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California Energy Commission

DRAFT STAFF REPORT

2019-2020 Investment Plan Update for the Alternative and Renewable Fuel and Vehicle Technology Program

California Energy Commission

Edmund G. Brown Jr., Governor

November 2018 | CEC-600-2018-005-SD

California Energy Commission

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ABSTRACT

The *2019-2020 Investment Plan Update for the Alternative and Renewable Fuel and Vehicle Technology Program* guides the allocation of program funding for fiscal year 2019-2020. This *2019-2020 Investment Plan Update* covers the eleventh year of the program and reflects laws, executive orders, and policies to reduce greenhouse gas emissions, petroleum dependence, and criteria pollution emissions. It details how the California Energy Commission determines the goal-driven priorities of the program by incorporating input from stakeholders and the Alternative and Renewable Fuel and Vehicle Technology Program (ARFVTP) Advisory Committee and by analyzing project opportunities for funding. These priorities are consistent with the overall goal of the program "to develop and deploy innovative technologies that transform California's fuel and vehicle types to help attain the state's climate change policies."

This *2019-2020 Investment Plan Update* establishes funding allocations based on the identified needs and opportunities of a variety of alternative fuels and vehicle technologies. As an update, the *2019-2020 Investment Plan Update* relies on the narrative and analyses developed in previous investment plans, most recently the *2018-2019 Investment Plan Update.*

This draft staff report represents the first step in developing the *2019-2020 Investment Plan Update*. Before the adoption of the report at an Energy Commission business meeting in spring 2019, the Energy Commission expects to release a revised staff report in January 2019 and a lead commissioner report in March 2019, as well as convene public advisory committee meetings in the fourth quarter of 2018 and the first quarter of 2019.

Keywords: California Energy Commission, Alternative and Renewable Fuel and Vehicle Technology Program, AB 118, AB 8, funding program, alternative transportation fuels, investment plan, electric vehicles, hydrogen, biofuels, biomethane, biodiesel, renewable diesel, diesel substitutes, gasoline substitutes, renewable gasoline, ethanol, natural gas, federal cost-sharing, workforce training, sustainability, fueling stations, fuel production, alternative fuel infrastructure, manufacturing

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EXECUTIVE SUMMARY

Over the past decade, California has led the nation in combating climate change through aggressive greenhouse gas (GHG) emission reduction goals and innovative funding programs. The California Energy Commission's Alternative and Renewable Fuel and Vehicle Technology Program (ARFVTP) was one of the first programs created by the California Legislature to help achieve the state's climate change policies. The program has successfully done so with steady investments designed to transform California's fuel and vehicle types. Now in its eleventh year, the ARFVTP has provided more than $789 million to more than 600 agreements covering a broad spectrum of alternative fuels and technologies. In this time, California has experienced rapid growth in the sales of plug-in electric vehicles, the introduction of hydrogen fuel cell electric vehicles, and a notable increase in the in-state production and use of low-carbon alternative fuels. The ARFVTP has supported this emerging revolution in the transportation sector with significant investments in alternative fuel vehicles and supporting infrastructure and will continue to do so with this *2019-2020 Investment Plan Update*.

Purpose of the ARFVTP

Since 2006, California has set several pivotal goals to reduce GHG emissions and address the threat posed by global climate change. These goals require incremental progress that will ultimately lead to major emission reductions, including:

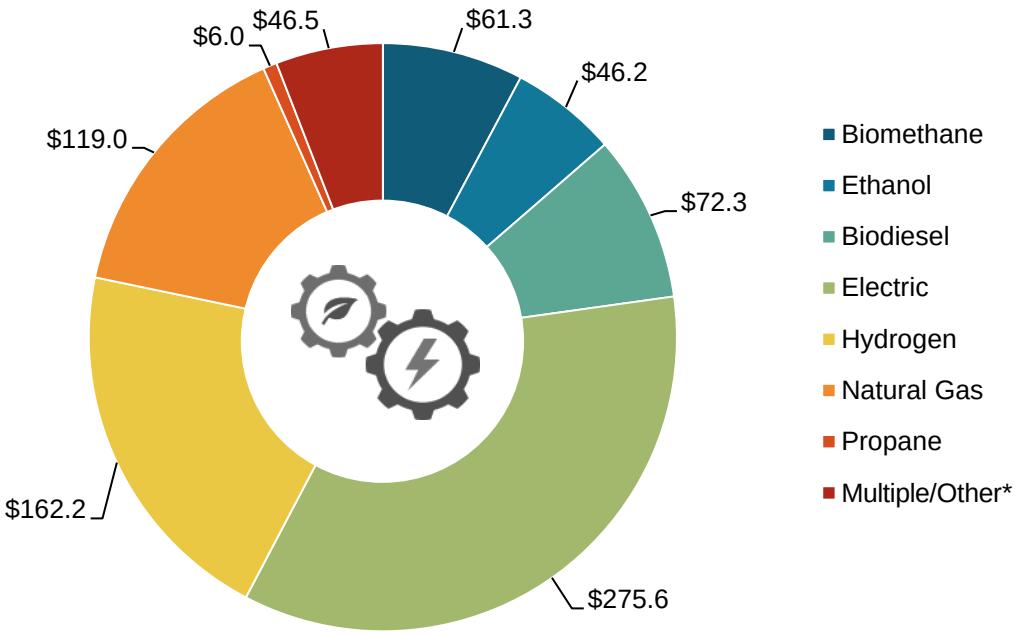
- Reducing GHG emissions to 1990 levels by 2020.
- Reducing GHG emissions to 40 percent below 1990 levels by 2030.
- Reducing short-lived climate pollutant emissions, such as methane, to 40 to 50 percent below 2013 levels by 2030.
- Achieving a carbon-neutral economy by 2045.

