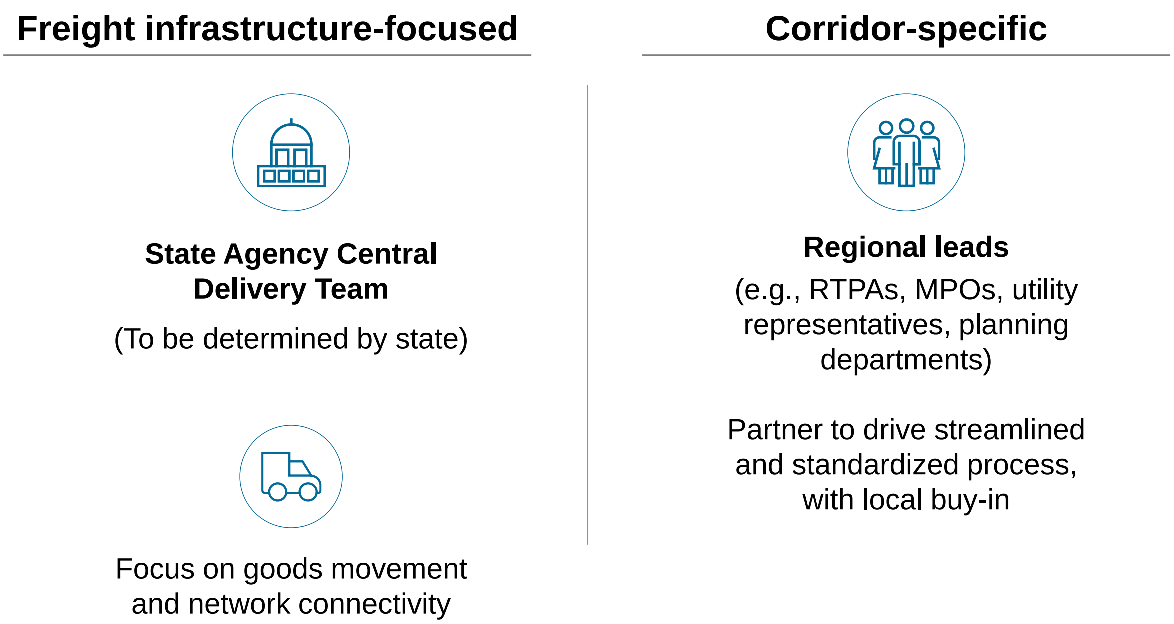
The statewide nature of the transition to zero-emission freight is unprecedented. It will require the coordination of many different stakeholder groups across the state such as local permitting agencies, utility companies, Regional Transportation Planning Agencies and Metropolitan Planning Organizations, ports, the California Public Utilities Commission, the California Energy Commission, private entities like start-up companies, and established corporations like beneficial cargo owners and fleets. In addition, communities impacted by poor air quality should be involved in the planning process for zero-emission freight infrastructure. It is important to include local transportation equity leaders, environmental justice organizations, community-based organizations, impacted communities, and tribal leaders early in the planning process. It will be important to ensure alignment among these various groups to facilitate the timely development of zero-emission freight infrastructure.

As the publicly accessible initial viable network is developed, the state also needs to have a consistent focus on equity and accessibility (for example, to ensure that station locations in underserved communities are included and prioritized in station development).

4.7 Solution: Create a Central Delivery Team

The central delivery team could include both a statewide public agency to oversee statewide development, as well as Regional Transportation Planning Agencies and Metropolitan Planning Organizations to coordinate station funding, permitting, and development at the local level. The site knowledge of a regional or local agency, combined with the funding, state permitting, and the corridor focus of a statewide agency, could position the state to achieve the goals identified in the Assessment. Exhibit 20 provides a visualization of the central delivery team recommendation.

Exhibit 20: Visualization of the idea of a central delivery team



A central delivery team should complete the following actions:

- Carry out the *Recommendations for a central delivery team* identified below.
- Participate in the Freight Infrastructure Planning workgroup that is led by the California Public Utilities Commission, if appropriate. This effort establishes an interagency process including agencies such as the California Energy Commission, Caltrans, the California Air Resources Board, and the Commission to develop common data inputs and assumptions to support planning for the long lead time utility-side electric infrastructure.
- Work with stakeholders to strategically select specific project locations or target small areas for collaboration with state agencies to deliver project sequencing goals. Project sequencing is the idea of finishing segments of a corridor one after another to systematically build a support system one segment at a time.
- Ensure stakeholders are aware of available funding sources and existing public private partnership models.
- At the funding stage, a central delivery team could inform local municipality leads of pipeline projects to reduce the time it takes to have local permits approved, where feasible. As zoning,

permitting, and construction occur for each charging station, the central delivery team could collaborate very closely to minimize delays in the process.

- Regularly communicate with utility companies, the California Energy Commission, the California Public Utilities Commission, the Governor's Office of Business and Economic Development, and other stakeholders to facilitate grid optimization for battery electric stations and procurement and delivery for hydrogen stations.
- Help ensure timely and equitable implementation solutions throughout California.

On May 19, 2023, Governor Newsom issued Executive Order N-8-23, which convened an Infrastructure Strike Team to coordinate across State agencies to facilitate the delivery of infrastructure projects, including zero-emission vehicle infrastructure. The central delivery team could be led by an agency or agencies that are part of the strike team. Exhibit 21 shows examples of central delivery team actions.

Exhibit 21: Example central delivery team actions

IVN = Initial Viable Network; State Agency Central Delivery Team; Regional leads; Cross-agency exercise

Station development phase	Project proposal	Funding awarded	Permitting	Design and Right-of-Way	Construction	On-going
IVN delivery team lead	State Agency Central Delivery Team; Regional leads	State Agency Central Delivery Team; Regional leads	State Agency Central Delivery Team	State Agency Central Delivery Team; Regional leads	Regional leads	Cross-agency exercise
Potential central delivery team support to project sponsors	• **Match project sponsors** with most eligible funding source • **Coordinate with utilities** to ensure grid capacity before construction • **Develop workforce training programs**	• **Proactively notify local leads** of upcoming project pipelines within their jurisdictions	• **Coordinate with municipalities** to batch and streamline permitting • **Assist project sponsors in navigating permitting process**	• **Standardize zoning and design** as much as possible for charging and hydrogen fueling stations, as possible (goal to reduce timeframe by 12-18 months)	• **Monitor buildout and delivery** of charging and fueling stations	• **Develop lessons learned** and cost/ development database to inform future build-outs and drive performance improvement

Recommendations for a central delivery team

- The Administration should consider designating one lead group or agency to carry out the functions of the central delivery team outlined in this Assessment. This could be an agency that is currently part of the Executive Order N-8-23 strike team or the Administration could direct the Executive Order N-8-23 strike team to identify and designate such a group. The intent of the central delivery team would be to act as a lead in coordinating zero-emission freight infrastructure planning and implementation, including carrying out the actions included in this Assessment where feasible. The central delivery team should function as a cross-agency team including the California Energy Commission, Caltrans, the California State Transportation Agency, the Governor's Office of Business and Economic Development, California Air Resource Board, California Public Utilities Commission, the Commission, and any other state agencies or entities determined necessary.

- The central delivery team should identify leads from Regional Transportation Planning Agencies, Metropolitan Planning Organizations, ports, utilities, fleets, state-agencies, and other stakeholders (similar to the SB 671 workgroup) that are necessary to build stations quickly.
- The central delivery team should, in coordination with impacted communities, community-based organizations, equity advocates, public health advocates, tribal nations, and environmental advocates, develop a process for impacted communities, community-based organizations, equity advocates, public health advocates, tribal nations, environmental advocates, and any other groups identified to be included in zero-emission station location planning and implementation. Assuming locations around the Top 6 corridors are prioritized, then communities along these corridors should also be prioritized. Outreach efforts should be culturally competent and community specific. In-person meetings and meetings in other languages should be offered when needed. Efforts like the Los Angeles Cleantech Incubator and Coalition for Environmental Health and Justice effort on the I-710 should be used as an example of the type of process needed. In developing the process, the central delivery team should coordinate with the CalSTA Anti-Displacement sub-committee and the interagency Equity Advisory Committee to utilize their expertise and to facilitate the use of existing and any new needed project specific anti-displacement strategies. Existing processes already required under law should also be considered to avoid "re-inventing the wheel." The central delivery team should work with community colleges and ports that provide training programs to support training, reskilling, and upskilling freight industry workers, as necessary. Additional information related to existing training programs can be found in Chapter 5. In addition, the central delivery team should work with state agencies, local agencies, colleges, and other stakeholders as appropriate to develop and provide training to local municipal staff to inform them of critical changes and to publicize more broadly what the changes are.

Zero-Emission Needs in the Baja California and Baja Sur Region

One key consideration for the state is the importance and complexity of goods movement across its border with Mexico. Some truck companies based in Mexico that operate in California may be subject to California's Advanced Clean Fleets regulation, but likely do not currently have the zero-emission trucks, electric grid capacity, or regulatory policy to support the underlying zero-emission freight movement[1]. The transition to zero-emission vehicles is particularly complex for this region. In 2021, the corridors connecting California to Mexico handled freight goods valued at $71.8 billion[2]. The region is significant for the trade relationship between the United States and Mexico, and a smooth transition that maintains freight movement will be critical for both economies.

Addressing this challenge could involve a high level of involvement from the central delivery team to ensure an appropriate collaboration with Mexico to facilitate goods movement across affected corridors, and to help identify strategies in this region.

Example of a community-centered zero-emission station site planning process

- The Los Angeles Cleantech Incubator collaboration with the Coalition for Environmental Health & Justice on the California Energy Commission funded I-710 Blueprint project is an example of a planning process that leverages community knowledge and expertise to produce more robust and grounded recommendations. The Coalition for Environmental Health & Justice (which includes the environmental justice, base-building organizations of East Yard Communities for Environmental Justice, Communities for a Better Environment, Long Beach Alliance for Children with Asthma, and Long Beach Residents Empowered, among other groups) worked with community members along the I-710 freeway corridor to gather and share input on the priority depot site selection process. This work provided the project team with a richer understanding of high-traffic and high pollution areas near industrial areas. The Coalition for Environmental Health & Justice's priority considerations included: Focus on improving community health through lessening emissions from medium-duty and heavy-duty vehicles
- Avoiding inducing traffic in disproportionately impacted areas, such as near residential areas or sensitive receptors such as schools, senior centers, hospitals, supportive housing, etc.
- Improving air quality in areas with significant air pollution from goods movement.
- Avoiding safety risks to surrounding communities.
- Prioritizing opportunities for small trucking businesses with fewer resources to invest in zero-emission infrastructure.

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[1] Source: San Diego Association of Governments, Caltrans, and Imperial County Transportation Commission Memorandum re: Zero-emission freight transition at Baja Border, May 5, 2022.

[2] Source: San Diego Association of Governments, Caltrans, and Imperial County Transportation Commission Memorandum re: Zero-emission freight transition at Baja Border, May 5, 2022.

The Coalition for Environmental Health & Justice ultimately selected 16 initial sites to prioritize for truck charging infrastructure deployments based on technical information compiled by the Los Angeles Cleantech Incubator, such as a Geographic Information System map that displayed “hotspots” for fast- and slow-charging opportunities based on truck traffic and grid capacity. The Coalition for Environmental Health & Justice held inter-regional, intergenerational convenings to explain and discuss the map with community members from across the I-710 corridor.

The Coalition for Environmental Health & Justice worked to create accessible discussion spaces using visual tools where community members could break down technical concepts and jargon such as slow and fast charging and grid capacity. This was not a result of a single conversation, but rather continued collaboration over several months. Through continued discussions, community members steadily wielded their expanded technical knowledge alongside their existing expertise and lived experiences about their neighborhoods to identify local areas that could be a good fit for battery-electric truck charging depots.

Once the Coalition for Environmental Health & Justice generated the list of 16 sites, the Los Angeles Cleantech Incubator conducted outreach to property owners and managers to share information and gauge interest. Following this outreach, the Los Angeles Cleantech Incubator deemed 4 sites as priorities and set up site visits. The Coalition for Environmental Health & Justice also participated in site visits and community members were able to learn more about the process for developing these sites into battery-electric truck charging depots.

The success of this collaboration was a result of the Los Angeles Cleantech Incubator bringing environmental justice partners in early, not just to share information or to inform them of the project but to substantively engage with their expertise to create better outcomes. This is an example of how to work toward the transition to zero-emission freight in an equitable and community-centered way.

Part 5: Additional implications

Chapter Summary

As California transitions to zero-emission freight, there are several impacts California must consider and plan for. These include impacts associated with heavier zero-emission trucks, potential impacts to residents and businesses, and workforce support needs. This chapter explores these challenges and what the state can do to plan for them. This chapter also covers several potential benefits of the transition to zero-emission freight.

Potential benefits from the deployment of zero-emission medium- and heavy-duty vehicles: The transition to zero-emission freight infrastructure could have both economic and health benefits for California's citizens, including, an estimated $18.6 billion in savings in statewide health spending from criteria emission reductions through 2040 as a result of the Advanced Clean Fleets and Advanced Clean Truck regulations, and an estimated 1,720 lives saved.

Impact on roads and bridges: Zero-emission trucks will introduce heavier axle loads and may increase damage to the pavements they use. Heavier trucks may also impact fleets, requiring them to move the same amount of cargo with more trucks. It is recommended Caltrans evaluate what policies are necessary to address this challenge.

Avoiding resident and business displacement: The Commission reviewed several resources related to effective ways of avoiding displacement, such as the SB 1 Competitive Programs Transportation Equity Supplement, the California State Transportation Agency's Anti-Displacement Subcommittee Workplan, the Caltrans Project Development Procedures Manual, and the online California Estimated Displacement Risk Model provided by the Urban Displacement Project. The guidance and direction from these resources, as well as the California Transportation Agency's forthcoming memo on Policy Recommendations to Promote Anti-Displacement Activities within State Transportation Funding Programs, should be used when implementing next steps such as identifying project locations. In addition, a central delivery team could engage with local transportation equity leaders, environmental justice organizations, impacted communities, community-based organizations, and tribal leaders to obtain their perspective during the planning process.

Potential workforce challenges: The transition to zero-emission trucks will impact workforces such as vehicle manufacturers, fleet owners, individual truck owners, logistics providers, automobile maintenance workers, and others. The Assessment identifies existing training programs and recommends the central delivery team help educate impacted stakeholders about existing resources.

5.1 Benefits of the transition to zero-emission freight

The transition to zero-emission freight infrastructure could have both economic and health benefits for California's citizens, economy, and freight industry.

The Gross Regional Product in California could increase 10 percent by 2040 because of the zero-emissions infrastructure transition[3] This was determined by an analysis of the value chain for zero-emission infrastructure development (for example, looking at electric power, vehicle manufacturing, fueling station development, and ancillary industry impacts) to determine a return on investment (including direct, indirect, and induced) within the zero-emission vehicle value chain.

For this calculation, industries were identified using the North American Industry Classification System database. Figures for 2022 were then identified for each industry. Economic multipliers were applied to the Gross Regional Products of each industry based on their relative value added versus other investments in other industries. These multipliers were used to calculate a return on investment in the zero-emissions infrastructure value chain using a bottom-up approach.

The state could experience a savings of around $18.6 billion in statewide health spending from criteria emission reductions (pollution) and that 1,720 lives will be saved from criteria emission reductions through 2040 from implementation of the Advanced Clean Fleets regulation. California citizens could also benefit from the transition to zero-emissions infrastructure from a public health perspective. It is expected that carbon dioxide, total organic gases, oxides of nitrogen, and particulate matters 10 and 2.5 by approximately 23 percent in 2030, and by 53 percent in 2040.

5.2 Potential weight impacts on roads and bridges

Currently, the Federal Highway Administration limits Gross Vehicle Weight to 80,000 pounds. A recent amendment to the weight limit suggests that a vehicle, if operated by an engine fueled primarily by natural gas or powered primarily by means of electric battery power, may exceed the weight limit on the power unit by up to 2,000 pounds (up to a maximum gross vehicle weight of 82,000 pounds). Fuel cell electric vehicles are not covered under the amendment currently. As of April 2022, approximately 2 to 12 percent of trucks are overweight in California; this could increase as zero-emission trucks are adopted. Zero-emission battery electric trucks and hydrogen fuel cell trucks may introduce heavier axle loads than existing internal combustion engine trucks on roadways, since their battery or tank and drive train can contribute to a heavier vehicle weight than internal combustion engine trucks.

In a preliminary estimate determined through collaboration between the Commission and Caltrans using the "PaveM" model, road maintenance costs in California could increase by more than $100 million per year under the 2,000-pound weight increase currently allowed by state and federal laws. Maintenance costs are expected to increase with further increases to allowable weights. Caltrans is

[3] Source: Lightcast economic multipliers, North American Industry Classification System (NAICS) database.

performing additional analysis on projected road maintenance costs from heavy-duty zero-emission trucks and will provide this information as it becomes available.

