Zero-Emission Vehicles and Infrastructure

In his 2015 inaugural speech, Governor Edmund G. Brown Jr. put forward a goal to reduce today's petroleum use in cars and trucks by up to 50 percent by 2030. This was part of his strategy to reduce greenhouse gas (GHG) emissions 40 percent below 1990 levels by 2030 as directed in Executive Order B-30-15. On September 8, 2016, Governor Brown signed Senate Bill 32 (Pavley, Chapter 249, Statutes of 2016), putting into law a statewide goal to reduce GHG emissions 40 percent below 1990 levels by 2030. With transportation accounting for about 37 percent of California’s GHG emissions in 2014,1 transforming California's transportation system away from gasoline to zero-emission vehicles is fundamental to the state’s efforts to reduce GHG emissions.

On March 23, 2012, Governor Brown issued Executive Order B-16-2012 to encourage ZEVs in California and set a long-term goal of reaching 1.5 million ZEVs on California's roadways by 2025. The executive order established milestones for three periods:

- By 2015, California’s major metropolitan areas will be able to accommodate ZEVs through infrastructure plans.
- By 2020, California’s ZEV infrastructure will be able to support up to 1 million vehicles.
- By 2025, 1.5 million ZEVs will be on California’s roadways with easy access to infrastructure.

Continuing Advancement

Zero-emission vehicles (ZEVs) – plug-in electric vehicles (PEVs)2 and fuel cell electric vehicles (FCEVs) – continue to need investments in “front-loading” the charging and refueling infrastructure to support new vehicle rollouts, technological advancements in battery capacity and vehicle range, increased power capacities of fast chargers, and advancements in producing and dispensing hydrogen fuel. In addition to Executive Order B-16-2012, the following provide guidance to the Energy Commission and collaborative statewide efforts in the advancement of ZEVs and supporting infrastructure:

- Governor's 2016 ZEV Action Plan3

Released to the public in mid-October 2016, the updated 2016 ZEV Action Plan outlines progress to date and identifies new actions state agencies will take in continued pursuit of the milestones in the Governor’s executive order.

This 2016 ZEV Action Plan highlights the following priorities for ZEVs:

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2 Includes battery electric vehicles (BEVs) and plug-in hybrid electric (PHEVs).
California Energy Commission – Tracking Progress

- Raising consumer awareness and education about ZEVs
- Ensuring ZEVs are accessible to a broad range of Californians
- Making ZEV technologies commercially viable in targeted applications the medium-duty, heavy-duty, and freight sectors
- Aiding ZEV market growth beyond California

The 2016 ZEV Action Plan introduces new actions to meet these priorities and build California’s ZEV market, remove barriers to future market growth, and ensure this transition benefits the state and its residents. The intent is to clearly communicate what state government will do to advance ZEVs and serve as a “to-do” list for the Governor’s Office and state agencies to enhance interagency coordination. The Energy Commission has been tasked in various lead and supporting roles within the 2016 ZEV Action Plan. For public tracking, staff is developing an informational dashboard Web page for the Energy Commission’s activities on the action plan.

- California Sustainable Freight Action Plan

Governor Brown’s Executive Order B-32-15 directed the Secretary of California State Transportation Agency (CALSTA), Secretary of the California Environmental Protection Agency (CalEPA), and the Secretary of the Natural Resources Agency to lead other relevant state departments in developing an integrated action plan by July 2016 that “establishes clear targets to improve freight efficiency, transition to zero-emission technologies, and increase competitiveness of California’s freight system.” The participating state departments are the California Air Resources Board (CARB), California Department of Transportation (Caltrans), Energy Commission, and the Governor’s Office of Business and Economic Development (GO-Biz).

This action plan will serve to coordinate state agency priorities and timing on actions to influence freight transportation and energy infrastructure, vehicle and equipment technologies, and facility and operations efficiency, rather than the traditional and separate planning efforts for transportation, environment, and energy. The action plan includes recommendations on:

- A long-term 2050 vision and guiding principles for California’s future freight transport system.
- Targets for 2030 to guide the state toward meeting the vision.
- Opportunities to leverage state freight transport system investments.
- Actions to initiate over the next five years to advance toward the targets and the vision.

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- Pilot projects to achieve on-the-ground progress in the near term.
- Additional concepts for further exploration and development, if viable.

- Senate Bill 350 (De León, Chapter 547, Statutes of 2015) – Clean Energy and Pollution Reduction Act

SB 350 increases California’s renewable electricity procurement goal from 33 percent by 2020 to 50 percent by 2030. Further, SB 350 requires a doubling of statewide energy efficiency savings in electricity and natural gas end uses by 2030. To help ensure these goals are met and the GHG emission reductions are realized, specified load-serving entities are required to develop integrated resource plans (IRPs). These IRPs will detail how each entity will meet their customers resource needs, reduce GHG emissions, and ramp up the deployment of clean energy resources.

SB 350 requires California’s publicly owned utilities (POUs) with annual electricity demand exceeding 700 gigawatt-hours to develop and adopt IRPs by January 1, 2019. The IRPs must discuss how each POU plans to meet GHG reduction targets established by the ARB and identify procurement plans of at least 50 percent renewable energy resources by 2030. SB 350 requires that the POU IRPs also address their procurement plans for electrification of the transportation sector within their service territory. The IRPs must be submitted to the Energy Commission to review for consistency with the legislative requirements. To expedite review of the IRPs, SB 350 authorizes the Energy Commission to adopt guidelines that will provide a framework for the information and data to be submitted by POUs.

- Volkswagen Settlement – California ZEV Investments

Appendix C of the consent decree (the ZEV Investment Commitment) requires VW to invest $800 million in ZEV projects in California over a 10-year period. Eligible projects include installing ZEV fueling infrastructure (for both electric- and hydrogen-powered cars), funding brand-neutral consumer awareness campaigns that will help grow the ZEV vehicle market, and investing in projects such as car-sharing programs that will increase access to ZEVs for all consumers in California, including those in lower-income and disadvantaged communities. These projects will support the next generation of California ZEVs, helping grow the state’s burgeoning ZEV program and laying the foundation for achieving the state’s air quality and climate change goals.