Achieving these goals will require significant technological and market changes within the transportation sector, which accounts for roughly 50 percent of state greenhouse gas emissions. California and the federal government have also established numerous goals and policies to reduce criteria air pollution and increase the prevalence of alternative fuels and vehicles.

To help address these goals, the California Legislature passed Assembly Bill 118 (Núñez, Chapter 750, Statutes of 2007). This legislation created the ARFVTP, which is administered by the Energy Commission. With funds collected from vehicle and vessel registration, vehicle identification plates, and smog-abatement fees, the ARFVTP funds projects that will "transform California's fuel and vehicle types to help attain the state's climate change policies." Assembly Bill 8 (Perea, Chapter 401, Statutes of 2013) subsequently extended the collection of fees that support the ARFVTP through January 1, 2024. The statute also emphasizes "develop[ing] and deploy[ing] technology and alternative and renewable fuels in the marketplace, without adopting any one preferred

fuel or technology." Figure ES-1 illustrates the types of projects funded by the ARFVTP, sorted by the fuel or technology type.

Figure ES-1: ARFVTP Funding by Fuel Type as of September 1, 2018 (in Millions)



Source: California Energy Commission. As of September 1, 2018. *Some agreements, such as those for multifuel, regional readiness plans, or workforce training, cannot be readily categorized by fuel type.

Investments to Date

Since the first ARFVTP investment plan was released in 2009, the Energy Commission has continuously invested in projects that support the advancement and use of alternative fuels and advanced vehicle technologies. The Energy Commission, through the ARFVTP, has provided funding to cities, counties, school districts, universities, private companies, and other organizations throughout the state to pursue a wide variety of alternative fuel and advanced vehicle technology projects. A detailed summary of all projects funded to date by the ARFVTP can be found in Table ES-1, which is sorted by each specific funding area.

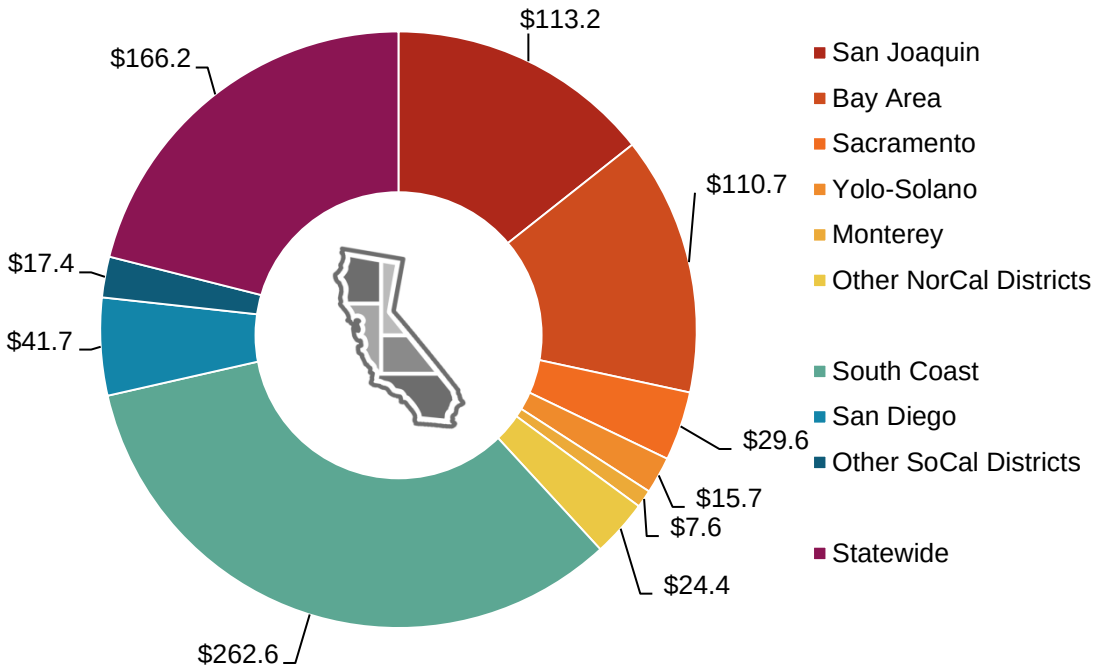
Table ES-1: ARFVTP Awards as of September 1, 2018