Without changes to Federal Highway limits on gross vehicle weights, heavier trucks may pose a challenge for fleets because businesses may be unable to afford the additional overweight fees required to operate the truck. Some SB 671 workgroup stakeholders have indicated the delivery of goods may require the use of more trucks to avoid being assessed additional overweight truck fees. This may increase the cost of goods for consumers and result in negative impacts to pavement quality, air quality, and truck drivers (if compensation is based on how much they deliver or by time-of-day delivery). To mitigate these impacts, fleets may consider using trucks with a smaller battery, investing in fast charging, and participating in truck-as-a-service, which provides one price to fleets for both trucks and infrastructure.

Due to technological advancements within the battery technology field, the weight differences between internal combustion engine trucks and zero-emissions trucks are anticipated to decrease over time. The estimated additional weights of zero-emission trucks from the 2020 University of California, Davis study, "Effects of Increased Weights of Alternative Fuel Trucks on Pavement and Bridges," showing the decrease over time are tabulated below. The exhibit below is from table 2.3 "Summary of Battery Electric Truck Weights," and table 2.5 "Summary of Fuel Cell Truck Weights" in the University of California, Davis study:

Exhibit 22: Battery Electric and Hydrogen Fuel Cell Electric Truck Weights

Additional truck weights of BEVs and FCEVs (in pounds)			
Powertrain	**Segment**	**2030**	**2050**
BEV	Heavy Duty Traffic Long haul	5,328	4,267
BEV	Heavy Duty Traffic Short haul	1,408	237
BEV	Medium Duty Traffic	1,444	606
FCEV	Heavy Duty Traffic Long haul	2,267	466
FCEV	Heavy Duty Traffic Short haul	601	-768
FCEV	Medium Duty Traffic	1,136	506

Recommendation related to the increased weight of zero-emission trucks on roads and bridges

Caltrans should evaluate the impacts of heavier zero-emission trucks on the state highway system and develop solutions to address the impacts. That evaluation should include potential roadway impacts,

impacts to other roadway users, and impacts to fleets. As a part of the solution process, climate adaptation strategies, such as resilient concrete, could be considered.

5.3 Methods to avoid resident and business displacement

There are several existing and in-development materials that speak to effective ways of avoiding displacement. Some tools from state agencies include the Commission's Senate Bill 1 Competitive Programs Transportation Equity Supplement[4], and the Caltrans Project Development Procedures Manual. The University of California, Los Angeles developed a white paper called, "White Paper on Anti-Displacement Strategy Effectiveness." This paper found that, "State agencies may best prevent displacement by prioritizing housing preservation and tenant protection policies where possible, whether in incentive programs or planning documents. However, the state's direct power to curb displacement lies primarily in the long-term, in how it channels its investments and disposes of its assets, i.e., public land, to foster housing production, preservation, and stability." The paper recommends an interagency working group on anti-displacement policies. A workgroup like this has been created and is being led by the California State Transportation Agency. The California State Transportation Agency has a draft Anti-Displacement Subcommittee Workplan that lays out next steps for interagency collaboration on this topic. This document is still in draft form and therefore is not publicly available currently. The California Transportation Agency has a forthcoming memo on Policy Recommendations to Promote Anti-Displacement Activities within State Transportation Funding Programs that will be a helpful resource. Another helpful tool is the state of Texas' Framework for Evaluating Anti-Displacement Policies. The framework considers the strengths and weaknesses of various policy tools and how they can be used to address the needs of vulnerable groups impacted by displacement. Finally, there is an online tool called the "California Estimated Displacement Risk Model" that identifies varying levels of displacement risk for low-income renter households in all census tracts in the state. This tool is provided by the Urban Displacement Project. The outcomes and recommendations of these resources should be referenced and integrated into station development procedures and practices in the coming years.

A central delivery team could engage with local transportation equity leaders, environmental justice organizations, impacted communities, community-based organizations, and tribal leaders to obtain their perspective and could use the development of zero-emission freight infrastructure as an opportunity to re-route trucks away from communities where possible.

For residents and businesses who are displaced, federal and state laws (the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, as amended, also known as the Uniform Relocation Act or just Uniform Act, and California Government Code, Chapter 16, Section 7260, et

[4] An example of the Equity Supplement can be found on page 51 of the 2022 Trade Corridor Enhancement Program Guidelines

seq.) require that relocation assistance be provided to any person, business, farm, or nonprofit operation displaced because of the acquisition of real property by a public entity for public use.

5.4 Potential workforce impacts

In general, demand for jobs within the internal combustion engine vehicle value chain may decrease, while demand for jobs within the zero-emission vehicle value chain may increase. As jobs may change from the internal combustion engine vehicle value chain to the zero-emission vehicle value chain, workers may require training, reskilling, and upskilling to adequately supply the labor pool. It will be important to also ensure that in the transition from an internal combustion engine workforce to a zero-emission workforce, the pay scale and benefits carry over to the new workforce.

The state, through the central delivery team, should consider providing guidance or trainings to facilitate this transition for acutely impacted workforces. There are a variety of organizations the central delivery team could work with to support the development of training programs. The California Community Colleges Association provides a resource for working with community colleges on existing and new training programs. Senate Bill 589 (Secretary of State, Chapter 732, Statutes of 2021) required the California Energy Commission to identify workforce development and training resources needed to meet electric vehicle adoption goals. The central delivery team could work with California Energy Commission staff to coordinate on ways to best support training programs. and policies that measurably and significantly increase priority populations' employment, earnings, and participation in employer-paid fringe benefits.

There are many kinds of training programs needed. For example, training should be developed for local municipalities to help staff understand the changes being made to permitting processes and any resources available to them.

There is a need for additional electrical power engineers as well as electric utility distribution design staff. The timelines to get experienced power engineers in place takes a minimum of 6 years and distribution designers approximately 2 to 3 years. Therefore, it is important to accelerate workforce training wherever possible.

There are also some existing training programs already in place. As part of their SB 589 effort, the California Energy Commission Clean Transportation Program has recently included new and expanded workforce development partners such as the California Conservation Corps through a $1 million agreement for the Transportation Electrification Training Project focused on classroom and on-the-job training for EV charger construction, installation, and maintenance. In 2022, the California Energy Commission provided project funding through a new partnership with the California Mobility Center focused on zero-emission vehicle manufacturing and service. Responsible State Agencies should continue to work to ensure that funding is identified and/or appropriated for the necessary training programs as identified in SB 589.

The California Workforce Development Board's High Road Construction Careers and Training Partnership[5] which develops partnership strategies for the State to engage with evolving sectors, including transportation. The Employment Training Panel[6] is another State-sponsored program that funds worker retraining programs that address evolving business and industry needs. In addition, the San Pedro Bay ports have also started a training center to train truck owners about maintenance of zero-emission trucks.[7]

The State should condition support for training programs on a demonstrated track record of significant and growing participation of members of low-income households, low-income communities, and disadvantaged communities as well as a demonstrated track record of having significantly boosted employment and compensation outcomes for such priority populations.

5.5 Potential uses for microgrids

Zero-emission truck adoption could increase the electricity demand for California's existing electricity grid. Microgrids could be necessary to supplement existing grid capacity and to improve resiliency under certain considerations. Microgrids are grid systems consisting of small-scale generation and distribution networks that can operate in isolation from national, state, or regional grid infrastructure or be connected to them. Microgrids provide two primary functions:

- Backup power / resiliency: In the event of major storms, disasters, or public safety power shutoff events, microgrids can continue to provide power to customers
- Supplementing capacity: In urban areas where the demand exceeds existing grid capacity, microgrids can provide necessary supplementary power

Microgrids are an important resiliency feature. Installing a microgrid, where feasible, can provide back-up power in an emergency and can help ensure customers receive power.

Project sponsors should evaluate whether microgrids will be necessary for the station development, based on the following considerations:

- Capacity: Microgrids can be a cost-effective option for small scale demand (up to 2 megawatts).

[5] More information on the High Road Training Partnership is available here: https://cwdb.ca.gov/initiatives/high-road-training-partnerships/

[6] More information on the Employment Training Panel is available here: https://etp.ca.gov/

[7] More information on this training center is available here: https://www.supplychaindive.com/news/Port-Long-Beach-Los-Angeles-110-million-goods-movement-training-campus/646061/ and here: https://www.portoflosangeles.org/references/2023-news-releases/news_032423_gmtc_pledge

- Energy source: Microgrids can be powered by solar panels; propane, and natural gas; hydrogen; or wind turbines. Specific site features and other factors, such as the companies involved in building the station, may determine which power source may be best suited for each station.

Recommendation related to microgrids

- As zero-emission stations are being built along the “Top 6” freight corridors, the state or central delivery team should assess where additional microgrids may be installed as a transportation system resiliency feature.

Part 6: Engagement

Chapter Summary

The Commission developed the Assessment in collaboration with the SB 671 workgroup and with several other state agencies, including the California Air Resources Board, the California Energy Commission, the Governor's Office of Business and Economic Development, the Caltrans, the California State Transportation Agency, and the California Public Utilities Commission.

Beginning in December of 2021, the Commission led 14 workgroup meetings (a meeting was held approximately every 5 weeks) to discuss the development of the Assessment. The Commission held bi-weekly meetings with the state agencies mentioned above to coordinate Assessment work. The workgroup was public, and anyone interested in participating was encouraged to join. The list of participating organizations can be found in Appendix 4 of this report.

The Assessment was developed in collaboration with the SB 671 workgroup and several other state agencies, including the California Air Resources Board, the California Energy Commission, the Governor's Office of Business and Economic Development, the Caltrans, the California State Transportation Agency, and the California Public Utilities Commission.

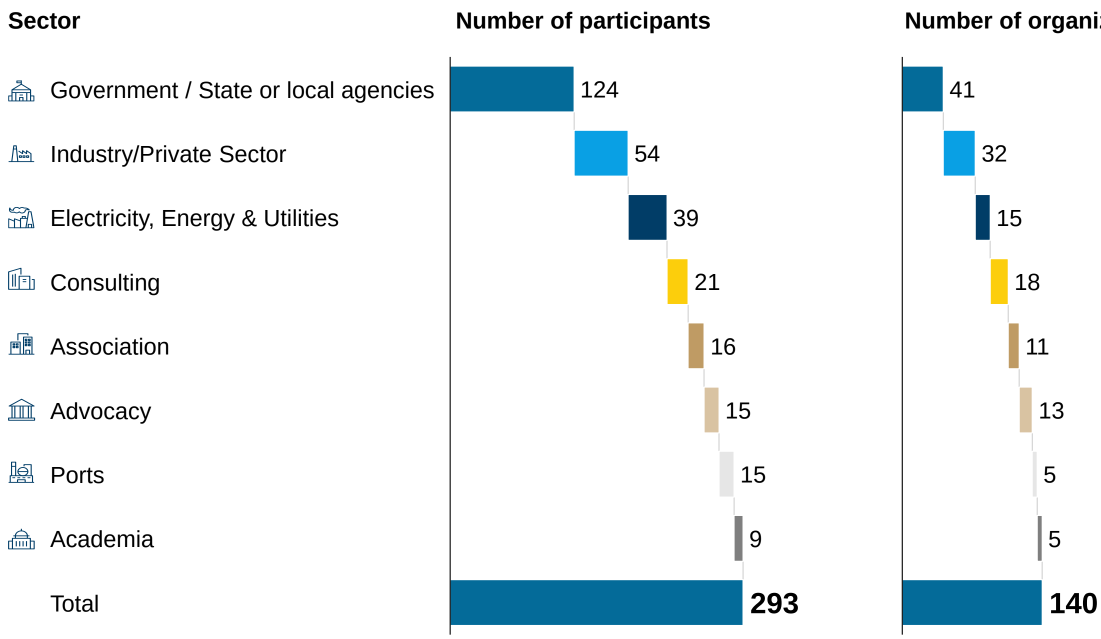
The workgroup was public, and anyone interested in participating was encouraged to join. The Commission reached out to advocates and experts from the freight industry when establishing the workgroup. The workgroup includes stakeholders such as trucking associations, warehouse owners, beneficial cargo owners, carriers, truck stop owners, ports, equity and climate advocates, utilities, energy companies, oil companies, local governments, state agencies, and transportation planning agencies. The list of participating organizations can be found in Appendix 4 of this report.

Beginning in December of 2021, the Commission led 14 workgroup meetings (a meeting was held approximately every 5 weeks) to discuss the development of the Assessment. The Commission held bi-weekly meetings with the state agencies mentioned above to coordinate Assessment work. In addition to scheduled workgroup meetings, the Commission occasionally held individual meetings with experts to solicit their expertise in a specific area. The Commission sent the SB 671 workgroup several requests for information to gather expertise in developing fields, such as expected zero-emission station capacity, costs, fuel efficiency, and other similar topics. Information from workgroup members, along with research, is the basis from which the Assessment was built. Detailed information on the meetings including agendas and presentation slides used for the meetings can be found on the Commission website here.

The Commission engaged a consulting firm though a Request for Proposals process to support the state in developing the Assessment by reviewing existing literature, conducting detailed analyses, and compiling the final outputs, including visuals, executive summaries, and other materials aimed at informing the Legislature. The Assessment was delivered as 14 well-defined tasks. The consultants established a regular cadence of working sessions and interim updates to the Commission. Understanding the Assessment required input from, and coordination with, many public and private sector organizations. A stakeholder engagement plan was co-created with the consultant.

300 individuals and 140 organizations requested to be on the SB 671 workgroup list. 85 to 100 people regularly participated in workgroup meetings. Exhibit 23 shows the participants and organizations by sector.

Exhibit 23: SB 671 Workgroup Participation



~300 individuals and 140 organizations participated in the Assessment process

Part 7: Summary of key recommendations

Recommendation for public funding

- Allocate available public funds, where feasible, to support the build out of the 2035 initial viable network cost. The total cost of $10 to $15 billion will need to be shared between private and public funding and come from all available fund sources.

Recommendations for streamlining zero-emission station development

- To shorten the station delivery timeframe, a central delivery team should be created to coordinate state and local stakeholders to implement the recommendations noted in this list. This central delivery team should function as part of or in coordination with the Executive Order N-8-23 Strike Team.
- The central delivery team should work to create a set of standardized station development model(s) (zoning and building permits) that can be replicated for each station across a priority corridor, based on affected local municipality guidelines.
- To complement recent efforts to improve California Environmental Quality Act timeframes, the Legislature should consider enacting a Categorical Exemption from CEQA for zero-emission freight charging and hydrogen fueling stations.
    - It is recommended that, where possible, zero-emission infrastructure encourage the re-routing of trucks away from communities, and that environmental and air quality stakeholders, impacted communities, and community-based organizations are involved in the development process, general planning process, and location planning process. A specific process related to this suggestion is included in the central delivery team recommendations.
- The Legislature should set a statutory default permit approval deadline for zero-emission freight charging and hydrogen fueling stations similar to AB 970 (McCarty, Chapter 710, Statutes of 2021) that allows a permit for a passenger battery electric vehicle charging station to be deemed complete if it is not approved or otherwise commented on within a specified time period. In addition, existing law, SB 1291 (Archuleta, Chapter 373, Statutes of 2022), requires cities and counties to administratively approve an application to install electric vehicle charging stations and hydrogen-fueling stations through the issuance of a building permit or similar nondiscretionary permit if the location meets certain criteria. The provision of a default permit approval deadline for zero-emission freight charging and hydrogen fueling stations should be made permanent.
- The central delivery team should take a corridor approach to combine and sequence station development where feasible. In other words, synchronize building stations along the selected top freight corridor until the whole corridor is complete prior to moving to the next corridor. The selection process should start first with the “Top 6” corridors and move next to the 34 Priority Freight

Corridors. These decisions should be made in collaboration with stakeholders, because while this is an ideal goal, the timing of station development depends on market readiness in each corridor.

- The initial viable network may be developed to allow smaller segments along the initial viable network to be useable by freight operators as sections of corridors and freight journeys are constructed (for example, given the prevalence of intra-California freight journeys on the I-5 corridor, starting construction at the ports and working north or south along the corridor).

The California Public Utilities Commission, the Commission, and other relevant state agencies should continue to collaborate on the Freight Infrastructure Planning process to proactively update electric infrastructure plans and to coordinate freight modeling efforts. It should be noted that this process is a long-term solution and results will begin to be realized after the next five years. The state, and specifically a central delivery team, if one is identified, should continue to work to identify short-term solutions.