- ARB’s Midterm Review of the Advanced Clean Cars Program

In 2012, the CARB adopted the Advanced Clean Cars (ACC) program, a comprehensive set of standards for new vehicles in California through model year 2025. The

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components of the ACC program are the Low-Emission Vehicle III (LEV III) regulations that reduce criteria pollutants and GHG emissions from light- and medium-duty vehicles for model years 2015 through 2025 and the ZEV regulation, which acts as the focused technology-forcing piece of the ACC program by requiring manufacturers to produce increasing numbers of ZEVs (battery-electric including plug-in hybrids [PHEVs] and fuel cell electric vehicles) in the 2018 through 2025 model years.

A significant part of CARB’s January 2017 Midterm Review focused on progress in technology since the original analysis and adoption of the standards in 2012. Advancements have already occurred in the vehicle and engine technologies being introduced by vehicle manufacturers to reduce GHG and criteria pollutant emissions, including particulate matter. ZEV technology has also seen significant development that, in many cases, is beyond what was envisioned just four years ago.

Below are highlights in ZEV advancements:

- Through May 2017, nearly 300,000 ZEVs and PHEVs have been sold in California. This contributes toward the more than 600,000 ZEVs and PHEVs in the United States and the expected 2 million ZEVs and PHEVs around the world by year’s end.

- Battery technology has improved, and battery costs (as well as other component costs) have fallen dramatically (largely due to reduced material costs, manufacturing improvements, and higher manufacturing volumes), leading to an increase from 25 PHEV and BEV models offered today to manufacturer announcements of more than 70 models to be released over the next five model years.

- ZEV electric infrastructure in California has grown with substantial investments in the past several years, and accelerated investments are expected as new infrastructure developments emerge. More than 10,000 Level 2 \(^7\) and 1,500 direct current fast charger (DCFC) connectors have been deployed across California.

- California’s current programs enabled by important legislation (most prominently Assembly Bill 8 [Perea, Chapter 401, Statutes of 2013]) are launching the first major FCEV market and hydrogen fueling network in the United States. Three FCEVs are for sale in California, while 28 retail hydrogen refueling stations are open in California with an additional 32 stations proposed or already in development. Toyota and Honda have also announced partnerships with private companies for financial support of additional stations in California and the Northeast.

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\(^7\) Level 2 chargers use 208/240 volts, up to 19.2 kW (80 amps), whereas Level 1 chargers use 110/120 volts, 1.4 to 1.9 kW (12 to 16 amps).
The aforementioned provided additional strategic framework for the Energy Commission’s Alternative and Renewable Fuels and Vehicle Technology Program investments.

**Alternative and Renewable Fuel and Vehicle Technology Program (ARFVTP)**
The California Legislature passed Assembly Bill 118 (Núñez, Chapter 750, Statutes of 2007) that created the ARFVTP, administered by the Energy Commission. With funds collected from vehicle and vessel registration, vehicle identification plates, and smog-abatement fees, the ARFVTP provides up to $100 million per year for projects that will "transform California’s fuel and vehicle types to help attain the state’s climate change policies." The statute also calls for the Energy Commission to “develop and deploy technology and alternative and renewable fuels in the marketplace, without adopting any one preferred fuel or technology.” Assembly Bill 8 (Perea, Chapter 401, Statutes of 2013) subsequently extended the collection of fees that support the ARFVTP through January 1, 2024.

As part of the ARFVTP, the Energy Commission prepares and adopts an annual investment plan update that identifies the funding priorities for the coming fiscal year.

Cumulative program allocations for ZEVs as of June 2017 include:

- $80.1 million for electric vehicle (EV) charging infrastructure, which consists of:
  - $6 million for single-family residential and private fleets.
  - $31 million for corridor installations.
  - $16 million for commercial installations.
  - $8.2 million for data collection of deployed infrastructure and vehicle usage.
  - $15.2 million for pending award to provide EV incentives.
  - $3.7 million for multiunit and workplace installations.

- $105.3 million for 60 retail hydrogen refueling stations and $12.8 million for ongoing operation and maintenance of 45 hydrogen refueling stations until adequate FCEVs are brought to market by automakers to support the stations.

- $10.0 million to support hydrogen refueling for public infrastructure, including testing and temporary refueling.

- $7.0 million to California Department of Food and Agriculture/Division of Measurement Standards (CDFA/DMS) for the development of hydrogen purity and dispensing standards for hydrogen and electricity. Also, $500,000 was provided to CDFA/DMS to operate the United States Department of Energy (U.S. DOE) Hydrogen Station Equipment Performance (HyStEP) device.

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• $2.0 million loan loss reserve program with California Pollution Control Financing Authority for EV charger installation loans.

• $129.4 million to help California companies demonstrate zero-emission medium- and heavy-duty advanced technologies for trucks, buses, and freight movement. These projects, which are located in and provide benefits to disadvantaged communities, are critical to bring these technologies to market.

• $46.5 million in funding for start-ups and small manufacturers of advanced technology vehicles, components, and batteries to expand their plants and assembly lines.

• $9.75 million for ZEV regional readiness planning.

• $49.0 million to the CARB to support the Clean Vehicle Rebate Project.

**ZEV Infrastructure**

ZEVs, like any new consumer technology, require time for public understanding, acceptance, and broad adoption. As a start, more drivers need to know that ZEVs are an attractive and increasingly cost-effective option for their vehicle needs. Also, research demonstrates that peer-to-peer recommendations and direct experience driving or riding in the vehicles continue to be important for consumers who are considering switching to ZEVs. To help ZEV drivers locate charging and refueling stations, the Energy Commission accesses the U.S. DOE’s Alternative Fuels Data Center\(^9\) to provide current information and data of the availability and location of EV chargers that have been installed by other public and private entities. This information is combined with data on charger installations provided by Energy Commission grants to allow staff to analyze potential siting needs.