Funded Activity	Cumulative Awards to Date (in Millions)*	# of Projects or Units
Alternative Fuel Production		
Biomethane Production	$61.3	21 Projects
Gasoline Substitutes Production	$29.5	14 Projects
Diesel Substitutes Production	$68.3	24 Projects
Renewable Hydrogen Production	$4.0	1 Project
Alternative Fuel Infrastructure		
Electric Vehicle Charging Infrastructure**	$94.9	8,832 Charging Connectors
Hydrogen Refueling Infrastructure	$140.6	64 Fueling Stations
E85 Fueling Infrastructure	$13.7	59 Fueling Stations
Upstream Biodiesel Infrastructure	$4.0	4 Infrastructure Sites
Natural Gas Fueling Infrastructure	$22.0	64 Fueling Stations
Alternative Fuel and Advanced Technology Vehicles		
Natural Gas Vehicle Deployment***	$82.8	3,127+ Vehicles
Propane Vehicle Deployment	$6.0	514 Trucks
Hybrid and ZEV Deployment (Including CVRP, HVIP, and Low-Income Mobility Incentives)	$32.0	10,700 Cars and 150 Trucks
Advanced Technology Freight and Fleet Vehicles****	$126.3	48 Demonstrations
Related Needs and Opportunities		
Manufacturing	$43.6	21 Manufacturing Projects
Workforce Training and Development	$31.5	17,440 Trainees
Fuel Standards and Equipment Certification	$3.9	1 Project
Sustainability Studies	$2.0	2 Projects
Regional Alternative Fuel Readiness	$11.4	52 Regional Plans
Centers for Alternative Fuels	$5.6	5 Centers
Technical Assistance and Program Evaluation	$5.7	n/a
Total	**$789.2**	

Source: California Energy Commission. *Includes all agreements that have been approved at an Energy Commission business meeting or are expected for business meeting approval following a notice of proposed award. For canceled and completed projects, includes only funding received from ARFVTP, which may be smaller than initial award. Due to rounding, "total" may not match sum of rows. **Includes $38.8 million for the California Electric Vehicle Infrastructure Project to provide EV incentives throughout California, which will fund a yet-to-be-determined number of EV chargers. ***Funding includes both completed and pending vehicle incentives, as well as funds reserved for future incentives. ****Includes projects from the former Medium- and Heavy-Duty Vehicle Technology Demonstration category.

Geographically, Figure ES-2 illustrates the distribution of ARFVTP funding throughout the state divided by air district.

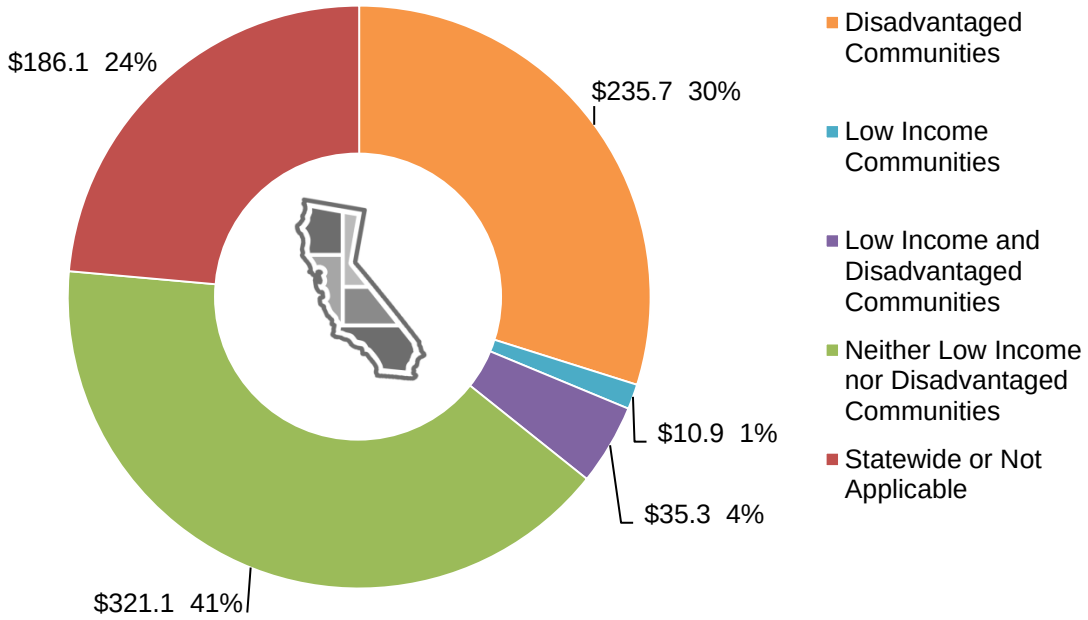
Figure ES-2: ARFVTP Funding by Air District (in Millions)



Source: California Energy Commission. As of September 1, 2018.

The Energy Commission also seeks to increase the participation of disadvantaged and underrepresented communities from a diverse range of geographical regions in implementing the ARFVTP. As depicted in Figure ES-3, roughly 34 percent of ARFVTP project funding has gone into disadvantaged communities as defined by CalEnviroScreen. When excluding ARFVTP projects that occur statewide or without an applicable site address, this funding share is closer to 45 percent.

Figure ES-3: ARFVTP Funding Toward Disadvantaged Communities (in Millions)



Source: California Energy Commission. As of September 1, 2018.

Context of the ARFVTP Investment Plan Update

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. The funding allocations reflect the potential for each alternative fuel and vehicle technology to contribute to the goals of the program; the anticipated barriers and opportunities associated with each fuel or technology; the effect of other investments, policies, programs, and statutes; and a portfolio-based approach that avoids adopting any single preferred fuel or technology.