Recommendations for supporting fleet and truck owners through the zero-emission vehicle transition

- The Legislature should create a new limited-term (five-year) zero-emission truck incentive program to assist fleets with purchasing zero-emission trucks. Program development should take place with input from communities, and fleets of all sizes including those who will be impacted by regulations and should be flexible to ensure support in a way that is considerate of their needs.
  - Retrofitting traditional internal combustion engine trucks to zero-emission power trains should be explored as an option to reduce costs. This option may be less expensive than purchasing a new zero-emission truck.
- The California Air Resources Board could create a provision within the Low Carbon Fuel Standard program to support buildout and operation of fast charging and hydrogen fueling infrastructure for medium-duty and heavy-duty vehicles, similar to the existing capacity crediting provision in the Low Carbon Fuel Standard regulation.[1]
- State agencies, Regional Transportation Planning Agencies, Metropolitan Planning Organizations, and the Legislature, should consider how the state may support Mexico-based fleets, operating within California, in the transition to zero-emission freight. Mexico-based fleets, operating within California, do not currently have public incentives from the Mexican government to support the transition to zero-emission trucks and the infrastructure to support electricity or hydrogen does not exist. The following potential financing strategies and energy support strategies should be

[1] Low Carbon Fuel Standard program information can be found online here: https://ww2.arb.ca.gov/sites/default/files/classic/fuels/lcfs/guidance/zev_infra_crediting_overview.pdf

considered to support Mexico-based fleets and should be considered to support the transition at the California border:

- State agencies, Regional Transportation Planning Agencies, and Metropolitan Planning Organizations should apply for federal funding programs designed to support zero-emission trucks and infrastructure in border areas.
- The Legislature should explore developing a state program that allows public funding to be spent in border regions for zero-emission freight pilot projects that provide benefits to California, where allowable by law.
- State agencies should build on existing public private partnership programs that exist in public organizations such as the San Diego Association of Governments to implement zero emission charging and hydrogen fueling within the border region.
- State agencies, Regional Transportation Planning Agencies, and Metropolitan Planning Organizations should partner with the North American Development Bank (NADBank) or similar organizations where possible. The North American Development Bank NADBank was created with the passage of the North American Free Trade Agreement and focuses on providing funding and technical assistance to border communities in the United States and Mexico.
- State agencies should request Congress reinstate the federal Coordinated Border Infrastructure Program that allowed funds to be used for pilot projects that spanned both sides of the United States and Mexico border. Although Mexico is California's number one trading partner, most of these recommendations apply to the U.S. states that border California. These strategies should be employed at all California borders.

- The Legislature should authorize a vehicle buy-back program that would appropriate funds to a state agency that would work with truck sales companies to set aside funds to buy back used zero-emission trucks from fleets once they reach their useful life as a "new" vehicle. This could be added as a new component of existing or new truck incentive programs.

Recommendations for a central delivery team

- The Administration should consider designating one lead group or agency to carry out the functions of the central delivery team outlined in this Assessment. This could be an agency that is currently part of the Executive Order N-8-23 strike team or the Administration could direct the Executive Order N-8-23 strike team to identify and designate such a group. The intent of the central delivery team would be to act as a lead in coordinating zero-emission freight infrastructure planning and implementation, including carrying out the actions included in this Assessment where feasible. The central delivery team should function as a cross-agency team including the California Energy Commission, Caltrans, the California State Transportation Agency, the Governor's Office of Business and Economic Development, California Air Resource Board, California Public Utilities Commission, the Commission, and any other state agencies or entities determined necessary.

- The central delivery team should identify leads from Regional Transportation Planning Agencies, Metropolitan Planning Organizations, ports, utilities, fleets, state-agencies, and other stakeholders (similar to the SB 671 workgroup) that are necessary to build stations quickly.
- The central delivery team should, in coordination with impacted communities, community-based organizations, equity advocates, public health advocates, tribal nations, and environmental advocates, develop a process for impacted communities, community-based organizations, equity advocates, public health advocates, tribal nations, environmental advocates, and any other groups identified to be included in zero-emission station location planning and implementation. Assuming locations around the Top 6 corridors are prioritized, then communities along these corridors should also be prioritized. Outreach efforts should be culturally competent and community specific. In-person meetings and meetings in other languages should be offered when needed. Efforts like the Los Angeles Cleantech Incubator and Coalition for Environmental Health and Justice effort on the I-710 should be used as an example of the type of process needed. In developing the process, the central delivery team should coordinate with the CalSTA Anti-Displacement sub-committee and the interagency Equity Advisory Committee to utilize their expertise and to facilitate the use of existing and any new needed project specific anti-displacement strategies. Existing processes already required under law should also be considered to avoid “re-inventing the wheel.” The central delivery team should work with community colleges and ports that provide training programs to support training, reskilling, and upskilling freight industry workers, as necessary. Additional information related to existing training programs can be found in Chapter 5. In addition, the central delivery team should work with state agencies, local agencies, colleges, and other stakeholders as appropriate to develop and provide training to local municipal staff to inform them of critical changes and to publicize more broadly what the changes are.
- The central delivery team should work with community colleges and ports that provide training programs to support training, reskilling, and upskilling freight industry workers, as necessary. Additional information related to existing training programs can be found in Chapter 5.

Recommendation related to the increased weight of zero-emission trucks on roads and bridges

- Caltrans should evaluate the impacts of heavier zero-emission trucks on the state highway system and develop solutions to address the impacts. That evaluation should include potential roadway impacts, impacts to other roadway users, and impacts to fleets. As a part of the solution process, climate adaptation strategies, such as resilient concrete, could be considered.

Recommendation related to microgrids

- As zero-emission stations are being built along the “Top 6” freight corridors, the state or central delivery team should assess where additional microgrids may be installed as a transportation system resiliency feature.

Part 8: Appendices

Appendix 1: Technical appendix

1.1 Importance of the US-Mexico border

The border region is both essential for trade and impacted by poor air quality. Some of the largest supply chains in the nation are connected through the border region, the core of California's freight economy, generating billions per year in international trade. Mexico became the United States' top trade partner in 2019 and has remained in the top two positions since then. Meanwhile, residents who live near these trade routes have faced some of the worst air quality in the region. The International Border Community, which includes San Ysidro and Otay Mesa, is designated through Assembly Bill 617 and the California Air Resource Board's Community Air Protection Program as an area disproportionately affected by exposure to air pollution from mobile and stationary sources. At the binational land ports of entry, emissions are a concern due to commercial vehicle transport and idling while waiting to cross the border. An important challenge for the region is twofold: recognizing the importance of trucking as the dominant mode of goods movement and backbone of California's freight economy while also recognizing the need to reduce air pollution in impacted communities and reduce greenhouse gas emissions.

In November of 2022, cross border truckers, truck companies, chambers of commerce, and other border stakeholders met with various state agencies in Otay Mesa about the proposed California Air Resource Board Advance Clean Fleets regulation. This meeting was hosted by the California Air Resource Board. The meeting highlighted the state's need to hear comments from stakeholders both in Mexico and the United States about planning implementation of the Advanced Clean Fleets rule. Caltrans and the San Diego Association of Governments conducted interviews over a three-week period with shippers, carriers, truck drivers, truck companies, energy policy experts, customs brokers, a media representative, and manufacturers. For more information, please see the "Zero-Emission Freight Transition at the California and Baja California Border" Commission agenda item from May 2023 about this topic and the formal memorandum between Caltrans, the San Diego Association of Governments, and the Imperial County Transportation Commission, titled, "Zero Emission Freight Transition at the California-Baja California Border."

1.2 Alignment with existing plans

The "Top 6" freight corridors align well with the Caltrans Interregional Transportation Strategic Plan corridors. The Interregional Transportation Strategic Plan identifies eleven Strategic Interregional Corridors that connect California's major regions. Exhibit 23 shows the corridors[2]. In addition, the Commission has worked with Caltrans to align the priority freight corridors and "Top 6" freight corridors

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[2] More information on Interregional Transportation Strategic Plan corridors can be found on the Caltrans website: https://dot.ca.gov/-/media/dot-media/programs/transportation-planning/documents/itspaddendum_final-a11y.pdf

with Alternative Fuel Corridors. The federal government designates corridors as Alternative Fuel Corridors in California based on Caltrans' recommendation. Once designated, Alternative Fuel Corridors are eligible for federal funding programs such as the National Electric Vehicle Infrastructure funding program. Currently, all the "Top 6" corridors and most of the priority freight corridors are designated as Alternative Fuel Corridors. Exhibit 24 shows existing and nominated Alternative Fuel Corridors.[3]

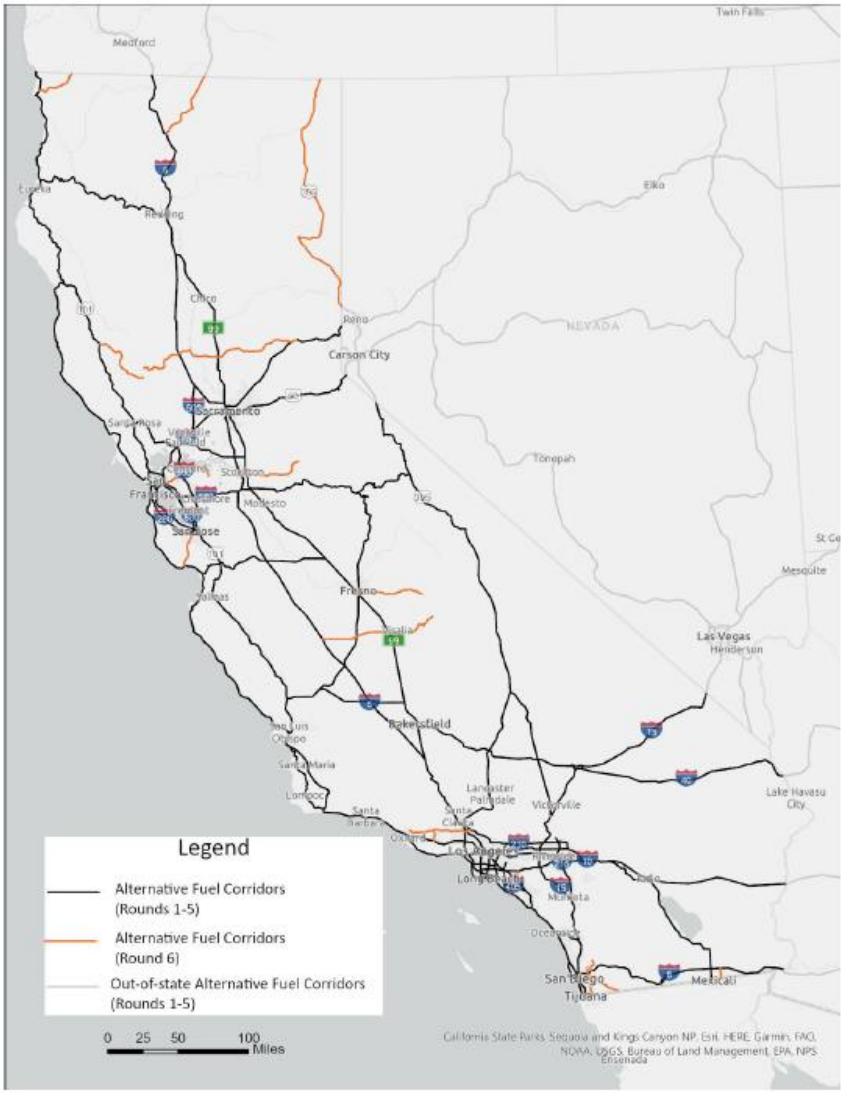
Exhibit 24: Interregional Transportation Strategic Plan corridors

Strategic Interregional Corridors

1. United States/Mexico Border Region - Inland Empire Connections Corridor
2. South Coast - Central Coast Corridor
3. Central Coast - San Jose/San Francisco Bay Area Corridor
4. San Jose/San Francisco Bay Area - North Coast Corridor
5. San Jose/San Francisco Bay Area - Central Valley - Los Angeles Corridor
6. Sacramento Valley - Oregon Border Corridor
7. High Desert - Eastern Sierra - Northern Nevada Corridor
8. Southern California - Southern Nevada/Arizona Corridor
9. Central Coast - San Joaquin Valley East-West Connections Corridor
10. San Jose/San Francisco Bay Area - Sacramento - Northern Nevada Corridor
11. North Coast - Northern Nevada Connections Corridor

[3] More information on Alternative Fuel Corridors can be found on the National Electric Vehicle Infrastructure plan website: https://dot.ca.gov/-/media/dot-media/programs/esta/documents/nevi/california-nevi-deployment-plan-ada-rev-20220804.pdf

Exhibit 25: Existing and nominated Alternative Fuel Corridors



In the map above, the term "Rounds 1-5" refers to corridors that were previously designated as Alternative Fuel Corridors by the Federal Highway Administration. The term "Round 6" refers to corridors Caltrans has nominated as Alternative Fuel Corridors that await Federal Highway Administration approval for inclusion as Alternative Fuel Corridors.

1.3 Vehicle class types mentioned in this report

The SB 671 Assessment defines heavy and medium duty truck zero-emission infrastructure needs. As such the Assessment uses the following cross walk of vehicle types to define focus areas for the study. The report studies Vehicles Classes 4 through 6 for medium duty and Vehicle Classes 7 through 8 and above for heavy-duty as defined by the Federal Highway Administration and the California Air

Resources Board. Classes 1 through 3 are largely non-commercial and therefore not included. Exhibit 25 compares truck vehicle classes defined by each agency.

Exhibit 26: Truck vehicle class type comparison

GVWR categories for this assessment	FHWA GVWR class / weight	FHWA MCFM class / weight	CARB 202x vehicle class	CEC GVWR class / weight	HPMS Vehicle class	HPMS classification
Light-Duty (LDT) <14k lbs.	Class 1: 0 to 6K lbs	Class 1: 0 to 6K lbs	LDT1/2: < 6K lbs	Class 1: 0 to 6K lbs	**Class 1** Motorcycle	Non-commercial: Class 1-3
	Class 2: >6k to 10K lbs	Class 2: >6k to 10K lbs	MDV: 5751 – 8500 lbs LHD1: 8501-10K lbs	Class 2: >6k to 10K lbs	**Class 2** Passenger cars	
	Class 3: >10K to 14K lbs	Class 3: >10K to 14K lbs	LHD2: >10K-14K lbs	Class 3: >10K to 14K lbs	**Class 3** 4 tire, single unit	
Medium-Duty (MDT) 14k-26k lbs.	Class 4: >14k to 16K lbs	Class 4: >14k to 16K lbs	Class 4: >14k to 16K lbs	Class 4: >14k to 16K lbs	**Class 4** Buses	Single-unit commercial: Class 4-7
	Class 5: >16K to 19.5K lbs	Class 5: >16K to 19.5K lbs	Class 5: >16K to 19.5K lbs	Class 5: >16K to 19.5K lbs	**Class 5** 2 axle, 6 tire, single unit	Vehicles with power units and chassis permanently attached. SUs are popular for retail delivery, construction, utilities, and services
	Class 6: >19.5K to 26K lbs	Class 6: >19.5K to 26K lbs	Class 6: >19.5K to 26K lbs	Class 6: >19.5K to 26K lbs	**Class 6** 3 axle, single unit	
Heavy-Duty (HDT) >26k lbs.	Class 7: >26K to 33K lbs	Class 7: >26K to 33K lbs	Class 7: >26K to 33K lbs	Class 7: >26K to 33K lbs	**Class 7** ≥ 4 axle, single unit	
	Class 8: >33K lbs	Class 8: >33K lbs	Class 8: >33K lbs	Class 8: >33K lbs	**Class 8** ≤ 4 axle, single trailer	Combination commercial: Class 8-13
					Class 9 6-Axle tractor semitrailer	Vehicles made up of two or more units, most commonly a tractor and a semitrailer
					Class 10 ≥ 6 axle, single trailer	
					Class 11 ≤ 5 axle, multi trailer	
					Class 12 6 axle, multi trailer	
					Class 13 ≥ 7 axle, multi-tailer	

Please note: EMFAC vehicle classes from Class 4 - 8 also include use-case designations such as Public, Utility, Instate Delivery, Single Dump, etc. CEC categorizes class 2b and 3 vehicles as medium duty

1.4 Infrastructure assessment detailed methodology

The calculation of infrastructure needs began with estimates of total zero-emission trucks that would be on the roads in California in the four study years. The Commission used vehicle estimates from the California Air Resources Board. Using California Air Resources Board zero-emission vehicle counts brings the infrastructure needs assessment into alignment with the California Air Resources Board's Advanced Clean Trucks and Advanced Clean Fleets regulations. Below are the total zero-emission vehicle counts from the California Air Resources Board in each of the 4 study years.