**PEV Charging Infrastructure**

Since the first ARFVTP EV-related awards for electric bus and light-duty vehicle development and demonstration in 2009, the program has awarded nearly $80.1 million ($13.0 million in 2016) for almost 9,000 charging outlets at public and private sites. To date, ARFVTP funds have provided 38.8 percent of statewide total public charging sites and 37.9 percent of charging outlets – specifically, 1,418 publicly accessible sites (includes planned sites) with 4,635 public charging outlets (includes planned outlets).

• About 13 percent of funding was spent in disadvantaged communities, which exceeds Senate Bill 535 (De León, Chapter 830, Statutes of 2012) requirements that at least 10 percent of the proceeds from the Greenhouse Gas Reduction Fund must be for projects within disadvantaged communities.

• **Figure 1** illustrates charging outlets, by type, funded by ARFVTP. The numbers used to construct the figure are listed in **Table 1**.

\(^9\) [http://www.afdc.energy.gov](http://www.afdc.energy.gov)
Table 1: Charging Outlets Funded by ARFVTP as of March 2017

<table>
<thead>
<tr>
<th></th>
<th>Private Installations</th>
<th>Publicly Accessible Installations</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Single-Family Residential</td>
<td>Private Fleet</td>
<td>Multiunit Dwelling</td>
</tr>
<tr>
<td>Installed</td>
<td>3,936</td>
<td>107</td>
<td>327</td>
</tr>
<tr>
<td>Planned (under construction)</td>
<td>0</td>
<td>0</td>
<td>18</td>
</tr>
<tr>
<td>Subtotal</td>
<td>3,936</td>
<td>107</td>
<td>345</td>
</tr>
<tr>
<td>Private/Public Subtotal</td>
<td>4,043</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Energy Commission staff

While the ARFVTP originally funded charging infrastructure at single family sites and non-publicly accessible private fleets (as shown in Figure 1), the program has shifted to fund publicly accessible chargers strategically located to support multi-unit and single family residences that do not have garages, dedicated parking, or utility service to support charging on site.

Direct Current Fast Charging (DCFC) Corridor Chargers

In October 2013, the governments of California, Washington, Oregon, and British Columbia signed an agreement called the “Pacific Coast Action Plan on Climate and Energy” that includes a commitment to transition the West Coast to clean modes of transportation. One action is to expand the use of BEVs. In support, the states of Washington and Oregon installed the Pacific
Northwest portion of the West Coast Electric Highway, currently a network of DCFC stations located every 25 to 50 miles along Interstate 5 and other major roadways in the Pacific Northwest.

DCFCs can support charging at much higher rates than Level 2 charging. DCFCs located along major interregional corridors can enable long-distance travel by BEVs, provide a quicker alternative to charging at destinations or at home, and serve the needs of drivers without access to charging at home, such as those living in multiunit housing.

California is completing DCFC on highway corridors. The first grant funding opportunity (GFO) 15-601 for corridor charging was released in July 2015 for projects to install DCFC on Interstate 5 and Highway 99 from the Oregon border to Oceanside, as well as U.S. Highway 101 between San Jose and Buellton. Nine projects were funded for $8.9 million in April 2016 that added 61 DCFC and 42 Level 2 charging stations at 41 sites (represented by the green dots in Figure 2).

The most recently completed PEV charging infrastructure solicitation, GFO-15-603 (January 2016), built upon the previous DCFC deployment efforts of GFO-15-601 and sought to deploy DCFC along specific corridors on state and interstate highways in California. Twenty-one projects were funded for $13.9 million. These awards will add 130 DCFC and 81 Level 2 charging stations at 79 sites (represented by the blue dots in Figure 2).

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10 "West Coast Electric Highway" is a trademarked name under the jurisdiction of the Washington Department of Transportation and has specific requirements for its adoption and use.
Figure 2: GFO-15-601 and GFO-15-603 DC Fast Charging Corridors

Other DCFC sites include existing sites, planned sites that were not part of GFO-15-601 and GFO-15-603, planned public sites listed on the US DOE’s Alternative Fuels Data Center, and other known planned public sites not funded by the Energy Commission.
Next-generation BEVs with higher-capacity batteries will require higher-powered DCFCs than current-generation BEVs. The Energy Commission is considering how best to apply ARFVTP funding to meet the anticipated infrastructure needs of future PEVs.

There is no universal standard for the DCFC connectors. Those connectors fall into three categories, SAE CCS\textsuperscript{11}, CHAdeMO\textsuperscript{12}, and Tesla superchargers. Figure 3 shows existing and planned DCFC sites in California that have both CHAdeMO and SAE CCS Combo charging standards available. The red dots represent existing and planned sites with both standards, and the blue dots represent Energy Commission-planned sites. (DCFCs with only one standard – CHAdeMO or SAE CCS Combo – are not shown). The 15-mile radius of the purple shaded circle indicates the charging safety net available for vehicles with DCFC capability using either charging standard. The map indicates distances on the highway corridor that provide no more than 30 miles to the next DCFC and where gaps may still exist greater than 30 miles. (Where purple circles touch or overlap, the distance would be less than 30 miles.)

\textbf{Figure 3: DCFC Corridor Network}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{dcfc_map.png}
\caption{DCFC Corridor Network}
\end{figure}

\textsuperscript{11} Society of Automotive Engineers Combined Charging System.

\textsuperscript{12} CHAdeMO is a trade name of a quick charging method for PEVs. It is an abbreviation of “CHArge de Move”, equivalent to “charge for moving.”
Filling in Charging Infrastructure Gaps Using Block Grants, Regional Modeling, and Data Collection

To provide more focused PEV infrastructure projects that will target more specific projects and gaps in charging availability, ARFVTP awarded funding to a not-for-profit block grant recipient. The block grant recipient will be responsible for identifying charger incentive opportunities and implementing those incentive projects with grant funding for various PEV charger incentive projects throughout California, developing simple and user-friendly application documents for each EV charger incentive project, and developing an outreach and advertisement plan for each approved EV charger incentive project, including appropriate outreach materials to reach targeted markets and areas.