The funding recommendations in this report are guided by, and complementary to, energy policies and regulations such as the Low-Carbon Fuel Standard, the Renewable Fuel Standard, the Governor's *Zero-Emission Vehicle Action Plan*, and the *California Sustainable Freight Action Plan*. The Low-Carbon Fuel Standard provides a per-gallon (or per-kilowatt-hour, per-therm, or per-kilogram) financial incentive to the producers of low-carbon alternative fuels based on the life-cycle carbon intensity of a fuel, with carbon intensity defined as a measure of greenhouse gas emissions per unit of energy. Similarly, the federal Renewable Fuel Standard provides a direct incentive for the introduction of biofuels. Both complement ARFVTP investments by creating market incentives for near-term GHG reductions and alternative fuel use, allowing the ARFVTP to focus more resources on longer-term market transformation goals. The *Zero-Emission Vehicle Action Plan* articulates market transformation goals for zero-emission vehicles

and calls for developing infrastructure networks and community readiness plans for plug-in electric vehicles and fuel cell electric vehicles, which are priorities for the ARFVTP. In addition, the *California Sustainable Freight Action Plan* establishes targets, policies, programs, investments, and pilot projects to improve freight efficiency, transition to zero-emission technologies, and maintain the competitiveness of the California freight system.

In January 2018, Governor Edmund G. Brown Jr. issued Executive Order B-48-18 to extend the state's support of zero-emission vehicles. This executive order directs the state government to work with the private sector and other levels of government to deploy at least 5 million zero-emission vehicles in California by 2030. The executive order also calls for the installation and construction of 250,000 electric vehicle chargers, including 10,000 direct current fast chargers, and 200 hydrogen refueling stations by 2025. The ARFVTP's funding to date has supported infrastructure for the 475,000 zero-emission vehicles in California, roughly half of all such vehicles in the United States. The proposed funding recommendations in this *2019-2020 Investment Plan Update* were developed to help achieve the aforementioned goals. California's transportation electrification efforts will also be supported by nearly $800 million in investments into charging infrastructure and related activities by the state's investor-owned electric utilities, as approved by the California Public Utilities Commission under the authority of Senate Bill 350 (De León, Chapter 547, Statutes of 2015).

2019-2020 Investment Plan Update

The *2019-2020 Investment Plan Update* builds on the analyses and recommendations contained in previously adopted investment plan updates. Past projects also provide direct feedback on how the ARFVTP can maximize value in supporting the transformation of the California transportation sector toward fuels and technologies that can meet the more aggressive emission reductions required by 2030 and 2050.

Assembly Bill 1314 (Wieckowski, Chapter 487, Statutes of 2011) reduced the scope of the annual ARFVTP investment plan to an update. The update builds on the work of previous investment plans while highlighting differences from those previous years. The resulting funding allocations are intended to reflect the unique technological and market conditions for each of these fuels and technologies, as well as state goals, policies, and directives. These are discussed in Chapters 3 through 6 of this report, which describe the barriers and opportunities associated with zero-emission vehicle infrastructure, advanced technology freight and fleet vehicles, low-carbon fuel production, and other related activities.

For FY 2019-2020, Energy Commission staff expects a total of $95.2 million will be made available for the purposes described in this investment plan update. Table ES-2 outlines the funding allocations of the two most recent investment plan updates, and Table ES-3 shows the proposed funding allocations for FY 2019-2020.

Table ES-2: Previously Approved Investment Plan Allocations (in Millions)

Category	Funded Activity	2017-2018	2018-2019*
Zero-Emission Vehicle Infrastructure	Electric Vehicle Charging Infrastructure	$16.6	$94.2
	Hydrogen Refueling Infrastructure	$19.4	$20
	Manufacturing	$4.9	$8.5
	Workforce Training and Development	$3.4	
	Emerging Opportunities	$0.4**	-
Advanced Technology Vehicle Support	Advanced Freight and Fleet Technologies	$17.5	$17.5
Alternative Fuel Production	Low-Carbon Fuel Production and Supply	$22.9**	$25***
Natural Gas Vehicles and Infrastructure	Natural Gas Vehicles	$9.7	-
	Natural Gas Fueling Infrastructure	$2.4	-
	Total	**$97.2**	**$165.2**

Source: California Energy Commission. *Funding allocations for FY 2018-2019 were revised at the October 3, 2018, Energy Commission business meeting. The revised allocations are reflected in this table. **The Energy Commission modified funding allocations for FY 2017-2018 at the January 17, 2018, business meeting. A total of $3,517,715 was reallocated from the Emerging Opportunities allocation to the Biofuel Production and Supply allocation. ***Funding for Low-Carbon Fuel Production and Supply for FY 2018-2019 includes $12.5 million from the Greenhouse Gas Reduction Fund and $12.5 million from the Alternative and Renewable Fuel and Vehicle Technology Fund.