	# ZEVs			
Vehicle class	2025	2030	2035	2040
Class 4-7 (T6TS)	4,483	9,491	17,824	20,282
Class 4	1,283	5,884	15,229	25,405
Class 5	2,441	14,971	36,972	49,117

Class 6	3,360	18,311	45,434	59,212
Class 7	1,325	11,482	26,999	39,035
Class 8	3,103	20,400	48,336	73,805
Class 7 Tractor Day Cab	268	4,215	9,816	14,552
Class 8 Tractor Day Cab	2,498	17,777	26,488	26,747
Class 8 Tractor Sleeper Cab + Day Cab	2,662	32,301	98,651	178,878
Total	21,422	134,831	325,749	487,033

Percent Splits of Technology Type

Next, the total zero-emission vehicles were multiplied by a percent split of battery electric trucks and hydrogen fuel cell electric trucks. The percentage used depended on the scenario. Each percent split is explained in more detail below.

Accelerated Battery Electric Adoption Scenario

The Commission worked with the California Energy Commission on the percentage used in the accelerated battery electric adoption scenario. The California Energy Commission prepares the Integrated Energy Policy Report (IEPR). The IEPR provides a cohesive approach to identifying and solving the state’s pressing energy needs and issues. The report, which is crafted in collaboration with a range of stakeholders, develops and implements energy plans and policies. The percent of battery electric trucks and hydrogen fuel cell electric trucks used was from the 2022 IEPR’s Additional Achievable Transportation Electrification (AATE) 3 scenario. This is one of the several scenarios in the IEPR.

It should be noted that the 2023 Integrated Energy Policy Report does not have the exact same energy needs estimates as the Assessment. With many entities working in this developing area, it is best to consider estimated outputs as a range of potential outcomes. It should also be noted that IEPR is a separate assumption from the Assembly Bill 2127 report that the California Energy Commission Develops. The Assembly Bill 2127 report estimates of chargers needed is higher than what was estimated in the Assessment.

Below are the percentages used for the accelerated battery electric adoption scenario.

	2025		2030		2035		2040	
Vehicle class	% BEV	% FCEV	% BEV	% FCEV	% BEV	% FCEV	% BEV	% FCEV
Class 4-7 (T6TS)	100.00%	0.00%	100.00%	0.00%	99.62%	0.38%	97.80%	2.20%
Class 4	100.00%	0.00%	100.00%	0.00%	100.00%	0.00%	100.00%	0.00%
Class 5	100.00%	0.00%	100.00%	0.00%	100.00%	0.00%	100.00%	0.00%
Class 6	100.00%	0.00%	99.69%	0.31%	98.25%	1.75%	92.22%	7.78%
Class 7	100.00%	0.00%	100.00%	0.00%	100.00%	0.00%	100.00%	0.00%
Class 8	100.00%	0.00%	100.00%	0.00%	100.00%	0.00%	100.00%	0.00%
Class 7 Tractor Day Cab	100.00%	0.00%	100.00%	0.00%	100.00%	0.00%	100.00%	0.00%
Class 8 Tractor Day Cab	100.00%	0.00%	100.00%	0.00%	100.00%	0.00%	72.90%	27.10%
Class 8 Tractor Sleeper Cab + Day Cab	100.00%	0.00%	100.00%	0.00%	100.00%	0.00%	100.00%	0.00%

Accelerated Hydrogen Fuel Cell Electric Vehicle Adoption Scenario

The Commission worked with the California Hydrogen Coalition on the accelerated hydrogen fuel cell electric vehicle adoption scenario. The percentages used in this scenario are based on a general understanding of the potential impacts of the future cost of hydrogen per kilogram, hydrogen vehicle fuel efficiency, and the type of hydrogen fuel cell electric trucks that may be available in the study years. It is important to note that the Governor’s Office of Business and Economic Development is working with stakeholders to accelerate the use of clean hydrogen in California, and to lower the cost of hydrogen. California was recently awarded $1.2 billion in federal funds in support of a hydrogen hub to produce and utilize renewable, clean hydrogen across California. These funds will help support a lower cost of hydrogen and more accessible hydrogen in California. Below are the percentages used in this scenario. In this case the same percent split was assumed across all four study years.

Vehicle class	% BEV	% FCEV
Class 4-7 (T6TS)	67%	33%
Class 4	67%	33%
Class 5	67%	33%
Class 6	67%	33%
Class 7	50%	50%
Class 8	50%	50%
Class 7 Tractor Day Cab	25%	75%
Class 8 Tractor Day Cab	25%	75%
Class 8 Tractor Sleeper Cab + Day Cab	25%	75%

Balanced Adoption Scenario

The Commission used data from a McKinsey Center for Future Mobility (MCFM) national study for the balanced adoption scenario. The MCFM scenarios are based on the speed of electrification of fleets from slow to faster based the transition required to meet international decarbonization commitments. Of the four scenarios (Fading Momentum, Current Trajectory, Further Acceleration, and Achieved Commitments), the Commission used the percentages from the Further Acceleration scenario for the balanced adoption scenario. The Fleet Decarbonization model is modelled based on a variety of commercial medium duty and heavy-duty vehicles and trucks currently available in the market as well as a variety of use cases (urban, regional, long-haul, drayage). The percentage of battery electric and hydrogen fuel cell electric trucks in 2025, 2030, 2035, and 2040 are consistent (within 1-3%) with CARB's projected percentages for each technology. The only difference was the MCFM Further Acceleration had a more conservation ramp up in adoption of FCEVs in the earlier years than the CARB projections.

For this Assessment, the California Air Resources Board vehicle classes 4 through 6 are classified as medium-duty, and vehicle classes 7 through 8 are classified as heavy-duty.

	2025		2030		2035		2040	
Vehicle class	% BEV	% FCEV	% BEV	% FCEV	% BEV	% FCEV	% BEV	% FCEV
MDT	98%	2%	90%	10%	82%	18%	75%	25%
HDT	83%	17%	61%	39%	45%	55%	41%	59%

Annual Average Vehicle Miles Travelled

Once the amount of battery electric trucks and hydrogen fuel cell electric trucks had been identified, the total trucks, both battery electric and hydrogen fuel cell electric, were multiplied by the average annual vehicle miles travelled in each vehicle class to arrive at total battery electric truck vehicle miles and total hydrogen fuel cell electric truck vehicle miles.

- # Of battery electric trucks x average annual vehicle miles travelled = total battery electric truck vehicle miles
- # Of hydrogen fuel cell electric trucks x average annual vehicle miles travelled = total fuel cell electric truck miles

The vehicle miles travelled data was from a 2019 Eastern Research Group Heavy-Duty Vehicle Accrual Rates study prepared for the California Air Resources Board.[4] This information was used at the recommendation of the California Air Resources Board, as it provides some more current information that what was available at the time in the California Air Resources Board's Emission Factor (known as EMFAC) tool for medium-duty and heavy-duty vehicles.

The Eastern Research Group report used vehicle miles travelled accrual rates by vehicle class type. The term "accrual rate" refers to the annual miles accumulated per vehicle. Accrual rates vary by age and generally decrease for older vehicles. The Commission averaged vehicle miles travelled data from 10 years of vehicle age within each vehicle class to arrive at a more accurate estimate. Below are the average annual vehicle miles traveled inputs for each vehicle class.

[4] The California Air Resources Board report that is the source of the vehicle miles travelled data is available here: https://ww2.arb.ca.gov/sites/default/files/2021-02/erg_finalreport_hdv_accruals_20190614_plus_addendum.pdf

Vehicle class	Avg Annual VMT (mi)
Class 4-7 (T6TS)	13,856
Class 4	19,924
Class 5	19,672
Class 6	20,340
Class 7	20,455
Class 8	24,130
Class 7 Tractor Day Cab	22,369
Class 8 Tractor Day Cab	49,050
Class 8 Tractor Sleeper Cab + Day Cab	67,799

Fuel Efficiency

At this point in the methodology, the total battery electric truck vehicle miles and the total hydrogen fuel cell electric truck vehicle miles have been identified. These miles were then multiplied by fuel efficiency estimates to get an estimate of average annual electricity needed and hydrogen needed in each of the four study years.

- Total battery electric truck vehicle miles travelled x fuel efficiency = total electricity needed (annual)
- Total hydrogen fuel cell electric truck vehicle miles travelled x fuel efficiency = total hydrogen needed (annual)

The battery electric truck fuel efficiency was measured in kilowatt hours per mile. The fuel efficiency estimates used were from the University of California, Davis. Below are the battery electric truck fuel efficiency inputs.

The estimates UCD provided were provided in Gasoline Gallon Equivalent, or miles per gallon. The Commission converted the miles per gallon estimates into kilowatt hours per mile using the conversion rates below.

1 mile per gallon equivalent (MPGe) =	0.03	Mile per kilowatt hour (mi/kWh)	=	33.71	Kilowatt hours per mile (kWh/mi)

	BEV Efficiency (kWh/mi)			
Vehicle Class	2025	2030	2035	2040
Class 4-7 (T6TS) (delivery)	0.83	0.79	0.77	0.73
Class 4 (delivery)	0.83	0.79	0.77	0.73
Class 5 (delivery)	0.83	0.79	0.77	0.73
Class 6 (delivery)	0.83	0.79	0.77	0.73
Class 7 (regional)	2.35	2.2	2.09	1.88
Class 8 (regional)	2.35	2.2	2.09	1.88
Class 7 Tractor Day Cab (regional)	2.35	2.2	2.09	1.88
Class 8 Tractor Day Cab (long-haul)	2.14	1.99	1.88	1.83
Class 8 Tractor Sleeper Cab + Day Cab (long-haul)	2.14	1.99	1.88	1.83

The hydrogen fuel cell electric truck fuel efficiency was measured in kilograms per mile. The fuel efficiency estimates used were based on expert interviews and input. Below are the hydrogen fuel cell electric truck fuel efficiency inputs. As can be seen from the table below, there was one efficiency estimate used in all four study years. Miles per gallon equivalents were converted to kilograms per mile.

1 mile per gallon equivalent (MPGe) =	1.019	Mile per kilogram of hydrogen (mi/kg H2)	=	0.981354	Kilograms of hydrogen per mile (kg H2/mi)

	FCEV Efficiency
Vehicle Class	kg/mi
Class 4-7 (T6TS) (delivery)	0.06
Class 4 (delivery)	0.06
Class 5 (delivery)	0.06
Class 6 (delivery)	0.06
Class 7 (regional)	0.11
Class 8 (regional)	0.11
Class 7 Tractor Day Cab (regional)	0.11

	FCEV Efficiency
Class 8 Tractor Day Cab (long-haul)	0.11
Class 8 Tractor Sleeper Cab + Day Cab (long-haul)	0.11

Utilization

The Commission assumed a 20 percent utilization rate for both battery electric charging stations and hydrogen fueling stations. This percent was informed by McKinsey Center for Future Mobility as well as feedback from the SB 671 Working group and is within the bounds of what is normal today for diesel stations. It is possible that over time, utilization may increase, but since 20 percent is on the high end of utilization assumptions, this percent was kept static for the each of the four study years. See the article linked below from McKinsey that discusses the utilization of charging stations.

https://www.mckinsey.com/features/mckinsey-center-for-future-mobility/our-insights/can-public-ev-fast-charging-stations-be-profitable-in-the-united-states

Charger Archetypes and Use Cases

For battery electric vehicles, the Commission completed an additional step to inform the total electricity needed each year – this additional information is called charger archetypes. The charger archetype scenarios were created using data from the McKinsey Center for Future Mobility, Fleet Electrification Model. The back-up information is not published, but for reference, see two reports below where this data was also used:

- Preparing the world for zero-emission trucks
- Can public EV-fast charging stations be profitable in the US?

To create the charging archetypes, the previously identified average annual kilowatt hours of electricity were further divided into long-haul, mid-haul (or regional), and short haul (or delivery) based on vehicle class. See below for the break-out of vehicle class by these general use cases.

Vehicle Class	General use case
Class 4-7 (T6TS) (delivery)	Short-haul or delivery
Class 4 (delivery)	Short-haul or delivery
Class 5 (delivery)	Short-haul or delivery
Class 6 (delivery)	Short-haul or delivery
Class 7 (regional)	Mid-haul or regional

Class 8 (regional)	Mid-haul or regional
Class 7 Tractor Day Cab (regional)	Mid-haul or regional
Class 8 Tractor Day Cab (long-haul)	Long-haul
Class 8 Tractor Sleeper Cab + Day Cab (long-haul)	Long-haul

Within each of these categories, the kilowatt hours were further divided into depot (also known as private location) charging and publicly accessible charging. The percent of assumed public versus depot charging varied based on the general use case category. Within each of these sub-categories, a specific type of charging behavior was assumed based on a range of potential charging options. The potential charging options included are listed below. The composition of assumed charging behavior was different based on the vehicle class, whether it was charging at a depot or public station, and the study year. The charging archetypes were informed by the McKinsey Center for Future Mobility Commercial Fleet Decarbonization tool (based on economical and widely available charging infrastructure currently in the market).

AC fast L2: 15- 22 kw
AC slow L1: <4kw kw
AC slow L2: 4 - 15 kw
DC 100 kw
DC 150 kw
DC 25 kw
DC 350 kw
DC 50 kw
DC 500 kw

Different charging levels each have a different energy output, so completing this step was necessary to identify the total electricity needed in each of the four study years. Different charger types and levels are necessary for overnight versus depot versus fast charging at public and private stations.

Assumptions about Battery Electric Truck Stations

To get to the number of charging stations needed, the average annual electricity needs to be divided by the average annual capacity of a charging station to dispense electricity. Therefore, several assumptions had to be made about charging stations. The Commission made assumptions about peak output, charger efficiency, average output discount, and utilization. These assumptions are outlined below.

Charger	Peak output (kW)	Charger efficiency	Average output discount	Utilization
L2	19	0.9	0.9	0.2
DC 50	50	0.9	0.9	0.2
DC 100	100	0.9	0.9	0.2
DC 150	150	0.9	0.9	0.2
DC 350	350	0.9	0.8	0.2
DC 500	500	0.9	0.8	0.2

The Commission also made assumptions about the number of chargers in depot (or private) stations and public stations based on input from truck stop owners and SB 671 workgroup input. These assumptions are below.

Station type	# Chargers per station
Depot	20
Public	10

Dividing the average annual electricity by the average annual station capacity to generate electricity equals the total number of battery electric stations needed.

Assumptions about Hydrogen Fuel Cell Stations

Similarly, for hydrogen fuel cell stations, several assumptions were made. The Commission assumed an average annual station capacity of 292,000 kilograms of hydrogen a year. This estimate is on the higher side of station capacity and the estimate remains static throughout the four study years. In actual practice, the capacity of a station depends on how many fueling positions the station has and capacity may vary. However, the estimate used represents a reasonable average.

The Commission assumed a 25 percent private and 75 percent private distribution between stations based on feedback from SB 671 workgroup members and the fueling use cases and archetypes (depot vs. public; fast vs. overnight charging).

Dividing the average annual kilograms of hydrogen needed by the average annual station capacity to dispense hydrogen equals the total number of hydrogen fueling stations needed.

1.5 Existing clean infrastructure plans and projects

There are several potential areas where entities have expressed an interest in building zero-emission freight stations in the same place where the Assessment identifies need. These areas are covered below.

1. EnergIIZE Projects

The first area of overlap is the California Energy Commission's EnergIIZE program. This program has funded several zero-emission freight infrastructure projects. There are several different funding opportunities called, "Funding Lanes" available in this program:

- "EV Fast Track" provides incentives of up to $500,000 per project for electric vehicle charger purchases.
- "EV Jump Start (Equity)" provides incentives of up to $750,000 per project for electric vehicle charger purchases.
- "EV Public Charging" provides incentives of up to $500,000 per project to public charging station developers. Level 2 chargers are not eligible.
- "Hydrogen Lane" provides incentives of up to $3 million per project for deployment of hydrogen fueling infrastructure equipment for medium- and heavy-duty vehicles.

As of July 2023, there are 111 electric charging and hydrogen fueling locations funded through this program. As of October 2023, EnergIIZE has awarded 151 projects for 1,435 EV chargers and 31 hydrogen dispensers. Some of these projects are located along key corridors or in dense urban areas. The timeframe for these projects is two to three years to develop these stations once funding is allocated for construction.

Specifically, the stations in Sacramento and Stockton along Interstate 5 and State Route 99, the stations in the Bay Area, the station on Interstate 80 at the edge of the California and Nevada border, the stations along State Route 99 in Visalia and Bakersfield, and the stations in the Los Angeles area are all near the "Top 6" freight corridors or in dense urban areas where stations will be needed for an early milestone year. The California Energy Commission has an interactive online map dashboard which is updated in real time. It can be accessed online at: https://calstartorg.maps.arcgis.com/apps/dashboards/93ba3501edad4f51beb4d8d4dda46647. The timeline of when these stations will be built is around two to three years from the time the funds have been allocated. These stations are locations where entities have applied for and received incentive funding for zero-emission freight infrastructure.

2. Truck Stops

There are several large truck stop companies that have plans to add electric truck charging, hydrogen fueling, or both at their existing locations. Since truck stops are public and since many of these locations exist along key freight corridors already, these locations represent an important piece of planned zero-emission freight infrastructure.