The Energy Commission staff will conduct modeling (EVI-Pro\textsuperscript{13}) and analysis to help the block grant recipient identify charger incentive projects based on geographical regions (counties and intercounty). Staff is also collecting usage data on existing chargers to determine locational requirements (for example destination, workplace, corridors, sites that can serve multiple users including different types of non-single-family residences, and so forth).

Hydrogen Refueling Station Infrastructure

In comparison to plug-in electric vehicles (battery-electric and plug-in hybrid electric vehicles) that use all battery-electric power or battery-electric power with a small gasoline engine, FCEVs use an electric motor and an electric drivetrain and are powered by the energy available in hydrogen stored as pressurized hydrogen gas in onboard tanks. The hydrogen gas is mixed with oxygen in a fuel cell, causing an electrochemical reaction and generating electric current, heat, and water. The system produces electricity, which drives the electric motor; the tailpipe emissions are water vapor.

The progression in the development of hydrogen refueling station infrastructure is shown in Figure 4. As of July 5, 2017, there are 28 open-retail hydrogen refueling stations in California capable of supporting up to 7,450 FCEVs.

\textsuperscript{13} EVI-Pro model analyzes regional demand by assessing existing vehicular travel, imposing electric vehicle charging infrastructure analysis at more localized levels based on different types of EVs and ranges, and incorporating interregional travel to try to answer questions of what types and how much of each type of chargers are needed to support electric vehicles on California's roads in future years. Assessment considers demographics of California's market and economic signals rather than early adopters.
In California, the automakers' FCEV deployment is expected to closely follow the number of hydrogen refueling stations constructed in identified core market areas. The ARFVTP has invested $105.3 million to date for hydrogen station construction. This includes $33.4 million for 16 new hydrogen refueling stations announced with the Energy Commission’s Notice of Proposed Awards for GFO-15-605 in March 2017.

The Energy Commission has funded 60 stations (Figure 5) with a daily refueling capacity of 13,460 kilograms (kg)/day, enough to support 19,230 FCEVs. As of October 2016, 925 FCEVs were registered with the Department of Motor Vehicles (DMV). The CARB’s 2016 Annual Evaluation of Hydrogen FCEV Deployment and Hydrogen Fuel Station Network Development projects 13,500 FCEVs by 2019 and 43,600 by 2022.

14 The Energy Commission funded an additional 4 stations that are not included in the total because the stations were cancelled and the funds liquidated prior to station completion.
To ensure the coverage and capacity of the state-funded hydrogen refueling station network effectively meet the anticipated demand from FCEV drivers, the Energy Commission works closely with the CARB to analyze and model the appropriate location and size of stations. CARB’s California Hydrogen Infrastructure Tool (CHIT) was incorporated into the assessment of proposed station locations in the latest hydrogen refueling station grant solicitation, GFO-15-605. **Table 2** lists the counties covered by funded stations and includes the number of FCEVs projected to need access to a hydrogen station.
Table 2: Hydrogen Station Distribution

<table>
<thead>
<tr>
<th>Counties</th>
<th>Cities</th>
<th>Existing &amp; Planned Dispensing Capacity kg/day</th>
<th>Number of Expected FCEVs by 2022 (per CARB AB8 Report)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alameda</td>
<td>Fremont, Hayward, Emeryville, Oakland, Berkeley</td>
<td>1,380</td>
<td>2,812</td>
</tr>
<tr>
<td>Contra Costa</td>
<td>San Ramon, Walnut Creek</td>
<td>710</td>
<td>1,265</td>
</tr>
<tr>
<td>Los Angeles</td>
<td>Burbank, Los Angeles, Torrance, North Hollywood, South Pasadena, La Cañada-Flintridge, Long Beach, Woodland Hills, Rancho Palos Verdes, Santa Clarita, Lawndale, Santa Monica, Diamond Bar, Sherman Oaks</td>
<td>3,570</td>
<td>15,401</td>
</tr>
<tr>
<td>Orange</td>
<td>Irvine, San Juan Capistrano, Anaheim, Costa Mesa, Lake Forest, Orange, Huntington Beach</td>
<td>1,740</td>
<td>4,750</td>
</tr>
<tr>
<td>San Bernardino</td>
<td>Ontario</td>
<td>100</td>
<td>982</td>
</tr>
<tr>
<td>San Francisco</td>
<td>San Francisco</td>
<td>1,080</td>
<td>4,238</td>
</tr>
<tr>
<td>San Diego</td>
<td>San Diego,</td>
<td>490</td>
<td>3,833</td>
</tr>
<tr>
<td>San Mateo</td>
<td>South San Francisco, Woodside</td>
<td>320</td>
<td>1,383</td>
</tr>
<tr>
<td>Santa Clara</td>
<td>Palo Alto, Campbell, Saratoga, San Jose, Mountain View, Sunnyvale</td>
<td>1690</td>
<td>4,355</td>
</tr>
<tr>
<td>Fresno, Marin, Nevada, Merced, Riverside, Sacramento, Santa Barbara, Sonoma, Ventura, Yolo</td>
<td>Rohnert Park, Thousand Oaks, Truckee, Mill Valley, Santa Barbara, Riverside, Coalinga, West Sacramento, Citrus Heights, Sacramento, Santa Nella</td>
<td>2,380</td>
<td>3,397</td>
</tr>
</tbody>
</table>

Source: Energy Commission staff
Hydrogen refueling stations funded by the Energy Commission are required to dispense at least 33 percent renewable hydrogen on a per-kilogram basis. After all 60 ARFVTP-funded stations become open retail in the 2018–2019 time frame, the maximum daily fueling capacity will reach 13,460 kilograms per day (kg/day), requiring more than 4,440 kg/day of renewable hydrogen to meet the 33 percent requirement. Based on the growing number of FCEVs expected, the demand for renewable hydrogen is projected to reach 7,400 kg/day by 2022 for current and projected hydrogen refueling stations. The ARFVTP is exploring the availability of technology, resources, and strategies to increase the production of renewable hydrogen transportation fuel and to leverage existing stores of renewable energy and feedstocks sourced within California.