Table ES-3: Proposed Investment Plan Allocations for FY 2019-2020 (in Millions)

Category	Funded Activity	2019-2020
Zero-Emission Vehicle Infrastructure	Electric Vehicle Charging Infrastructure	$32.7
	Hydrogen Refueling Infrastructure	$20
	Manufacturing and Workforce Development	$5
Advanced Technology and Alternative Fuel Vehicle Support	Advanced Freight and Fleet Technologies	$17.5
	Natural Gas Vehicles and Infrastructure	-
Alternative Fuel Production	Low-Carbon Fuel Production and Supply	$20
	Total	**$95.2**

Source: California Energy Commission

CHAPTER 1: Introduction

California has been at the forefront of national efforts to combat climate change since the passage of the Global Warming Solutions Act of 2006, which established a goal of reducing statewide greenhouse gas (GHG) emissions to 1990 levels by 2020.[1] Senate Bill 32[2] established a goal of 40 percent below 1990 levels by 2030. Executive Order B-55-18 established a goal to achieve carbon neutrality as soon as possible, and no later than 2045, and to achieve and maintain net negative emissions thereafter.

Despite the federal government's decision to cease participation in the Paris Agreement to limit global warming, the California state government has maintained its aggressive fight against climate change. Governor Edmund G. Brown Jr., in responding to the federal government's decision, stated, *"The President has already said climate change is a hoax, which is the exact opposite of virtually all scientific and worldwide opinion. I don't believe fighting reality is a good strategy – not for America, not for anybody."*[3]

The Under2 Coalition, which was led in 2015 by California and the German state of Baden-Württemberg, has grown to include more than 200 subnational governments representing 17 percent of the global population and 40 percent of global gross domestic product. In June 2017, California cocreated the United States Climate Alliance, a bipartisan coalition of 17 states and U.S. territories committed to reducing greenhouse gas emissions in a manner consistent with the goals of the Paris Agreement. More recently, California hosted the Global Climate Action Summit in September 2018 with the aim to increase the commitments that have already been made in Paris by bringing together representatives from cities, states, and regional governments, as well as businesses to take local-scale climate action.

The state's efforts against global climate change have begun to show progress, and in 2016, California achieved its goal of reducing GHG emissions to 1990 levels, four years ahead of schedule. Despite the overall reduction in GHG emissions, emissions from the transportation sector increased 2 percent in 2016 as a result of higher vehicle-miles

1 Assembly Bill 32, Núñez, Chapter 488, Statutes of 2006.

2 Senate Bill 32, Pavley, Chapter 249, Statutes of 2016.

3 Office of Governor Edmund G. Brown Jr. June 01 2017. *CA Governor Brown, NY Governor Cuomo and WA Governor Inslee Announce Formation of U.S. Climate Alliance.* Available at https://www.gov.ca.gov/2017/06/01/news19818/

traveled and fuel consumption.[4] The transportation sector is the largest source of GHG emissions in California, with vehicles, oil extraction, and oil refining combined accounting for roughly 50 percent of in-state emissions.[5] To meet the goals set in international agreements, state laws, and executive orders, the state transportation sector will need to transition to low- and zero-carbon fuels and technologies. California has made progress in deploying low-carbon transportation options, with sales of low-carbon alternative fuels and zero-emission vehicles steadily increasing and new transportation technologies becoming commercially available. Even with these advances, though, petroleum-based fuels still account for about 90 percent of California ground transportation fuel and result in significant GHG emissions.[6]

In addition to greenhouse gases, the transportation sector is also a major emitter of criteria pollutants, with mobile sources responsible for nearly 80 percent of nitrogen oxide emissions and 90 percent of diesel particulate matter emissions statewide.[7] Protecting and improving public health in the state will require substantial reductions in criteria pollutant emissions. The California Air Resources Board (CARB) estimates that attaining federal air quality standards in 2023 and 2031 may require up to an 80 percent reduction of smog-forming emissions in parts of the state.[8] Table 1 highlights examples of significant policy goals and milestones that have been developed to address these issues, reduce emissions, and reduce petroleum use in California. Energy Commission staff consulted with other state agencies and considered these policies when developing this investment plan update.

4 California Air Resources Board. June 22, 2018. *California Greenhouse Gas Inventory for 2000-2016.* Available at https://www.arb.ca.gov/cc/inventory/data/tables/ghg_inventory_scopingplan_sum_2000-16.pdf.

5 California Air Resources Board. July 11, 2018. *California Greenhouse Gas Emission Inventory*. Available at https://www.arb.ca.gov/cc/inventory/data/data.htm.

6 Based on analysis from California Energy Commission Energy Assessments Division.

7 California Air Resources Board. May 2016. *Mobile Source Strategy*. Available at https://www.arb.ca.gov/planning/sip/2016sip/2016mobsrc.pdf.

8 California Air Resources Board. May 2016.*Mobile Source Strategy*. Available at https://www.arb.ca.gov/planning/sip/2016sip/2016mobsrc.pdf.