The Pilot Company plans to add zero-emission freight charging and/or re-fueling to all their California locations. Exhibits 27 and 28 show the locations.

Exhibit 27: Pilot Truck Stop Locations – Northern California

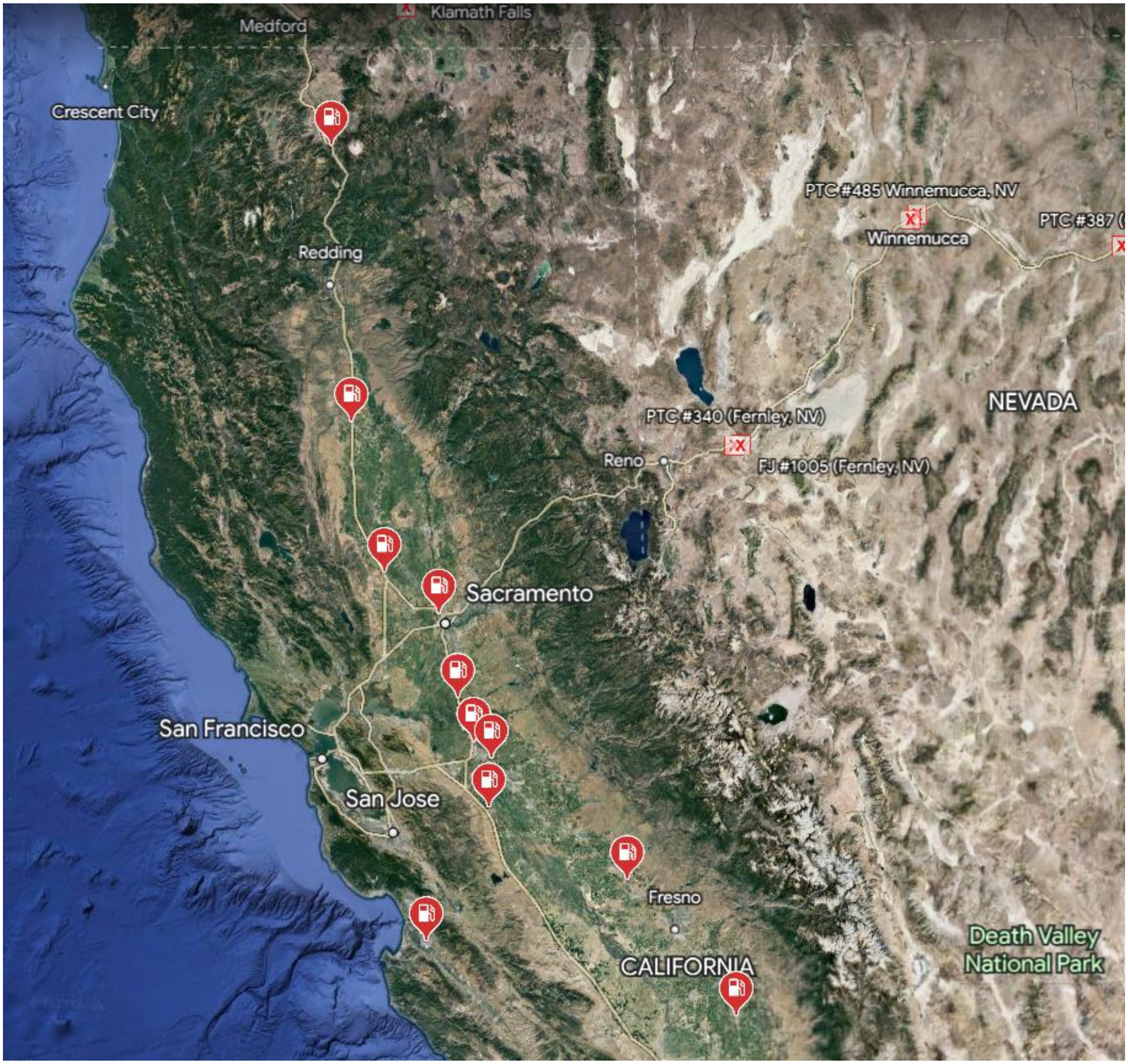
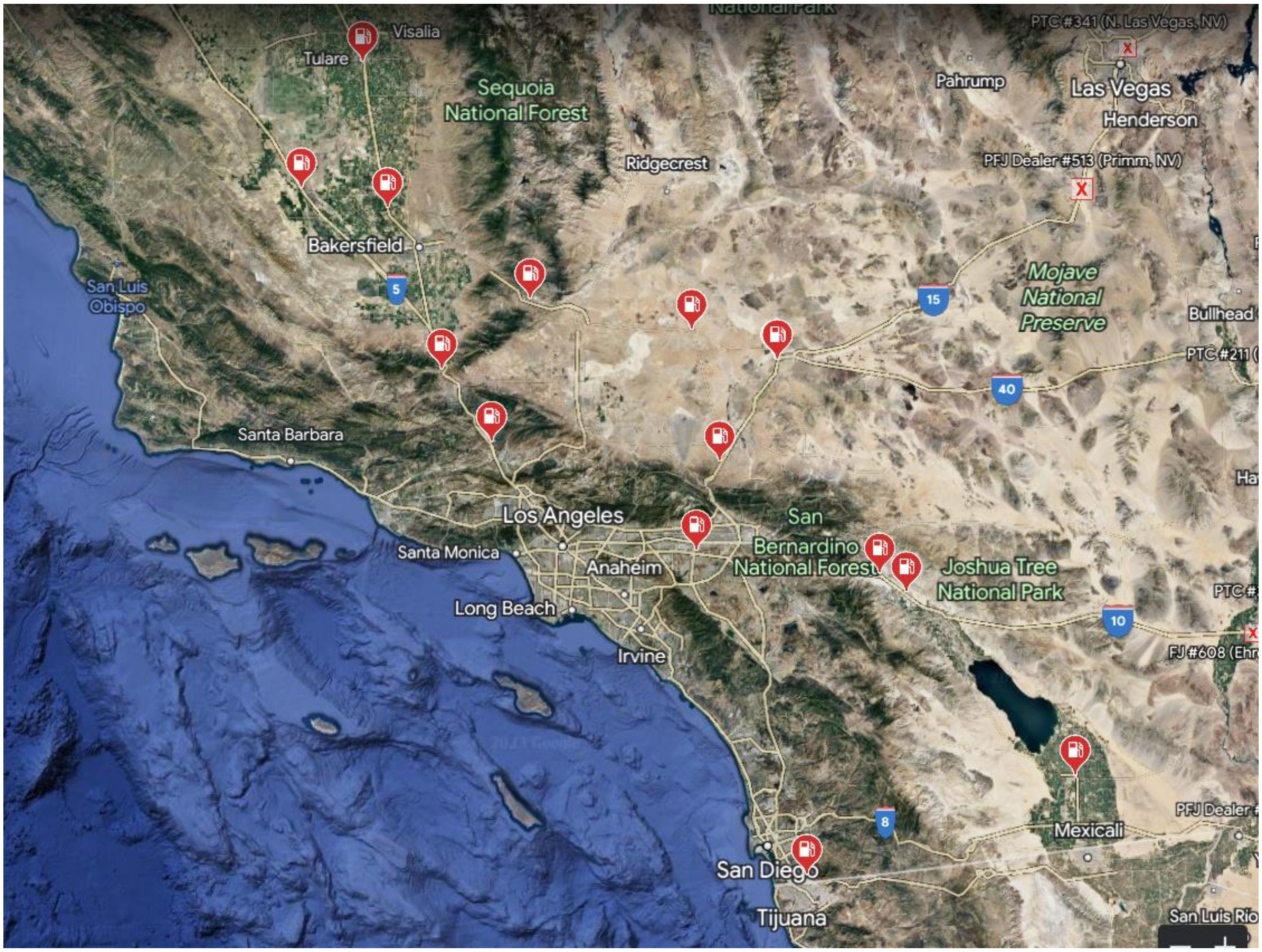


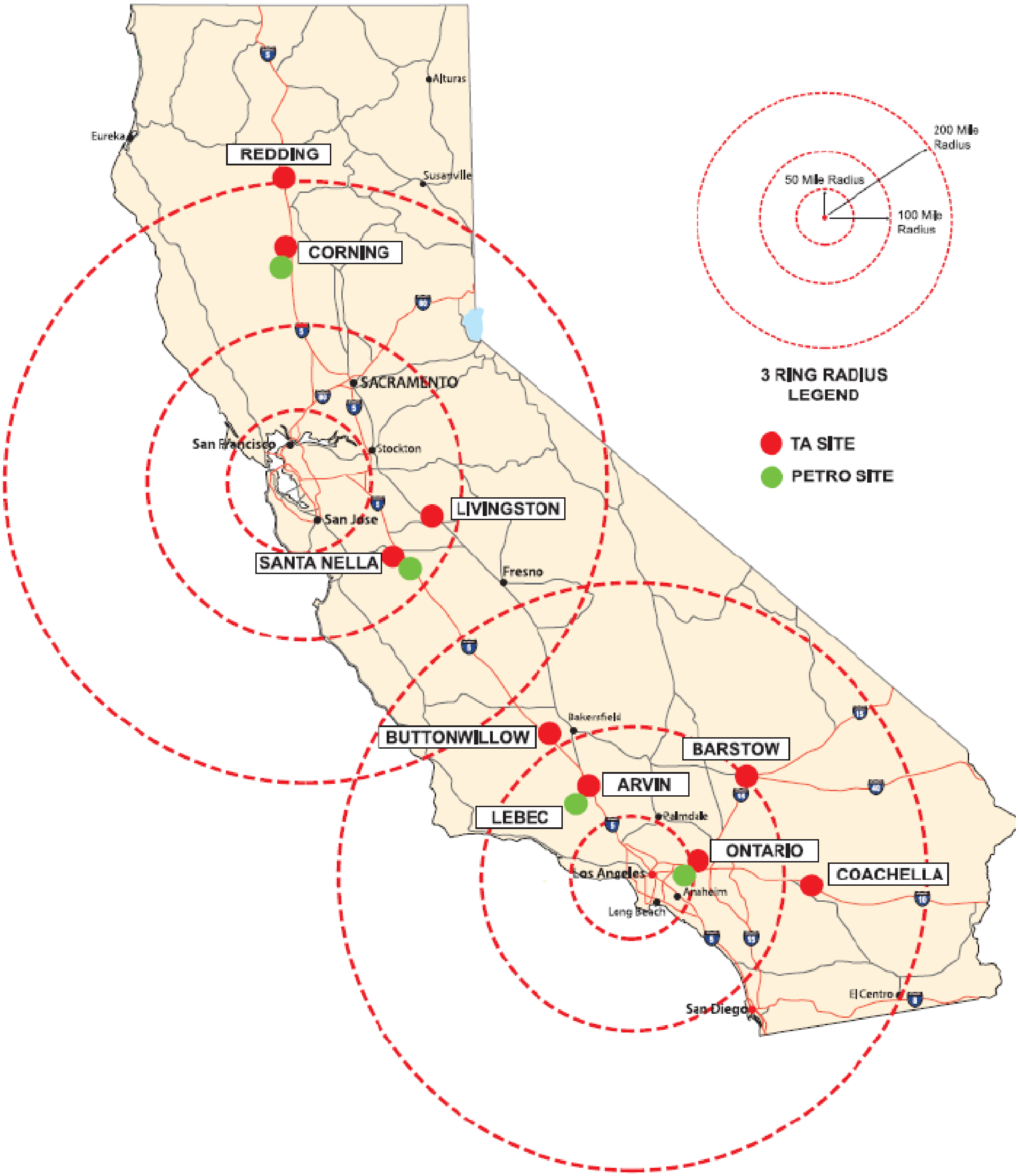
Exhibit 28. Pilot Truck Stop Locations – Southern California



Many of the Pilot truck stops are located along Interstate 5. There are several locations along State Route 99, on Interstate 15, Interstate 10, and near Otay Mesa East.

Similarly, Travel Centers of America is also planning to add electric truck high power charging stations to many of their existing locations. As shown in Exhibit 29, most of the locations are on Interstate 5; there are also locations on State Route 99, Interstate 40, and Interstate 10.

Exhibit 29: TravelCenters of America (shown as “TA” in the image) – Map of California Electric Truck High Power Charging Planned Locations



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1.6 Estimating tailpipe emissions and near-source impact reduction along "Top 6" corridors – Detailed methodology

Calculations for the reduction of tailpipe emissions assume vehicles miles travelled are generated solely by combustion engine powertrains. The calculation considers only tailpipe emissions and does not include vehicle manufacturing, tire and brake wear emissions, or energy production emissions.

Estimation of direct (tailpipe) emissions followed the following steps:

1. Identify the forecast of estimated vehicle miles traveled in the "Top 6" corridors (Sources: Freight Analysis Framework 5 with a base year of 2017 and forecast years 2023 through 2050 / Federal Highway Administration, and Freight Booster)
2. Identify the estimated average annual vehicles miles travelled in each year from 2024 through 2040 by powertrain and truck vehicle class projections using California Air Resources Board Advanced Clean Trucks and Advanced Clean Fleets data for vehicle class type and a California Air Resources Board 2019 report called, "Eastern Research Group Heavy-Duty Vehicle Accrual Rates" for vehicle miles travelled data.
3. Identify the tons of carbon dioxide, total organic gases, oxides of nitrogen, and particulate matters 10 and 2.5 for each year from 2024 through 2040 using EMFAC 2021 data.
4. For each emission type, multiply the average tons of emissions per vehicle per year by the number of internal combustion trucks that are estimated to operate in California each year.

Appendix 2: Projects identified by the SB 671 working group

#	Project name	(Freight) project type	Project sponsor(s)	Public or private
1	Otay Mesa East Point of Entry	Electric Charging	San Diego Association of Governments	Public
2	Harbor Drive and Vesta Street Bridge	Electric Charging	Multiple Entities including the San Diego Association of Governments	Public and Private
3	Madera Hydrogen Refueling Station	Hydrogen Fueling	Air Products	Public
4	Altasea - Port of Los Angeles	Hydrogen Fueling	Air Products	Public
5	Corona Hydrogen Refueling Station	Hydrogen Fueling	Air Products	Public
6	Fallbrook Hydrogen Refueling Station	Hydrogen Fueling	Air Products	Public
7	Galt Hydrogen Refueling Station	Hydrogen Fueling	Air Products	Public
8	Paramount Hydrogen Refueling Station	Hydrogen Fueling	Air Products	Public
9	Santa Clara Hydrogen Refueling Station	Hydrogen Fueling	Air Products	Public
10	Santa Fe Springs Hydrogen Refueling Station	Hydrogen Fueling	Air Products	Private
11	Visalia Hydrogen Refueling Station	Hydrogen Fueling	Air Products	Public
12	Westly Hydrogen Refueling Station	Hydrogen Fueling	Air Products	Public
13	Wilmington Hydrogen Refueling Station	Hydrogen Fueling	Air Products	Public
14	Ontario Hydrogen Refueling Station	Hydrogen Fueling	Nikola	Public
15	Stockton Hydrogen Refueling Station	Hydrogen Fueling	Nikola	Public
16	Colton (South) Hydrogen Refueling Station	Hydrogen Fueling	Nikola	Public
17	West Sacramento Hydrogen Refueling Station	Hydrogen Fueling	Nikola	Public

#	Project name	(Freight) project type	Project sponsor(s)	Public or private
18	Carson Hydrogen Refueling Station	Hydrogen Fueling	Nikola	Public
19	Goshen Hydrogen Refueling Station	Hydrogen Fueling	Nikola	Public
20	Coachella Hydrogen Refueling Station	Hydrogen Fueling	Nikola	Public
21	Oakland Hydrogen Refueling Station	Hydrogen Fueling	Nikola	Public
22	Dixon Hydrogen Refueling Station	Hydrogen Fueling	Nikola	Public
23	Port of San Diego Hydrogen Refueling Station	Hydrogen Fueling	Nikola	Public
24	San Diego (Otay Mesa) Hydrogen Refueling Station	Hydrogen Fueling	Nikola	Public
25	Fontana Hydrogen Refueling Station	Hydrogen Fueling	Nikola	Public
26	Colton (North) Hydrogen Refueling Station	Hydrogen Fueling	Nikola	Public
27	Santa Fe Springs Hydrogen Refueling Station	Hydrogen Fueling	Nikola	Public
28	Bakersfield Hydrogen Refueling Station	Hydrogen Fueling	Nikola	Public
29	Lathrop Hydrogen Refueling Station	Hydrogen Fueling	Nikola	Public
30	Rialto Hydrogen Refueling Station	Hydrogen Fueling	Nikola	Public
31	Vernon Hydrogen Refueling Station	Hydrogen Fueling	Nikola	Public
32	Fresno Hydrogen Refueling Station	Hydrogen Fueling	Nikola	Public
33	Tracy Hydrogen Refueling Station	Hydrogen Fueling	Nikola	Public
34	Madera Hydrogen Refueling Station	Hydrogen Fueling	Nikola	Public
35	Riverside Hydrogen Refueling Station	Hydrogen Fueling	Nikola	Public
36	Corona Hydrogen Refueling Station	Hydrogen Fueling	Nikola	Public
37	Santa Ana Hydrogen Refueling Station	Hydrogen Fueling	Nikola	Public
38	Barstow Hydrogen Refueling Station	Hydrogen Fueling	Nikola	Public
39	Escondido Hydrogen Refueling Station	Hydrogen Fueling	Nikola	Public
40	Modesto Hydrogen Refueling Station	Hydrogen Fueling	Nikola	Public