The Energy Commission annually analyzes the remaining cost and timing to establish the initial network of 100 hydrogen refueling stations and publishes the Joint Agency Staff Report on Assembly Bill 8: 2016 Annual Assessment of Time and Cost Needed to Attain 100 Hydrogen Refueling Stations in California each December. Conclusions from the latest joint report include coverage and capacity of the refueling network, FCEV deployment, the length of time to permit and construct stations, and the growth of the refueling network.

The importance of coverage and capacity was underscored in GFO-15-605 using the CARB’s CHIT tool and market viability as criteria in evaluating proposed station locations. The 60 ARFVTP-funded stations fueling capacity of about 13,460 kg/day is enough fuel for 19,230 FCEVs, which will satisfy projected FCEV demand for hydrogen through 2019.

As of October 5, 2016, DMV reported 925 FCEVs on California roads, a dramatic increase from the 331 FCEVs registered as of April 2016. The 2016 Annual Evaluation from CARB projects that 13,500 FCEVs will be deployed in California in 2019, and 43,600 FCEVs will be deployed in 2022. These projections anticipate an increase in FCEV deployment over the 2015 Annual Evaluation projections of 10,500 FCEVs in 2018 and 34,300 in 2021.

The 2016 Joint Report projected that with the continued business-as-usual allocation of $20.0 million annually, the growth in network capacity to 16,580 kg/day by 2022 will not meet the projected demand of more than 30,000 kg/day. With the larger-than-average capacity of stations funded under GFO-15-605, the projected network capacity by 2022 is expected to increase to possibly meet the demand.

The average station development time has fallen from just over four years (for stations funded in 2010) to two years (for stations funded in 2014). This indicates that faster development times are possible and that the long development times observed in the past will not necessarily continue into the future. The shortest station development time from initial permit application to open retail status took roughly 17 months for the Coalinga station. Timely safety planning, equipment ordering and delivery, contracting, utility connection, anticipation of local aesthetic requirements, fuel quality testing, dispenser evaluation, and compliance with standard fueling protocols all lead to stations becoming operational and open retail more quickly. Additional considerations to the overall pace of station development and fuel availability for FCEVs include the pace of funding program development, FCEV auto manufacturer release schedules, and customer adoption rates.
Funding from the ARFVTP in the amount of nearly $125.0 million plus match funding from the private sector averaging $695,500 per station remains necessary to meet the AB 8 goal of establishing at least 100 open retail stations by 2024.

The Energy Commission and the CARB are also developing an analysis framework to answer the question of when will California’s hydrogen refueling stations be self-sufficient and no longer require state support. Using Energy Commission, CARB, and National Renewable Energy Laboratory expertise, various metrics will be evaluated to determine when a business entity might consider pursuing hydrogen refueling as a worthwhile addition to its business operations.

Medium- and Heavy-Duty Vehicles and Infrastructure


In October 2016, the California Fuel Cell Partnership (CaFCP) released an action plan for the deployment of fuel cell trucks in California. Deployment of medium-duty and heavy-duty (MD/HD) fuel cell electric trucks (FCET) has the potential to significantly reduce the negative impacts associated with freight transport. The CaFCP led a team of original equipment manufacturers (OEMs), industry stakeholders, and state agencies, including the Energy Commission, to develop a focused strategy for FCET development. Two near-term vocational categories were selected: Vehicle Classes 4-6 urban “last-mile delivery” trucks and Classes 7-8 short-haul/drayage trucks. The action plan identified 14 highest priority recommendations including, but not limited to, technology transfer from buses, data collection, technology demonstrations, increased funding, and focus on hydrogen infrastructure.

ZEVs in the Freight Sector

In July 2015, Governor Brown issued Executive Order (EO) B-32-15, which provides a vision for California’s transition to a more efficient, more economically competitive, and less polluting freight transport system. EO B-32-15 directed state agencies to establish targets to improve freight efficiency, transition to zero-emission technologies, and increase competitiveness of the freight movement system. The targets include improving freight system efficiency by 25 percent, deploying more than 100,000 freight vehicles and equipment capable of zero-emission technology, and increasing competitiveness and economic growth in the freight system. In July 2016, the California Sustainable Freight Action Plan (CSFAP) was transmitted to the Governor.

Under the ARFVTP, the Energy Commission released two solicitations for the demonstration of advanced ZEV/near-ZEV technologies for medium- and heavy-duty vehicles and equipment at California seaports. The solicitation also included, as eligible for the first time, applications for intelligent transportation systems and technologies (ITS). A summary of these demonstrations is in Table 3 below:

15 “Last-mile trucks” are trucks that complete the final stage of delivery when shipments reach the destination. These vehicles travel from regional distribution centers to customers in local communities and return to a distribution hub at the end of the day.
Table 3: Medium- and Heavy-Duty ZEV Demonstrations at Seaports

<table>
<thead>
<tr>
<th></th>
<th>Port of Los Angeles (#1)</th>
<th>*Port of Los Angeles (#2)</th>
<th>San Diego Port Tenants Association</th>
<th>*Port of Long Beach</th>
<th>*South Coast Air Quality Management District</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount</td>
<td>$5,833,000</td>
<td>$4,524,000</td>
<td>$5,903,652</td>
<td>$9,755,000</td>
<td>$10,000,000</td>
</tr>
<tr>
<td>Total Vehicles/Equipment</td>
<td>25 Yard Tractors</td>
<td>3 Yard Tractors, 2 Top Handlers</td>
<td>10 Drayage Trucks, ITS</td>
<td>9 Gantry Cranes 16 Drayage Trucks</td>
<td>24 Drayage Trucks 1 Top Handler with Wireless Charging</td>
</tr>
<tr>
<td>Project Completion (Estimate)</td>
<td>2019</td>
<td>2020</td>
<td>2019</td>
<td>2020</td>
<td>2021</td>
</tr>
</tbody>
</table>