Table 1: Greenhouse Gas, Fuel, and Air Quality Goals and Milestones

Policy Origin	Objectives	Goals and Milestones
Assembly Bill 32	GHG Reduction	Reduce GHG emissions to 1990 levels by 2020
Senate Bill 32	GHG Reduction	Reduce GHG emissions to 40 percent below 1990 levels by 2030
Executive Order B-55-18	GHG Reduction	Achieve carbon neutrality by 2045
Senate Bill 1383	GHG Reduction	Reduce emissions of short-lived climate pollutants to 40 to 50 percent below 2013 levels by 2030
Low-Carbon Fuel Standard	GHG Reduction	Reduce carbon intensity of transportation fuels in California by 10 percent by 2020 and 20 percent by 2030
Energy Independence and Security Act of 2007 – Renewable Fuel Standard	Petroleum Reduction	36 billion gallons of renewable fuel by 2022 nationally
Clean Air Act; California State Implementation Plans	Air Quality	80 percent reduction in NO_X by 2031
Executive Order B-16-2012	Increase Zero-Emission Vehicles	Infrastructure to accommodate 1 million electric vehicles by 2020; 1.5 million electric vehicles deployed by 2025*
Executive Order B-48-18	Increase Zero-Emission Vehicles	250,000 electric vehicle chargers, including 10,000 DC fast chargers, and 200 hydrogen refueling stations by 2025; 5 million zero-emission vehicles by 2030
Executive Order B-32-15 on Sustainable Freight	Air Quality GHG Reduction Petroleum Reduction	Improve freight efficiency and transition freight movement to zero-emission technologies

Source: California Energy Commission. *Senate Bill 1275 (De León, Chapter 530, Statutes of 2014) subsequently established a target of 1 million zero-emission and near-zero-emission vehicles in California by 2023, as well as increased access to such vehicles for disadvantaged, low-income, and moderate-income communities and consumers.

To help address state climate change and air quality objectives, the California Legislature passed Assembly Bill 118 (Núñez, Chapter 750, Statutes of 2007). This legislation created the Alternative and Renewable Fuel and Vehicle Technology Program (ARFVTP), which is administered by the California Energy Commission. With funds collected from vehicle and vessel registration, vehicle identification plates, and smog abatement fees, the ARFVTP funds projects that will "transform California's fuel and vehicle types to help attain the state's climate change policies." This program includes projects that:

- Reduce criteria and toxic air pollutant emissions from vehicles.

- Reduce the use of and dependence on petroleum transportation fuels and increase the use of alternative and renewable fuels and advanced vehicle technologies.
- Produce sustainable alternative and renewable low-carbon fuels in California.
- Expand alternative fueling infrastructure and fueling stations available to the public, existing fleets, public transit, and transportation corridors.
- Improve the efficiency, performance, and market viability of alternative light-, medium-, and heavy-duty vehicle technologies.
- Retrofit medium- and heavy-duty on-road fleet and nonroad freight vehicles to alternative technologies or fuel use.
- Offer incentives for the purchase of alternative fuel vehicles.
- Establish workforce training programs and conduct public outreach on the benefits of alternative transportation fuels and vehicle technologies.
- Support local and regional planning for zero-emission vehicle and fueling infrastructure deployment.

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."[9] Assembly Bill 8 (Perea, Chapter 401, Statutes of 2013) 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. The funding allocations reflect the potential for each alternative fuel and vehicle technology to contribute to the goals of the program; the anticipated barriers and opportunities associated with each fuel or technology; the effect of other investments, policies, programs, and statutes; and a portfolio-based approach that avoids adopting any single preferred fuel or technology. The investment plan update also describes how the allocations will complement existing public and private efforts, including related state programs.

This *2019-2020 Investment Plan Update* is the eleventh investment plan in the history of the ARFVTP and builds on the analyses and recommendations contained in the prior documents. This draft staff report is the first version of the *2019-2020 Investment Plan Update*. The Energy Commission will hold two public meetings with the ARFVTP Advisory Committee, which are expected in the fourth quarter of 2018 and the first quarter of 2019. Representatives from fuel and technology industry groups, nongovernmental entities, other state agencies, and the public will be able to discuss and comment on drafts of this document during these meetings and through the Energy

9 California Health and Safety Code Section 44272(a).

Commission's docket system.[10] In accordance with state law, the Energy Commission will submit a draft of this investment plan update to the Legislature concurrent with the Governor's proposed budget in January 2019 and will submit the adopted investment plan update to the Legislature concurrent with the Governor's revised budget in May 2019.

Chapter 2 of this document provides an update on Energy Commission's implementation of the ARFVTP to date, as well as a review of the most relevant programs, policies, and regulations that affect the allocations of this investment plan update. The subsequent chapters are organized by specific investment areas. Chapter 3 focuses on charging and refueling infrastructure for zero-emission vehicles. Chapter 4 focuses on advanced technology and alternative fuel powertrains, infrastructure, and vehicle components for freight and fleet vehicles. Chapter 5 addresses the types of and opportunities for low-carbon fuel production within California. Finally, Chapter 6 summarizes the proposed funding allocations for FY 2019-2020.

10 The Energy Commission's docket for the *2019-2020 Investment Plan Update for the Alternative and Renewable Fuel and Vehicle Technology Program* (Docket #18-ALT-01) can be found at https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=18-ALT-01.

CHAPTER 2:
Context of the 2019-2020 Investment Plan

Implementation of the Alternative and Renewable Fuel and Vehicle Technology Program

The Energy Commission has followed a consistent approach toward implementing the ARFVTP since the beginning of the program. This approach, as summarized in Figure 1, begins with an annual investment plan update that determines the coming fiscal-year funding allocation for categories of projects.[11] Energy Commission staff initially proposes funding allocations based on consideration of policy priorities such as air quality standards, environmental justice, and zero-emission vehicle deployment; evaluation of complementary funding or regulations; identification of the primary market and technological opportunities and barriers; and the GHG emission reduction potential of alternative fuels and technologies (both near term and long term). Prior to official adoption by the Energy Commission at a public business meeting, the investment plan update is proposed and revised across several drafts and incorporates stakeholder input from public ARFVTP Advisory Committee meetings.