#	Project name	(Freight) project type	Project sponsor(s)	Public or private
41	Jurupa Valley Hydrogen Refueling Station	Hydrogen Fueling	Nikola	Public
42	Van Nuys Hydrogen Refueling Station	Hydrogen Fueling	Nikola	Public
43	Hesperia Hydrogen Refueling Station	Hydrogen Fueling	Nikola	Public
44	San Jose Hydrogen Refueling Station	Hydrogen Fueling	Nikola	Public
45	Richmond Hydrogen Refueling Station	Hydrogen Fueling	Nikola	Public
46	Moreno Valley Hydrogen Refueling Station	Hydrogen Fueling	Nikola	Public
47	Fairfield Hydrogen Refueling Station	Hydrogen Fueling	Nikola	Public
48	Sacramento Airport Hydrogen Refueling Station	Hydrogen Fueling	Nikola	Public
49	Castaic Hydrogen Refueling Station	Hydrogen Fueling	Nikola	Public
50	Fremont Hydrogen Refueling Station	Hydrogen Fueling	Nikola	Public
51	Lancaster Hydrogen Refueling Station	Hydrogen Fueling	Nikola	Public
52	Lodi Hydrogen Refueling Station	Hydrogen Fueling	Nikola	Public
53	Santa Rosa Hydrogen Refueling Station	Hydrogen Fueling	Nikola	Public
54	Redding Hydrogen Refueling Station	Hydrogen Fueling	Nikola	Public
55	Blythe Hydrogen Refueling Station	Hydrogen Fueling	Nikola	Public
56	San Luis Obispo (5) Hydrogen Refueling Station	Hydrogen Fueling	Nikola	Public
57	Patterson Hydrogen Refueling Station	Hydrogen Fueling	Nikola	Public
58	Kettleman City Hydrogen Refueling Station	Hydrogen Fueling	Nikola	Public
59	El Centro Hydrogen Refueling Station	Hydrogen Fueling	Nikola	Public
60	Industry Hydrogen Refueling Station	Hydrogen Fueling	Nikola	Public
61	Truckee Hydrogen Refueling Station	Hydrogen Fueling	Nikola	Public
62	Mojave Hydrogen Refueling Station	Hydrogen Fueling	Nikola	Public
63	Santa Maria Hydrogen Refueling Station	Hydrogen Fueling	Nikola	Public

#	Project name	(Freight) project type	Project sponsor(s)	Public or private
64	Travel Centers of America Ontario (A)	Electric Charging	Travel Centers of America	Public
65	Travel Centers of America Coachella	Electric Charging	Travel Centers of America	Public
66	Travel Centers of America Redding	Electric Charging	Travel Centers of America	Public
67	Travel Centers of America Corning (A)	Electric Charging	Travel Centers of America	Public
68	Travel Centers of America Buttonwillow	Electric Charging	Travel Centers of America	Public
69	Travel Centers of America Ontario (B)	Electric Charging	Travel Centers of America	Public
70	Travel Centers of America Santa Nella (A)	Electric Charging	Travel Centers of America	Public
71	Travel Centers of America Livingston	Electric Charging	Travel Centers of America	Public
72	Travel Centers of America Barstow	Electric Charging	Travel Centers of America	Public
73	Travel Centers of America Arvin	Electric Charging	Travel Centers of America	Public
74	Travel Centers of America Corning (B)	Electric Charging	Travel Centers of America	Public
75	Travel Centers of America Wheeler Ridge	Electric Charging	Travel Centers of America	Public

#	Project name	(Freight) project type	Project sponsor(s)	Public or private
66	Travel Centers of America Redding	Electric Charging	Travel Centers of America	Public
67	Travel Centers of America Corning (A)	Electric Charging	Travel Centers of America	Public
68	Travel Centers of America Buttonwillow	Electric Charging	Travel Centers of America	Public
69	Travel Centers of America Ontario (B)	Electric Charging	Travel Centers of America	Public
70	Travel Centers of America Santa Nella (A)	Electric Charging	Travel Centers of America	Public
71	Travel Centers of America Livingston	Electric Charging	Travel Centers of America	Public
72	Travel Centers of America Barstow	Electric Charging	Travel Centers of America	Public
73	Travel Centers of America Arvin	Electric Charging	Travel Centers of America	Public
74	Travel Centers of America Corning (B)	Electric Charging	Travel Centers of America	Public
75	Travel Centers of America Wheeler Ridge	Electric Charging	Travel Centers of America	Public
76	TA Santa Nella (B)	Electric Charging	Travel Centers of America	Public
77	Oxnard Harbor District - Port of Hueneme	Electric Charging and Hydrogen Fueling	Port of Hueneme	Public and Private

#	Project name	(Freight) project type	Project sponsor(s)	Public or private
78	Wireless Advanced Vehicle Electrification (various locations)	Electric Charging	WAVE	Public and Private
79	San Pedro Bay Ports Electric Charging	Electric Charging	Clean Energy California	Public

Appendix 3: SB 671 Workgroup Participants

Complete List of SB 671 Workgroup Participants

Academia

California State University, Long Beach
Rio Hondo College
Riverside University Health System
University of California, Davis
University of Southern California
Utah State University, ASPIRE

Advocacy

Coalition for Reimagined Mobility
Electrification Coalition
BizFed
CALSTART
California Council for Environmental and Economic Balance
California Hydrogen Business Council
California Electric Transportation Coalition
Coalition for Clean Air
Coalition for a Safe Environment
Columbia-Willamette Clean Cities Coalition
Communities for a Better Environment
California Hydrogen Coalition
The People's Collective for Environmental Justice
Placer County Tomorrow
Sierra Club California
West Coast Clean Transit Corridor Initiative

Association

American Trucking Associations
California Fuel Cell Partnership
California Trucking Association
Harbor Trucking Association
Hydrogen Fuel Cell Partnership
Los Angeles Cleantech Incubator
Northern California Power Agency
Otay Mesa Chamber of Commerce
Pacific Merchant Shipping Association
Truck and Engine Manufacturers Association
Western States Petroleum Association

Consulting

Actum (consultant to H2 Clipper)
Anrab Associates, Inc.
ArkSpring Consulting
Build Momentum
CEA Consulting
E Source
Emerson and Associates
Englander Knabe & Allen
Gladstein, Neandross & Associates
GLDPartners
HDR
Jacobs
Jove Hydrogen, KAMP Solutions
Peacock Piper Tong + Voss, LLP
Platinum Advisors
Policy in Motion
Ramboll Environ
Rebel Group
Smith, Watts & Hartmann
Starcrest Consulting Group, LLC
Tradesman Advisors

Electricity, Energy & Utilities

Blue Dot Energies
East Bay Community Energy
Forum Mobility
FreeWire Technologies
Northern California Power Agency
Pacific Gas and Electric Company
Sacramento Municipal Utility District
San Diego Gas and Electric
Southern California Gas Company
Southern California Edison
TeraWatt Infrastructure
Turlock Irrigation District
WattEV
WAVE Charging

Government / State or local agencies

Association of Monterey Bay Area Governments
California Air Resources Board
California Energy Commission

California Governor's Office of Business and Economic Development
California Highway Patrol
California Labor and Workforce Development Agency
California Public Utilities Commission
California State Senate Staff
California State Transportation Agency
Caltrans
City of San Diego
City of West Sacramento
County of San Diego (1st District) Staff
Fresno Council of Governments
Gateway Cities Council of Governments
Imperial County Transportation Commission
Kern Council of Governments
Lake Area Planning Council
Los Angeles County Metropolitan Transportation Authority
Metrolink
Metropolitan Transportation Commission
Orange County Transportation Authority
Placer County Transportation Planning Agency
Riverside County Transportation Commission
Sacramento Regional Transit District
San Diego Association of Governments
San Joaquin Council of Governments
Santa Barbara County Association of Governments
Santa Clara Valley Transportation Authority
Solano Transportation Authority
South Coast Air Quality Management District
Southern California Association of Governments
Tri-Valley - SJ Valley Regional Rail Authority US Army Corps of Engineers

Industry/Private sector

Air Products
Amazon
Apex Logistics, LLC
BNSF Railway
BP Pulse Fleet
Chicago Law Partners
Electric Power Research Institute
FedEx Corporation
FirstElement Fuel, Inc
FuturePorts
GTI Energy
International Warehouse Logistics Association
Maersk
Navistar, Inc.
Nikola Motor Company
Pacific Harbor Line
Penske Truck Leasing
Pilot Company
Prologis
The Home Depot
Tesla
Transfer Flow
TravelCenters of America
Trillium
Union Pacific Railroad
Volvo Group North America
Walmart
Watson Land Company
Weideman Group, Inc.

Ports

Port of Hueneme
Port of Oakland
Port of Long Beach
Port of Los Angeles
Port of Stockton

Appendix 4: Factsheets

Electricity:

How Electricity is Generated in California

California Transportation Commission

What is electricity?

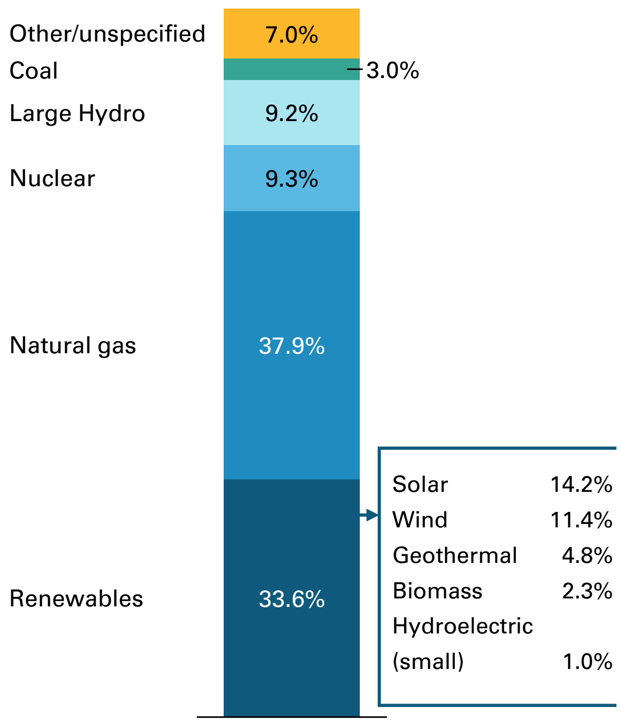
Electricity is one of the most widely used forms of energy; existing both as a basic part of nature and more formally as the flow of electrical power or charge.

The electricity that we use is a secondary energy source. Electricity is produced by converting primary sources of renewable and nonrenewable energy such as coal, natural gas, nuclear energy, solar energy, and wind energy, into electrical power. Electricity is also an energy carrier, meaning it can be converted to other forms of energy such as mechanical energy or heat.

In 2021, California's total electric system generation was 277,764 gigawatt-hours (GWh), making California the fourth-largest electricity producer in the nation and the nation's top producer of electricity from solar, geothermal, and biomass energy.

Sources of California electricity generation (total power mix), 2021

Total = 277,764 gigawatt-hours



Source: 2021 Total System Electric Generation, California Energy Commission – Total California Power Mix

How is electricity used in California?

Electricity usage has become common in our modern, everyday lives for lighting, heating, cooling, and refrigeration and for operating appliances, computers, electronics, machinery, and public transportation systems. Below is a breakout of where electricity is used the most:

46%
114,697 GWh
Commercial
(2022)

36%
90,415 GWh
Residential
(2022)

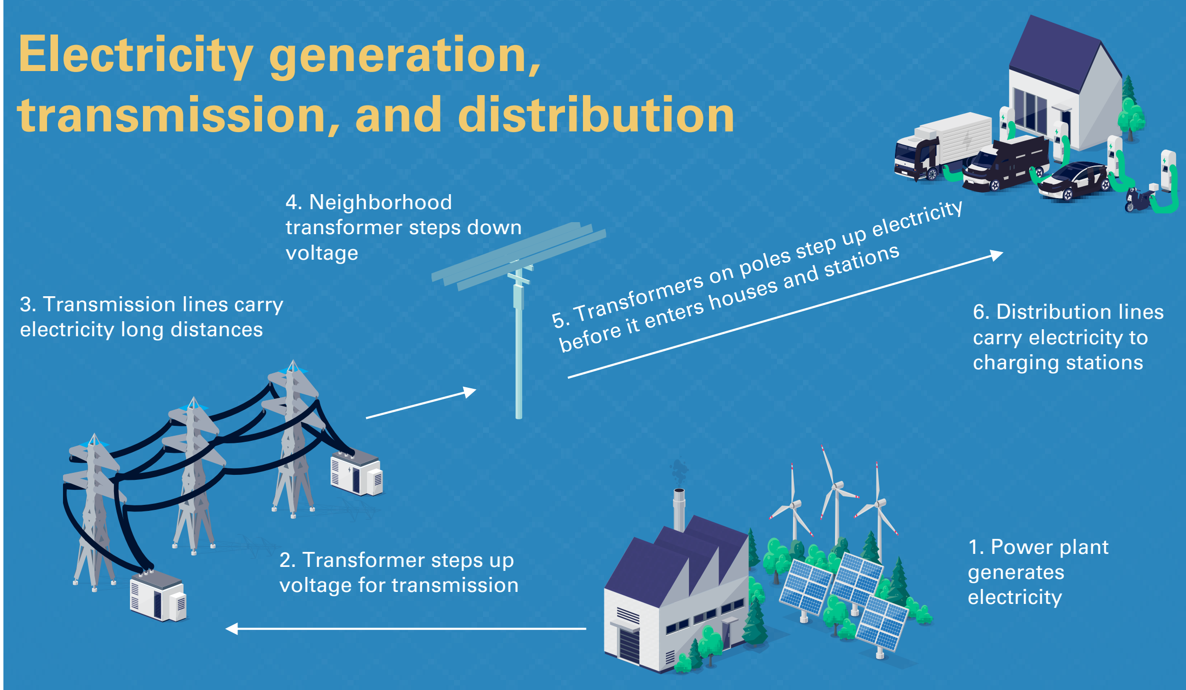
18%
46,148 GWh
Industrial
(2022)

0.3%
684 GWh
Transportation
(2022)

Source: U.S. Energy Information Administration, Region: California

How is electricity generated, transmitted, and distributed?

Electricity is generated at power plants and moves through a complex system, sometimes called "the grid". The electricity grid consists of hundreds of thousands of miles of high-voltage power lines and millions of miles of low-voltage power lines with distribution transformers. Transformers either condense electricity to be carried through long distance power lines or spread it out to be carried along local power lines. Power lines and transformers connect power plants to all customers across the state.



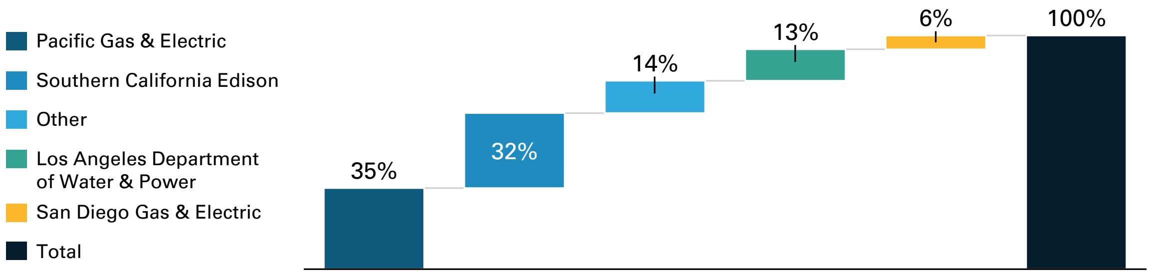
What is the landscape of electricity generation and transmission in CA?

The origin of the electricity that consumers purchase varies. Some electric utilities generate all the electricity they sell using just the power plants they own. Other utilities purchase electricity directly from other utilities, power marketers, and independent power producers or from a wholesale market organized by a regional transmission reliability organization.

Utility companies may be a not-for-profit municipal electric utility; an electric cooperative owned by its members; a private, for-profit electric utility owned by stockholders (often called an investor-owned utility); or a power marketer. **Local electric utilities operate the distribution system that connects consumers with the grid, regardless of the source of the electricity**. The major players in California are Pacific Gas & Electric, Southern California Edison and the Los Angeles Department of Water and Power.