*Pending business meeting approval. Source: Energy Commission staff

Regional Readiness Planning
Infrastructure planning for ZEV deployment requires coordination at a local and regional level. In 2017, the Energy Commission awarded $2.1 million (total of $9.75 million and 43 grants) for nine ZEV Regional Readiness Planning and Implementation grants. These grants aim to streamline the permitting process for future ZEV infrastructure, promote regional coordination through the establishment of ombudsman positions, conduct siting analysis, establish best practices for “ZEV-ready” building and public works guidelines, and provide public ZEV education and outreach. The nine ZEV regions are highlighted in Figure 6.
Figure 6: ZEV Readiness Regions

Legend

- North Coast
- Sonoma County
- Sacramento Region
- Tahoe Truckee
- Central Sierra
- Monterey Bay
- Central Coast
- San Bernardino
- San Diego

Source: Energy Commission staff
ZEVs in Disadvantaged Communities and Innovative Mobility Services

The Energy Commission has committed to ensure that all Californians have an opportunity to participate in and benefit from the ARFVTP. ARFVTP grant solicitations have scoring criteria to encourage projects in disadvantaged communities, which include those with disproportionate environmental pollution or a concentration of low-income households. As of April 2017, the Energy Commission has funded 791 Level 1 and Level 2 charging connectors, 108 DCFC connectors, and 15 hydrogen refueling station within disadvantaged communities scoring in the top 25 percent under CalEnviroScreen. ARFVTP funding opportunities for charging infrastructure will include charger installations that will serve workplaces and multiunit housing within these communities.

Funding opportunities will include projects for innovative mobility services, such as EV sharing, ride sharing, and alternative transit services that can promote innovative mobility service demonstrations in disadvantaged communities. These types of charging venues have the potential to broaden the market of BEV and PHEV purchases for those that do not have a dedicated parking space for charging.

Other Activities

Fixing America’s Surface Transportation Act

California (Governor’s Office, Energy Commission, Caltrans, CARB, CPUC, and CalSTA) submitted a joint proposal under the Fixing America’s Surface Transportation Act and in response to the U.S. Department of Transportation’s Federal Register notice of July 22, 2016. California nominated 32 essential corridors for zero-emission and alternative fuel designation under a nationwide designation to improve public access to alternative fuels, improve air quality, and reduce GHG emissions. In November 2016, the Federal Highway Administration announced the designations and identified 17 corridors (Figures 7 and 8) for designation in California. One of two designations were then assigned to each nominated highway segment: “Signage Ready,” meaning that there are a sufficient number of facilities on the corridor to warrant signage alerting drivers of the availability of alternative fueling stations, or “Signage Pending,” meaning that the corridor does not yet have sufficient alternative fuel facilities to warrant highway signage. Table 4 shows the designated corridors in California.

Table 4: California Designated Alternative Fuel Corridors

<table>
<thead>
<tr>
<th>Electric Vehicle</th>
<th>Hydrogen</th>
</tr>
</thead>
</table>

Source: Energy Commission staff

16 As determined by the Office of Environmental Health Hazard Assessment California Communities Environmental Health Screening (CalEnviroScreen) tool.
17 [http://www.energy.ca.gov/contracts/GFO-16-605/](http://www.energy.ca.gov/contracts/GFO-16-605/)
Figure 7: Electric Vehicle Alternative Fuel Corridors

California Alternative Fuel Corridors

**Electric Vehicle**

**EV Signage-Ready**
- I-5: From OR border to Stockton; from San Fernando to Mexico border
- SR-99: From Wheeler Ridge to Bakersfield; from Tulare to Red Bluff
- I-8: From San Diego to El Cajon, CA
- I-10: From Santa Monica to Indio
- I-15: From San Diego (at start of I-15) to Barstow
- I-405: From Mission Hills (at I-5) to Irvine (at I-5)
- I-80: From San Francisco to Cisco Grove
- I-255: From Tracy (at I-80) to Tracy (at I-5)
- I-580: From San Rafael (at US 101) to Tracy (at I-5)
- I-710: From Los Angeles (at E. Valley Road) to Long Beach
- I-480: From San Jose (at I-280) to Oakland (at I-80)
- I-280: From San Francisco (5th and King St) to San Jose (at I-80)
- SR-1: From Camino Capistrano (at I-5) to San Simeon; from Monterey to Pt. Bragg
- US-101: From Los Angeles (starting @ I-10/I-5 interchange) to Ukiah; from Rio Dell to Trinidad
- SR-60: From Los Angeles (start @ I-10/I-5 interchange) to Beaumont (end @ I-10)
- I-680: From Cordelia to San Jose (at I-280)

**EV Signage-Pending**
- I-5: From Stockton to San Fernando
- SR-99: From Bakersfield to Tulare
- I-8: From El Cajon, CA to AZ border
- I-10: From Indio to AZ border
- I-15: From Barstow to NV border
- I-40: Barstow to AZ border
- I-80: From Cisco Grove to NV border
- SR-1: From San Simeon to Monterey, and from Fort Bragg to Leggett
- US-101: From Ukiah to Rio Dell, and from Trinidad to OR border

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Source: Caltrans
Figure 8: Hydrogen Alternative Fuel Corridors

California Alternative Fuel Corridors
Hydrogen

Hydrogen Signage-Ready
I-5: From San Juan Capistrano to Burbank
I-405: From Los Angeles (@ Santa Monica Blvd) to Irvine (@ I-5)
I-80: From San Francisco to NV border
I-710: From Los Angeles (@ E. Valley Rd) to Long Beach
I-880: From San Jose (@ I-280) to Oakland (@ I-80)
I-280: From San Bruno (@ I-380) to San Jose (@ I-880)
SR-1: From Newport Beach to Santa Barbara
US-101: From Los Angeles (start @ I-101/5) to Santa Barbara, from San Jose to Mill Valley
SR-60: From Los Angeles (start @ I-101/5 interchange) to Diamond Bar (@SR-57)