Each investment plan update identifies funding allocations for particular segments of the supply chain for alternative fuel or vehicle technologies. The funding allocations typically do not, however, determine the specific focus of future funding solicitations. Based on these funding allocations, the Energy Commission subsequently issues a series of competitive solicitations, known as *grant funding opportunities* (GFOs, designated as "GFO-[Year]-XXX"). Each solicitation has a set of unique scoring criteria that reflect the selection preferences set by law.[12] When developing solicitations, cost-related scoring criteria are generally weighted more heavily for commercially mature technologies than precommercial technologies. Priority is also given to projects that will benefit economically disadvantaged areas or areas with poor air quality. Some solicitations are first-come, first-served and establish minimum requirements that must be achieved to be eligible for funding.

Energy Commission staff reviews, scores, and ranks the proposals for each solicitation using the evaluation criteria developed for the particular solicitation. Other state agencies and contractors may also provide technical assessments of the proposals. Based on the total scores of each application, the Energy Commission releases a notice

11 The previous investment plan update, covering fiscal year 2018-2019, was adopted at the May 9, 2018, Energy Commission business meeting. It is available at https://efiling.energy.ca.gov/getdocument.aspx?tn=223420.

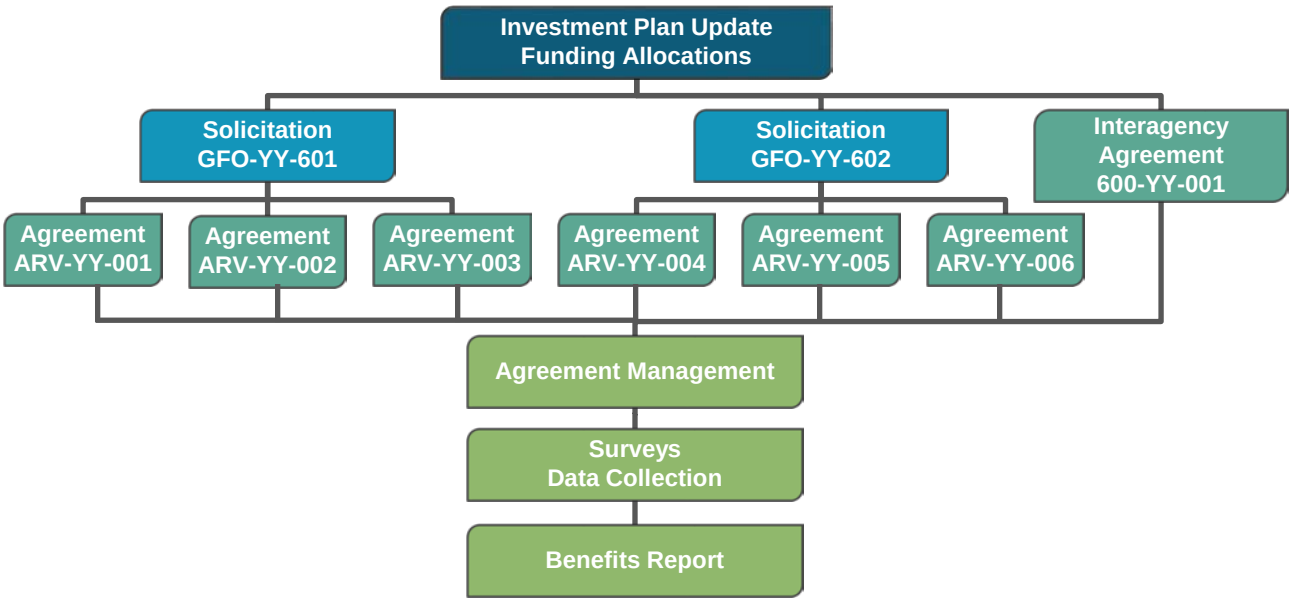
12 These preference criteria are listed in Health and Safety Code Section 44272 (c) and (d) and are applied when ranking funding proposals under ARFVTP solicitations.

of proposed awards (NOPA) for each solicitation. The NOPA ranks each application by score and provides a proposed funding amount for each proposal in order of score until available funding within the solicitation has been recommended for award. For specialized agreements with certain partner agencies, the Energy Commission may develop interagency agreements without using the solicitation process.

Each funded application becomes an agreement (usually designated as "ARV-[Year]-XXX") once it has been approved and signed by both the Energy Commission and the applicant. Energy Commission staff oversees completion of these agreements according to the respective schedules, budgets, scopes of work, and terms and conditions.

Data collection and project review are also key parts of ARFVTP implementation. The Energy Commission surveys funding recipients on the anticipated results of their projects, with questions relating to alternative fuel use, petroleum displacement, GHG emission reductions, air quality benefits, and in-state economic benefits. The Energy Commission also continues to collect data from funding recipients after completion of a project, typically for six months. Information from all these efforts feeds into the development of a biennial ARFVTP benefits report, as well as other ARFVTP measurement, verification, and evaluation efforts.