Source: California Energy Commission, U.S. Energy Information Administration, California Energy Commission

Estimate of the electricity main utility companies provide for transportation, 2025 forecast

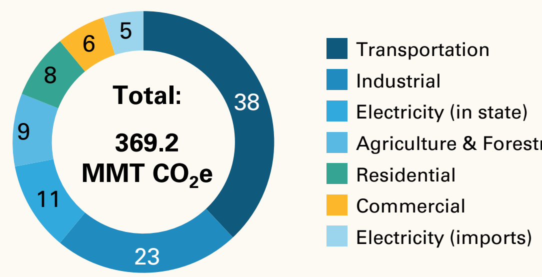


What are the current GHG emissions from CA transportation? What is the goal for reducing this?

Transportation is the largest contributor to green house gas (GHG) emissions in California, responsible for ~38% of emissions; heavy- and medium-duty trucks account for ~10% of total emissions themselves.

A goal in the California Air Resources Board's latest proposal is to reduce fossil fuel consumption to less than one-tenth of what we use today. The proposal could lead to a 71% reduction in smog-forming air pollution and save Californians $200 billion in health costs due to pollution by 2045.

Total CA Emissions (%)



Source: Release number 22-44, AB 32 Climate Change Scoping Plan, California Air Resources Board

How much electricity is needed on average at a truck charging station?

1 electric truck charging station **=**

~200-400 CA households

For comparison, CA currently has approximately

13.1 M households[2]

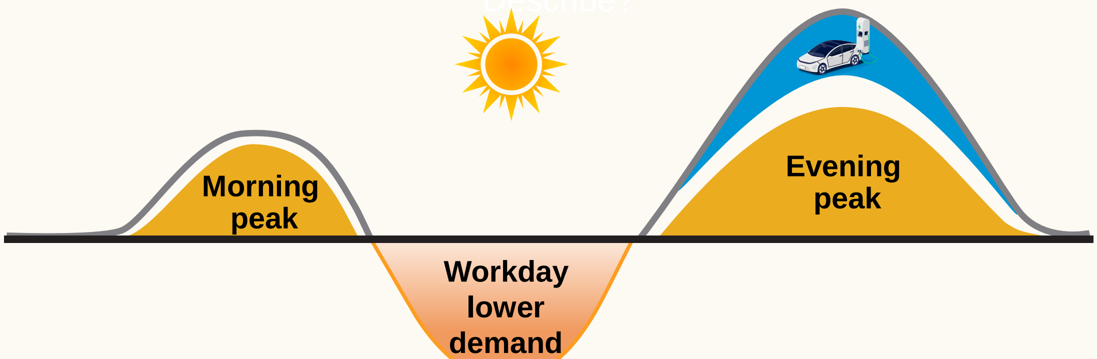
Approximately 200 to 400 households could be powered with same amount of electricity as an electric truck charging station in California. The electricity requirement per station is ~2 to 4.5 Million kilowatt-hours. Electricity consumption depends on the amount of time the chargers are in use (also called utilization). This was assumed to be between 10% and 20% - which gives us the range of electricity requirement. In 2021, the average annual electricity consumption for a U.S. residential utility customer was 10,632 kilowatt-hours (kWh)[1].

1. Source: U.S. Energy Information Administration
2. Source: U.S. Census Bureau

Note: A public truck charging station in this calculation comprises of 6 DC 350kW, 2 DC 500kW & 2 DC 100kW chargers and a private truck charging station / depot comprises of 4 DC 350kW, 2 DC 500kW, 8 DC 100kW and 6 DC 50kW chargers.

How could zero-emission vehicle (ZEV) adoption impact the grid?

The electrification of the transportation sector poses several challenges for the electricity sector in California. From an energy perspective, reaching the 2030 goal of 5 million electric vehicles could add an estimated 20-terawatt hours of annual electricity demand, an increase of about 10% of total electricity load in California. This increase comes amidst an overhaul of the state's electricity system as it strives to meet climate goals through regulation such as the Renewable Portfolio Standard (RPS), which requires a higher proportion of electricity generation from renewable energy sources (such as solar or wind). More energy demand requires more power generation, which may stress the capacity of the state's existing infrastructure, especially during high-use times (referred to as "peaks"). This additional demand may require significant upgrades throughout the energy system, though local distribution grids will likely require the most intervention (e.g., upgrading the capacity of local grids to handle longer and bigger peaks). However, new technologies could also help smooth demand over time, such as the strategic deployment of battery storage, the use of vehicle to grid supply, etc.



Source: Jenn A, Highleyman J. Distribution grid impacts of electric vehicles: A California case study. iScience. 2021 Dec 28;25(1):103686. doi: 10.1016/j.isci.2021.103686. PMID: 35036872; PMCID: PMC8749456, California ISO, Adapted from Duck curve published by Office of Energy Efficiency & Renewable Energy

What are microgrids and why are they important for ZEVs adoption?

Microgrids are grid systems consisting of small-scale generation and distribution networks, providing electricity to a limited number of customers. They can be powered by solar panels, diesel, hydro-electricity, or wind and battery storage. They can operate in isolation from national/state/regional electricity grids or connected to them. Microgrids can be used to supplement the existing grid capacity and to improve grid resiliency. When considering additional grid capacity to support ZEV infrastructure performance, total capacity needed, as well as cost and power generation source, should be evaluated. Microgrids can have the following examples of site-specific applications (non-exhaustive):

Source: Adapted from National Energy Education Development Project (public domain)

Key services offered by microgri

Backup Power/Resiliency

In the event of major storms, disasters, or public safety power shutoff (PSPS) events, mini-grids can continue to provide power to customers

Energy Optimization

Microgrids can help prevent the cost o electricity from getting too high durin peak pricing and provide frequency regulation and other ancillary services

Zero-Emission Vehicles:

Battery Electric Vehicles and Hydrogen Fuel Cell Electric Vehicles

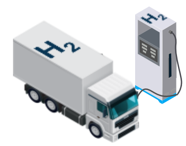
California Transportation Commission

A zero-emission vehicle (ZEV) is a vehicle that produces no criteria pollutant, toxic air contaminant, or greenhouse gas emissions when stationary or operating. ZEVs include battery-electric vehicles and hydrogen fuel-cell electric vehicles. This fact sheet and the Clean Freight Corridor Infrastructure assessment it accompanies focus on battery-electric vehicles and fuel-cell electric vehicles for freight hauling (movement of goods rather than people).

Battery electric vehicles (BEVs)

Battery electric vehicles (BEVs) have an electric motor instead of an internal combustion engine. A BEV does not contain the typical liquid fuel components, such as a fuel pump, fuel line, or fuel tank because it runs on electricity. BEVs use a large traction battery pack to power the electric motor and are charged by plugging into a wall outlet or charging equipment, sometimes called electric vehicle supply equipment (EVSE).

Fuel cell electric vehicles (FCEVs)



Fuel cell electric vehicles (FCEVs) use a fuel cell powered by hydrogen to produce electricity, rather than drawing electricity from a battery. The amount of energy stored onboard is determined by the size of the hydrogen fuel tank. Like battery-electric vehicles, fuel cell electric vehicles (FCEVs) use electricity to power an electric motor.

Overview of strengths of each type of ZEV with today's technology

Parameter	Battery electric vehicles (BEVs)	Fuel cell electric vehicles (FCEVs)
Emissions	Zero-emission	Zero-emission
Drive	Electric drive	Electric drive
Efficiency	Higher powertrain efficiency	More efficient than internal combustion engine vehicle
Range	Mileage Range is limited by battery size	Has a mileage range similar to diesel
Time to fuel	Charging times are longer (depending on charger type)	Fuels at the same rate as internal combustion engine vehicle
Infrastructure costs	Low initial infrastructure costs	High initial, low long-term infrastructure costs
Applicability	Best suited for shorter deliveries	Best suited for longer travel with heavier loads

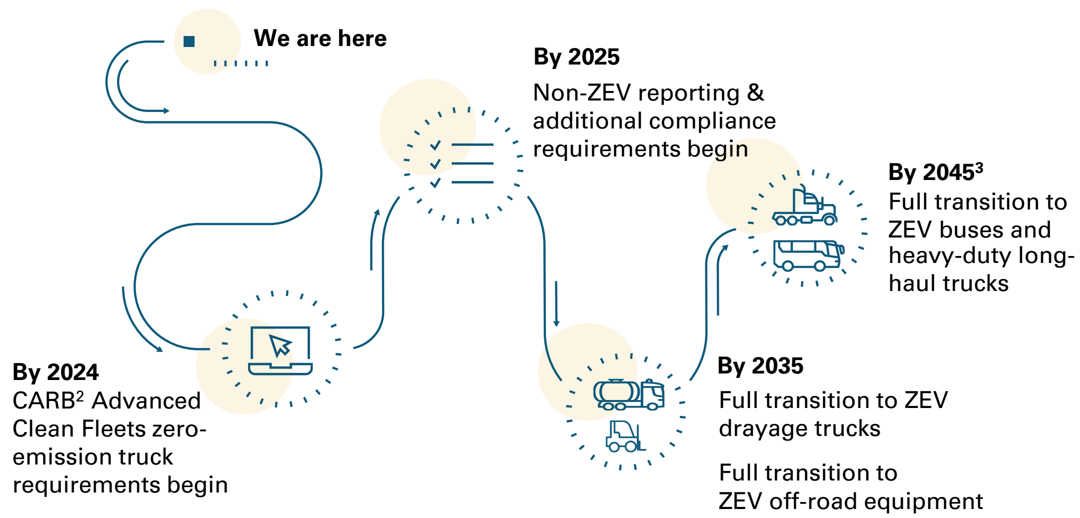
Source: Alternative Fuels Data Center, U.S Department of Energy, California Fuel Cell Partnership cafcp.org

Why do we need BEVs and FCEVs?

Transportation is the largest contributor of greenhouse gas (GHG) emissions in California. One of the goals in the latest California Air Resources Board (CARB) proposal is to achieve carbon neutrality by 2045 by reducing fossil fuel consumption (e.g., liquid petroleum) to less than one-tenth of what we use today – a 94% reduction in demand. This would require moving all types of vehicles, including public transit, passenger vehicles, and goods delivery/freight vehicles, to non-gas energy sources.

Zero-emission vehicles (ZEVs) could be a viable alternative to internal combustion engine trucks, as the technology has matured and total cost of ownership (TCO) parity could be achieved in the short–term. Supporting new ZEV[1] trucks, however, requires having viable charging and refueling infrastructure in place along California's people and goods movement corridors.

CARB Journey to full ZEV transition by 2045



What are the impacts/implications of moving from combustion engine trucks to BEV and FCEV trucks?

As fleets move increasingly to adopt zero-emission vehicles, the following impacts may be expected:

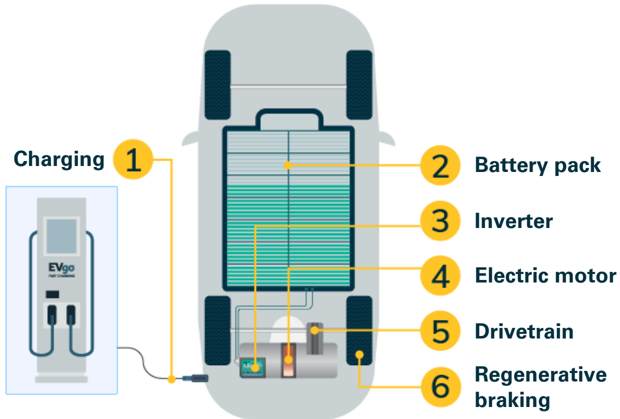
- **Infrastructure:** To support BEV and FCEV adoption, charging infrastructure, such as a network of refueling and recharging stations, can be further developed. A viable network could help to mitigate range constraints and enable faster ZEV adoption.
- **Grid:** Grid capacity expansion and/ or establishing microgrids could be needed to meet the rising electricity demand for electric vehicle charging and hydrogen production activities.
- **Road maintenance:** Zero-emission trucks are heavier and could lead to an increase in road and bridge wear and tear. Potential increases to vehicle weights could necessitate changes in the frequency and protocol of inspections and maintenance.

1. ZEV: Zero-emission vehicles, BEV: Battery electric vehicles, FCEV: Fuel-cell electric vehicle
2. CARB: California Air Resources Board
3. Where feasible

Source: California Air Resources Board, CTC working group

Battery electric vehicles (BEVs) charging

BEVs need to be recharged regularly, much like conventional vehicles need to be refueled. EV[1] charging is the process of using equipment to deliver electricity to the vehicle's battery, where electricity is stored (like a car's gas tank), to power its electric motor. The amount of time needed to charge depends primarily on the size of the charge, the size of the battery, and the state of the battery before charging (see an illustration of main components to the right). The higher the station's output or voltage rating, the faster the charging. Electric vehicle chargers are typically classified into four categories with varying voltage ratings: a Level 1 Charger uses 110/120 volts, a Level 2 charger uses 208/240 volts, a Level 3 charger uses 480 volts, and a DC fast charger uses between 200 and 600 volts.



Commercial BEVs can be charged at a privately owned power source, such as a facility's parking lot (commonly referred to as depot charging). They can also be charged at a public charging station. This usually involves charging a BEV in the middle of a vehicle's route using a DC fast charger, similar to refueling a diesel truck at a gas station located near a highway. The driver may also end the charging process before the battery is full. There are products available today that offer mobile charging options to fleets, such as wireless charging, grid-free charging using portable DC fast chargers, etc.

This chart shows common power ratings and average charge times for public EV infrastructure solutions. The difference in power ratings and charge times can be due to vehicle charging protocol (how the vehicle is designed to charge), the battery management system (BMS), environmental conditions, battery capacity (state of charge, overall kWh capacity), and charging hardware power rating. Level 1 charging is not included in this chart as its use is limited for most fleet, public and/or fee-based charging applications.

Public infrastructure needed for medium- and heavy-duty trucks in California

Public and fleet EV charging

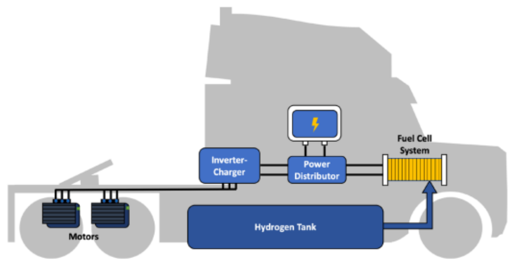
AC Level 2	Destination DC	DC Fast	DC High Power
6 to 19 kW	**20 to 100 kW**	**100 to 150 kW**	**150 to 600 kW+**
4 to 24 hours	**1 to 4 hours**	**15 to 60 mins**	**5 to 20 mins**
• Office, workplace • Multi-family residential • Hotel and hospitality • Overnight fleet • Supplement fast charging sites for PHEV[2] use	• Office, workplace • Retail and public commercial parking • Dealerships • Urban or overnight fleets • Sensitive power supply locations	• Retail, grocery and dining • Convenience fueling stations • Highway truck stops and travel plazas • Fleet depots	• Highway corridor travel • Metro 'charge and go' • Large commercial and private fleets • Bus, medium-, and heavy-duty vehicles

1. Electric vehicle
2. Plug-in Hybrid Electric Vehicles

Source: ZEV Truckstop, California Air Resources Board, EVgo, ABB e-mobility

Fuel cell electric vehicles (FCEVs) refueling

FCEVs are fueled with compressed hydrogen gas stored in a tank on the vehicle. The fuel cell doesn't burn the gas, but instead draws the hydrogen from the onboard tank and fuses it chemically with oxygen to make water. This process releases electricity that will continue to power the car's electric motor, with pure water as the only waste produced. Like conventional internal combustion engine vehicles, FCEVs can fuel in about 20 minutes and have expected ranges of up to 750 miles on a single "tank." Most hydrogen fueling stations are located at existing gas stations, using dispensers that look very similar to traditional gas pumps, but have a different nozzle and hose. Filling with hydrogen is fast, easy, and safe.



Medium- and heavy-duty FCEVs can be fueled by finding a public station that is accessible for larger vehicle types. Most hydrogen stations have two different refueling nozzles, one for 35 megapascal (MPa) fuel and another for 70 MPa fuel. While higher-pressure fuel provides greater vehicle range, there are fewer costs to deliver lower-pressure fuel.

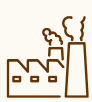
How is hydrogen produced?

Since hydrogen is always bonded to other elements, it must be separated and purified through a process in order to be used in a fuel cell. There are many options for this, as well as a wide variety of sources for hydrogen – many of which can be renewable and low- to zero-carbon.

In today's early market, hydrogen is supplied primarily by industrial gas companies that produce hydrogen from natural gas. Since fuel cells are more efficient than gasoline-powered engines, the overall greenhouse gas emissions from production are much lower (at least half) than using a conventional vehicle, despite the production source.