Hydrogen Signage-Pending

Source: Caltrans

While the data on this map has been examined for accuracy, Caltrans disclaims any responsibility for the accuracy or completeness of the data. In no event shall Caltrans become liable to users of this map, or to any other party, for any loss or damages, consequential or otherwise, including but not limited to time, money, or goodwill, arising from the use of this map product.
Publicly Owned Utilities (POU) and Investor-Owned Utilities (IOU)

In 2014, the CPUC adopted Decision 14-12-079 in Rulemaking 13-11-007, which allows for the consideration of utility ownership of EV charging stations and infrastructure on a case-specific basis. Subsequently, in 2016 the CPUC approved light-duty infrastructure pilot programs for Pacific Gas and Electric Company (PG&E), San Diego Gas & Electric Company (SDG&E), and Southern California Edison (SCE) to install charging stations summarized in Table 5.

Table 5: IOU Light-Duty PEV Charging Infrastructure Programs

<table>
<thead>
<tr>
<th></th>
<th>SDG&amp;E</th>
<th>SCE</th>
<th>PG&amp;E</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Program Name</strong></td>
<td>Power Your Drive</td>
<td>Charge-Ready</td>
<td>EV Charge Network</td>
</tr>
<tr>
<td><strong>Scope</strong></td>
<td>3,500 charging stations</td>
<td>1,500 charging stations</td>
<td>7,500 charging stations</td>
</tr>
<tr>
<td><strong>Budget</strong></td>
<td>$45M</td>
<td>$22M</td>
<td>$130M</td>
</tr>
<tr>
<td><strong>Markets</strong></td>
<td>Multifamily and workplaces</td>
<td>Multifamily, workplaces, and public</td>
<td>Multifamily and workplaces</td>
</tr>
<tr>
<td><strong>Disadvantaged</strong></td>
<td>≥ 10% charging stations in disadvantaged communities</td>
<td>≥ 10% charging stations in disadvantaged communities</td>
<td>≥ 15% charging stations in disadvantaged communities</td>
</tr>
<tr>
<td><strong>Program Start Date</strong></td>
<td>Expected mid-2017</td>
<td>May 27, 2016</td>
<td>Expected mid-2017</td>
</tr>
</tbody>
</table>

Source: CPUC

Consistent with SB 350, utilities in California must achieve widespread transportation electrification as a principal goal of their investment and resource planning. POUs, together with air districts, transportation planning agencies, and municipal governments, play an important coordinating role in reducing GHG from transportation 40 percent below 1990 levels by 2030 and improving air quality. POUs will be developing strategies to address procurement of transportation electrification in their integrated resource plans to be submitted in 2019. The Energy Commission is committed to supporting POUs efforts in this area.

The CPUC is working to implement the transportation electrification provisions of SB 350 by directing the six IOUs under CPUC jurisdiction to propose portfolios of transportation electrification programs and investments that can be implemented over the next two to five years. The CPUC is currently considering several charging infrastructure programs proposed by the IOUs as required under SB 350. PG&E, SCE, and SDG&E filed applications

18 Bear Valley Electric, Liberty Utilities, Pacific Corp, PG&E, SCE, and SDG&E
containing proposed transportation electrification projects on January 20, 2017. Together the three utilities submitted proposals to invest $1 billion in transportation electrification over an approximate five year period. A summary of the proposals is provided in Table 6. The smaller IOUs are required to submit applications by June 30, 2017.

Table 6: IOU Charging Infrastructure Pilot Projects

<table>
<thead>
<tr>
<th></th>
<th>On-road Medium/Heavy Duty Infrastructure</th>
<th>Residential Infrastructure</th>
<th>Off-road Infrastructure</th>
<th>Public DC Fast Charging</th>
<th>Taxi/Ridesharing</th>
<th>Education/Outreach</th>
<th>Total SDG&amp;E Request</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDG&amp;E</td>
<td>Fleet Delivery Services ~$779 M</td>
<td>~$230 M</td>
<td>~$13 M</td>
<td>~$30 M</td>
<td>~$7.5 M</td>
<td>~$3.6 M</td>
<td>$244 M</td>
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<tr>
<td></td>
<td>Residential Charging Infrastructure $226 M</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Commercial Grid Integration Rate</td>
<td>Residential Grid Integration Rate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>MD/HD and Forklift Port Electrification $2.4 M</td>
<td></td>
<td>Port of Long Beach Gaity Crane $4 M</td>
<td>EV Driver Rideshare Rewards $4 M</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCE</td>
<td>Transit Bus Make-Ready &amp; Rebate $4 M</td>
<td>Residential Make-Ready Rebate $4 M</td>
<td>Port of Long Beach ITS Terminal Yard Tractor $0.5 M</td>
<td>Urban DC Fast Charger Clusters $4 M</td>
<td></td>
<td></td>
<td>$574 M</td>
</tr>
<tr>
<td></td>
<td>MD/HD Charging Infrastructure $554 M</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Commercial EV Rate Design</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PG&amp;E</td>
<td>MD/HD Fleet $3.4 M</td>
<td></td>
<td>Idle-Reduction Technology $3.4 M</td>
<td>Fast Charge Infrastructure $22 M</td>
<td></td>
<td></td>
<td>$253 M</td>
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<tr>
<td></td>
<td>Electric School Bus Renewables Integration $3.4 M</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fleet Ready Make-Ready Infrastructure $210 M</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: CPUC

**Air District Grant Funding**

California air districts are also implementing programs to advance ZEVs. The two major programs monitored by Energy Commission staff are implemented by the Bay Area Air Quality Management District and the San Joaquin Valley Air Pollution Control District with the Transportation Fund for Clean Air (TCFA) Regional Fund.22


21 SDG&E Application and Testimony: [https://www.sdge.com/regulatory-filing/20491/application-sdge-authority-implement-priority-review-and-standard-review]

The Bay Area Air Quality Management District’s “Charge!” program is an incentive program that offers grant funding to help offset a portion of the cost of purchasing, installing, and operating new publicly available charging stations at workplaces, multiunit homes, and public locations. The goal of the Charge! Program is to rapidly expand access to charging stations to achieve the region's deployment goal of 247,000 EVs by 2025. The program has $5.0 million available from the TCFA Regional Fund.

San Joaquin Valley Air Pollution Control District Charge Up! EV Charger Incentive Program provides funding through revenue generated specifically through locally generated DMV fees for public agencies and businesses in the valley to fund the purchase and installation of new EV Level 2 chargers. The chargers must be available and open to the public for at least 30 hours per week during hours that would be reasonably used by the public.

Increasing Role of Private Investments

NRG Energy’s settlement with the CPUC provided the first major installations with private investments, eventually providing 200 public fast-charging stations and the infrastructure for 10,000 plug-in units at 1,000 diverse locations (to “make ready” the sites) statewide.

The New Energy and Industrial Technology Development Organization (NEDO), in a joint agreement between NEDO and the California Governor’s Office of Business and Economic Development, and in partnership with Nissan Motor Co., Nissan North America, Kanematsu, and EVgo, are conducting a demonstration project called “DRIVE THE ARC” that is installing fast chargers from Monterey to Tahoe. Their website identifies 25 sites available.

The BMW, Volkswagen, and ChargePoint announced the Express Charging Corridors Initiative (September 2016) that will install fast chargers nationwide. The primary goals will be to have 100 stations on both coasts with a station every 50 miles, within a half-mile of a major roadway, and allowing a charge in 20 minutes (ChargePoint news release).

As a settlement for diesel vehicle emission control tampering, California will receive about $1.2 billion for air pollution reduction and ZEV advancement projects from Volkswagen. This amount includes about $381.0 million from a national Environmental Mitigation Trust for projects to reduce nitrogen oxide emissions from vehicles, such as medium- and heavy-duty vehicles, and $800.0 million that Volkswagen will invest in ZEV-related programs. The ZEV program investment will occur over a 10-year period, and eligible projects include fueling infrastructure for BEVs, PHEVs, FCEVs, consumer awareness campaigns, and car-sharing programs. Volkswagen will submit four ZEV investment plans, valued at up to $80.0 million per year, to the CARB. These plans will be used to coordinate with and complement ARFVTP investments in electric charging infrastructure and hydrogen refueling infrastructure. The Energy Commission

24 Originally part of NRG.
25 Between 2009 and 2015, Volkswagen sold 2.0-liter diesel vehicles in California that used devices to defeat emission tests. To remedy the environmental harm, Volkswagen provided a settlement to California.
will monitor the development of the Volkswagen settlement investment plans to ensure that Energy Commission infrastructure projects are conducted cooperatively with the investments.

**Summary**

With the increased ARFVTP investments toward strengthening California’s network of electric charging systems and hydrogen refueling stations, collaboration with all partners is paramount. California’s global, national, state, and local partners form the foundation for strategic deployments to help strengthen the environment, the economy, and equity in the arena of advancing a sustainable zero-emission transportation landscape. Future programs will build from these established relationships to provide recharging and refueling opportunities for the medium- and heavy-duty vehicle industries in both goods and people movement.

**Additional References:**


2017 awards for Block Grant for Electric Vehicle Charger Incentive Projects [http://www.energy.ca.gov/contracts/GFO-16-603_NOPA.pdf](http://www.energy.ca.gov/contracts/GFO-16-603_NOPA.pdf)


http://www.energy.ca.gov/2016_energypolicy/

Sustainable Freight
www.casustainablefreight.org

For information on the data from the Clean Vehicle Rebate Project:
http://energycenter.org/clean-vehicle-rebate-project/cvrp-project-statistics

2016 ZEV Action Plan

California Air Resources Board’s 2016 Annual Evaluation of Fuel Cell Electric Vehicle Deployment and Hydrogen Fuel Station Network Development:

Department of Energy Alternate Fuel Data Center:
http://www.afdc.energy.gov

For information on clean and efficient vehicles available in California, see the California Air Resources Board buying guide for clean and efficient vehicles:
https://www.driveclean.ca.gov/

California Pollution Control Financing Authority’s Electric Vehicle Charging Station Financing Program:
http://www.treasurer.ca.gov/cpcfa/calcap/evcs/

For Information on the Statewide Plug-in Electric Vehicle Collaborative
http://www.pevcollaborative.org/

Pacific Coast Collaborative and West Coast Electric Highway
http://www.pacificcoastcollaborative.org/Pages/Welcome.aspx
http://www.westcoastgreenhighway.com/

Bay Area Air Quality Management District
Charge!
Transportation Fund for Clean Air Regional Fund

San Joaquin Valley Air Pollution Control District
Charge Up! EV Charger Incentive Program

ChargePoint
news release
The New Energy and Industrial Technology Development Organization (NEDO)

DRIVETHEARC

NRG Energy

CPUC

Volkswagen Decree

https://www.arb.ca.gov/msprog/vw_info/vw-diesel-info/vw-diesel-info.htm

Contacts:

Electric Vehicle Infrastructure:
Jennifer Allen, Jennifer.Allen@energy.ca.gov
Thanh Lopez, Thanh.Lopez@energy.ca.gov
Shaun Ransom, Shaun.Ransom@energy.ca.gov

Hydrogen Refueling Infrastructure:
Phil Cazel, Phil.Cazel@energy.ca.gov

Utility Programs/Transportation Electrification:
Noel Crisostomo, Noel.Crisostomo@energy.ca.gov

Media inquiries should be sent to the Media and Public Communications Office at (916) 654-4989 or by email at mediaoffice@energy.ca.gov.

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