California is working to have a reliable hydrogen supply: California Senate Bill 1505 requires 33% of hydrogen used for vehicle fuel in California, in the aggregate, to be produced from renewable energy sources. Two common methods exist to produce hydrogen from renewable sources: (1) electrolyzing (splitting) water with renewable electricity and using renewable biogas as the primary feedstock for steam methane reformation or (2) stationary fuel cell hydrogen generation.

Higher carbon



Brown hydrogen
Hydrogen produced as a by-product of industrial processes

Grey hydrogen
Hydrogen produced using fossil fuels

Lower carbon

Blue hydrogen
Hydrogen produced using fossil fuels where CO_2 is captured

Zero-carbon

Green hydrogen
Hydrogen can be produced using electrolysis powered by renewable electricity (e.g., nuclear)

An interactive map of all ZEV refueling locations in the United States and Canada can be found here: https://afdc.energy.gov/fuels/electricity_locations.html#/find/nearest?fuel=ELEC

Source: Hydrogen Station Permitting Guidebook (Sep '20), California Governor's office of business and economic development, DriveClean ca.gov, California Clean vehicle rebate project

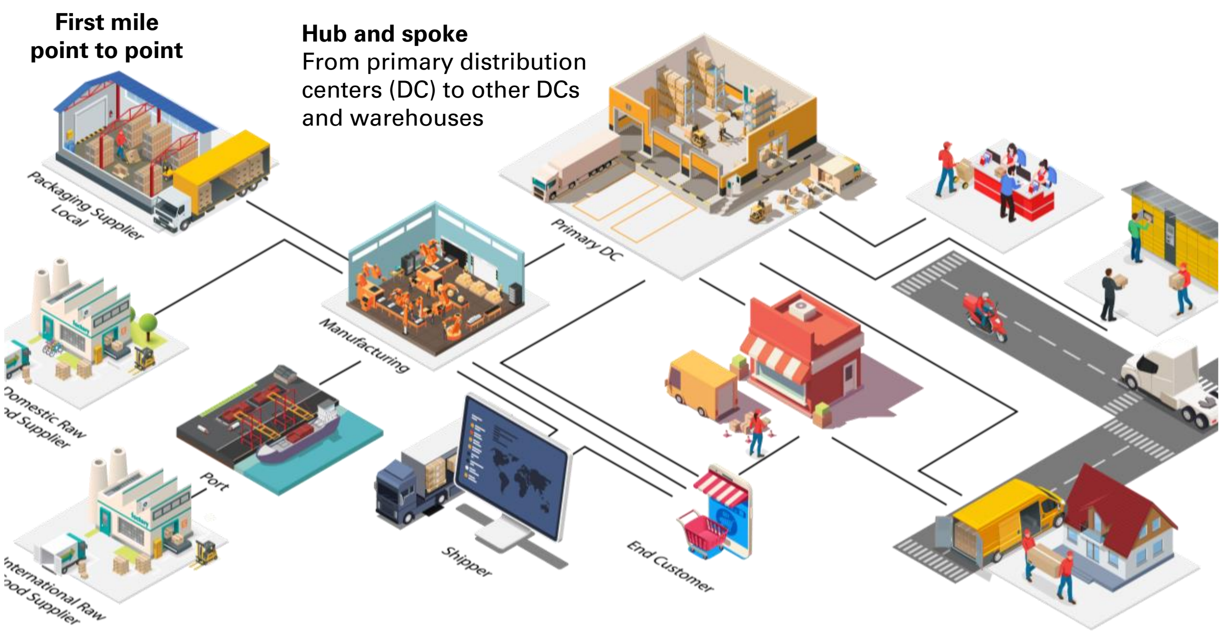
California Transportation Commission

How does freight work: California and its role in freight

What is freight?

Freight is the transportation of goods, commodities, and cargo by ship, aircraft, truck, or intermodal means (where more than one transportation mode - often via train and truck – is used). Freight can be transported domestically or internationally by land, air, or sea. Any shipment over 150 pounds is considered freight . Manufacturers buy raw materials and intermediate goods, process them in the production operation, and ship their products to customers. Domestic production and international trade are major drivers of freight transport and logistics demand. This fact sheet is focused on the transport of goods, commodities, and cargo via road (i.e., ground freight movement) and how truck fleets are involved in this process. Below is a graphic to illustrate how freight can reach consumers, using a manufacturing supply chain as an example.

Illustration of the freight value chain



First mile

Transportation of goods across the first leg of the supply chain could have different meanings for supply chains and industries (e.g., raw product to manufacturing site vs. product to retailer)

Hub and spoke model

Used to disperse inventory to multiple fulfillment centers from a large distribution center

Distribution loop / last mile

Transportation of goods from the nearest distribution hub to their final destination

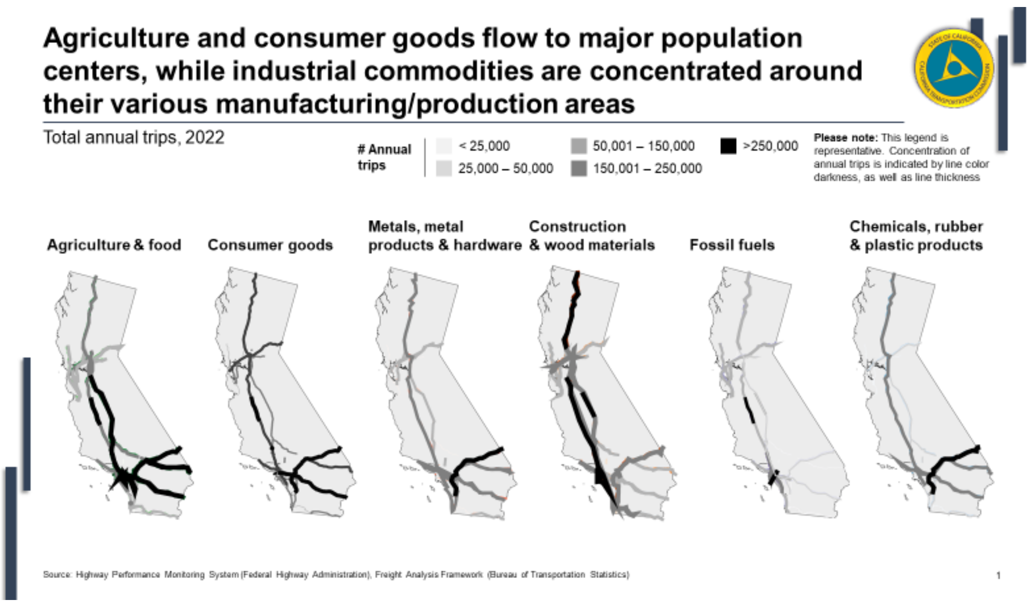
Source: Transportation Statistics Annual Report (TSAR), 2022, FedEx, CTC working group

What are California's key freight flows and how do they impact California's economy?

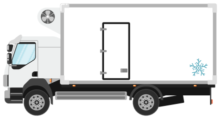
California is the nation's largest gateway for international trade and domestic commerce, with an estimated $2.8 trillion in freight flow value annually. CA has an extensive multi-modal freight system – spanning ports, roads, rail, and airports – that move millions of tons of cargo every day. While this cargo transportation system supports a vibrant economy, it is also is a source of pollution, generating poor air quality across the state.

Freight businesses may provide transportation services for cargo between retailers, wholesalers, factories, and more. Trucking plays a critical role to the California economy as the predominant mode of transportation for freight and goods. By weight, trucks transport the largest amount of goods into, within, and out of the state.

There are six broad categories of goods movement across California. Agricultural and consumer goods in California flow to major population centers, while industrial commodities are concentrated around various manufacturing hubs, production sites, and ports throughout the state.

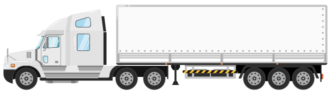


Trip length classification



Urban
Trips in and around cities and urban centers, usually for last mile delivery

Regional
Trips in between major cities and neighboring states, includes short-haul trips such as drayage



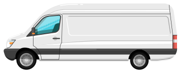
Long-haul
Trips much longer in length whether cross-country or several states away

Source: California Supply Chain Success Initiative Summary, California Air Resources Board, California Governor's Office of Business

What are the different types of trips? What are the types of vehicles currently used for moving freight?

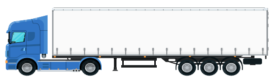
Truck types are determined using the Federal Highway Administration (FHWA) 13-bin vehicle classification system. generally, freight vehicles can be categorized into three major types: light-duty, medium-duty, and heavy-duty. The focus of this fact sheet and the broader SB 671 report is on medium-duty and heavy-duty trucks.

Truck type classification



Light-duty truck

Light-duty trucks are vehicles of Classes 1 – 3 (according to FHWA & CARB definitions), weighing <6-13k lbs.



Medium-duty truck

Medium-duty trucks are vehicles of Classes 4 – 6 (according to FHWA & CARB definitions), weighing 14 – 32k lbs.

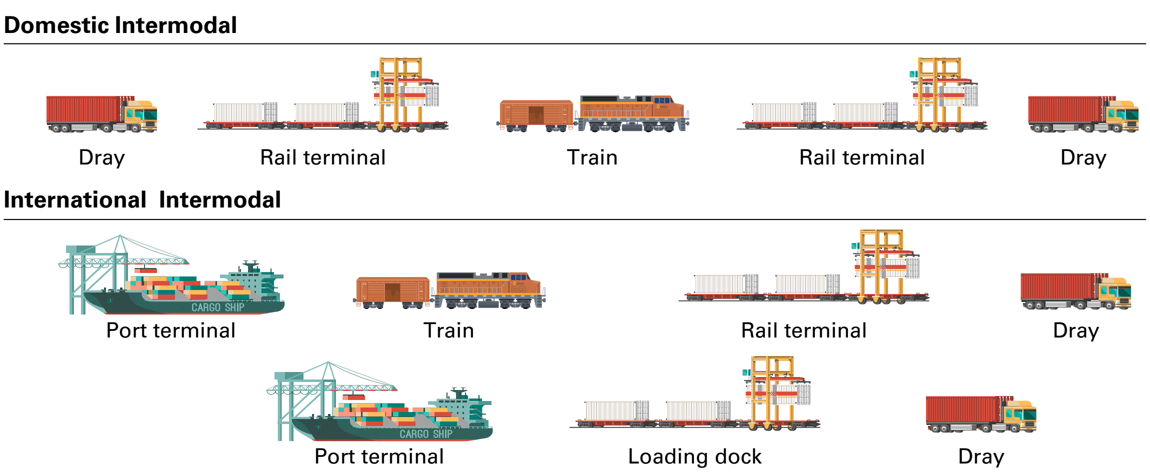
Heavy-duty truck

Heavy-duty trucks are vehicles of Classes 7 – 8 (according to FHWA & CARB definitions), weighing >33k lbs.

In general, medium-duty trucks are more frequently used for urban or delivery trips and heavy-duty trucks are used for drayage, regional, and long-haul trips.

What is drayage and what are the implications of transitioning to zero-emission trucks specific to the drayage industry?

Drayage is the short haul trucking that connects ports or inland intermodal terminals with a warehouse or distribution point. Generally, a dray (the road freight component) is part of an intermodal move or an import/export container. It is likely that zero-emission transition will happen in drayage first because of the short haul nature of this industry. California has a goal of transitioning to 100 percent zero-emission drayage trucks by 2035. The breakeven point of the zero-emission truck technology for drayage will happen before its long-haul counterpart. Drayage is critical in California, due to the volume of freight moved through the San Pedro Bay and the prevalence of intermodal trips for West Coast goods. Three key considerations for transitioning drayage fleets to zero-emission vehicles are the availability of trucks for purchase, the upfront capex needed by the fleet owners to make the transition, and reliable and available fueling and charging infrastructure with limited impact on freight operations.



Source: WEF report - Road Freight Zero: Pathways to faster adoption of zero-emission trucks

Who are fleet owners / operators? What are their current business models? How do freight businesses operate?

There are three key entities involved in freight movement: shippers, carriers/owner/operators and brokerage firms. Shippers are entities from which freight typically originates; they are generally producers or sellers of goods and services. Carriers/owner/operator are companies or individual truck owners who offer transportation services to shippers. Brokerage firms arrange transportation contracts between shippers and carriers/owner/operators. There are three levels of logistics companies relating to the party at which they operate: First-Party Logistics (1PL), Second-Party Logistics (2PL), and Third-Party Logistics (3PL).

1PL
- Shipper's own fleet carries products
- It is seen as a "cost of doing business" – these fleets do not generate revenue from transportation, but are a cost of bringing goods or services to market

2PL
- A shipper contracts a carrier or individual owner/operator to move products, but the shipper keeps logistics in-house
- The carrier or operator generates revenue from the transportation service rendered – they are paid for time and payload (weight) carried

3PL
- A shipper contracts with a 3PL provider to ship products and perform some or all logistics-related tasks
- The 3PL acts as a liaison for the shipper, and books cargo through the carriers/2PLs on the shipper's behalf
- A 3PL generates revenue based on a margin they charge on the underlying transportation cost/mechanics

What are the implications for fleet owners / operators transitioning to zero-emission trucks for the industry?

Infrastructure needs: Zero-emission (ZE) trucks will require new infrastructure in the forms of charging or hydrogen fueling stations. In some cases, charging and fueling operations can take place in depots using infrastructure built specifically for the fleet owner/operator. However, to increase route flexibility and to serve the full set of potential freight use cases, availability of public, on-the-go infrastructure throughout the entirety of key freight journeys is critical.

Large upfront capex cost and residual value: While zero-emission (ZE) trucks will eventually offset higher upfront capital expenses with lower operating expenses, during the transition period, fleets face the issue of expanding upfront capital spending for new vehicles and installing new depot infrastructure, plus the higher everyday operating expenses of running mixed fleets. Leasing and financing models remain uncertain due to the unclear resale values for ZE trucks

Changes in operations: Zero-emission (ZE) trucks are heavier than combustion engine trucks and this could result in potential payload loss, especially for heavy-duty ZEV on long-haul trips. Fueling and recharging time for battery electric trucks are expected to be longer than that of combustion engine trucks and could impact labor costs and speed of delivery.

Source: WEF report - Road Freight Zero: Pathways to faster adoption of zero-emission trucks, CTC working group

The business objective of fleet owners and operators is to maximize their margins by minimizing the cost and maximizing revenue. Fleet costs comprise of two major components – capex (capital expenses) and opex (operating expenses).

Capital expenses

Fixed costs such as vehicle costs, depot infrastructure, etc.

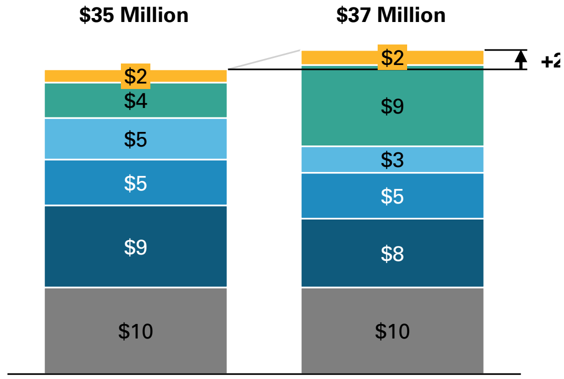
Operating expenses

Variable costs such as fuel, maintenance and repair, driver and other labor costs, etc.

Illustrative annual cost of truck fleets as of 2022
$ Millions

The graph depicts a comparison in overall cost (total cost of ownership) when comparing a traditional internal combustion engine truck with a fuel cell electric truck

- Other
- Operating margin
- Vehicle cost
- Fuel cost
- Maintenance
- Driver cost



Transitioning to zero-emission trucks

Many entities will be involved in transitioning from internal combustion engine vehicles to zero emission fleets. To the right is a description of the main players that could be involved in this work

Fleet operators | Financial institutions | Truck makers | Energy and infrastructure players | Government

In addition, several other entities will also have roles to play in the transition, from trailer manufacturers to telematics companies and beyond

What are the implications of intrastate vs. interstate traffic?

The main difference between the intra- and interstate traffic is the involvement of different regulators. The Federal government regulates interstate traffic. Companies that operate commercial vehicles transporting passengers or hauling cargo in interstate commerce must be registered with the Federal Motor Carrier Safety Administration (FMCSA) and must have a United States Department of Transportation (USDOT) number. A commercial vehicle operated only within the state of California must obtain a Motor Carrier Permit, a CA number and, as of September 2016, a U.S. Department of Transportation (DOT) number as well. Some out-of-state carriers must obtain a Motor Carrier Permit and a CA number in addition to the U.S. DOT number to come into California.

Source: WEF report - Road Freight Zero: Pathways to faster adoption of zero-emission trucks, Caltrans, CTC working Group