Figure 1: Schematic of ARFVTP Implementation



Source: California Energy Commission

Alternative Financing Mechanisms

To date, the Energy Commission has predominantly used grants to distribute funding, with awardees selected through competitive solicitations. As alternative fuels and technologies have advanced in the marketplace, the Energy Commission has also implemented alternative funding and financing mechanisms, when appropriate. Each of these mechanisms has respective strengths and weaknesses, and the Energy Commission weighs these options when developing the funding implementation strategy for each allocation. The most prominent funding mechanisms used for the ARFVTP by the Energy Commission are described below.

- **Competitive Solicitation for Grants** – This type of solicitation represents the most common funding mechanism for the ARFVTP to date. It is flexible, as project requirements and scoring criteria can be adapted for a broad variety of commercial and technological maturity levels. Competitive scoring allows for increased scrutiny on key issues for each project type. Because of the amount of time and attention required to review each application and oversee each subsequent award, this approach is more manageable when funding larger projects, typically of at least several hundreds of thousands of dollars. The specific time window for applying under these solicitations, as well as the uncertainty of receiving an award, may also result in greater uncertainty for project investors and applicants.
- **First-Come, First-Served** – This type of funding mechanism has been used by the ARFVTP for vehicle and infrastructure incentives. Once eligibility requirements are established, the funding can be administered relatively quickly and can provide greater market certainty for a project type. Although this funding mechanism requires the least amount of time and resources to apply for and approve, this incentive type has a higher likelihood of funding activities that would have already occurred as it lacks a method of evaluating the funding need for each project. For these reason, this approach is most suitable for less expensive and high-volume projects, such as incentives for commercially available vehicles and small-scale infrastructure.
- **Production or Operation Incentives** –The Energy Commission has used these types of incentives for in-state ethanol production and hydrogen refueling station operation and maintenance. The primary aim of these incentives is to provide greater market certainty, which allows for further investment from nongovernment sources. This funding typically requires commercial operation and is poorly suited for projects focused on technological research, development, or demonstration. It is also important that the ARFVTP seek options that limit such support to finite amounts of time or funding and avoid providing a perpetual subsidy without encouraging market maturation.
- **Loan Loss Reserve/Loan Guarantees** – These financing types are being tested by the ARFVTP as a way to potentially increase opportunities to leverage private financing and transition alternative fuel and vehicle investments from public to

private sources. These funding mechanisms become more appropriate as technologies and markets mature and are being tested with a pilot program for electric vehicle charging equipment.

- **Block Grants** – The Energy Commission has used this funding mechanism to distribute ARFVTP funding through other organizations such as local and regional governments, academic institutions, or nonprofit groups. Block grants allow the Energy Commission to select another organization to administer ARFVTP funding while following set procedures for project and applicant eligibility. This mechanism may be preferable when these other organizations either have more experience issuing certain types of incentives, or when they are more familiar with the needs and opportunities for specific project types or geographic areas.

In general, the most important factor in considering the appropriate funding mechanism for an activity has been the technological and market maturity of the fuel or technology. Public subsidies, most commonly in the form of grants, are vital to advance early stage technologies because private financiers are often unwilling to accept the high risks associated with these projects. As a technology or market matures, however, alternative financing mechanisms become a more effective method of support and can better leverage public funds with private financing. Energy Commission staff will continue to explore alternative financing strategies for the ARFVTP, such as loans, loan loss reserves, loan guarantees, and property assessment financing, as appropriate.

Program Outreach and Inclusion

The Energy Commission is committed to ensuring that a diverse range of applicants have the opportunity to participate in ARFVTP projects, including small businesses, women, minorities, the LGBT community, and disabled veterans, and is similarly committed to increasing their ARFVTP participation rates. During legislative testimony and at other public forums, Commissioner Janea Scott has reiterated the Energy Commission's commitment of targeted outreach to these communities to ensure a broad and diverse range of applicants in the ARFVTP. The Energy Commission also seeks to increase the participation of disadvantaged and underrepresented communities from a diverse range of geographical regions while implementing the ARFVTP. This effort includes:

- Initiating and implementing outreach to ensure that a diverse range of potential applicants know about, and understand how to participate in, ARFVTP activities, especially solicitations for projects.
- Targeting particular geographic regions within the state for certain program activities (for example, job training or workforce planning in disadvantaged communities).
- Reaching out to small business, women, minority, LGBT, and disabled veteran groups; sharing information from the ARFVTP Web page; and encouraging their presence and participation in ARFVTP workshops.

- Distributing ARFVTP information at key expositions and conferences throughout the state.
- Publishing Spanish-language translations of the 2016-2017, 2017-2018, and 2018-2019 Investment Plan Updates, as well as providing Spanish-language translations of the public notices for the ARFVTP Advisory Committee workshops.[13]

In addition to the above actions, the Energy Commission has provided a scoring preference for projects located in or benefitting disadvantaged communities, as defined by the CalEnviroScreen tool.[14] These preferences have been used in most recent ARFVTP solicitations, where appropriate, and about 45 percent of site-specific ARFVTP projects are located in or benefitting disadvantaged communities.

The Energy Commission plans to continue and enhance existing efforts and implement new activities to ensure that participation in the ARFVTP reflects the rich and diverse characteristics of California. These plans include, but are not limited to:

- Targeting particular geographic regions within California for a variety of program activities that will further Energy Commission outreach, especially in Southern California and the Central Valley.
- Continuing to hold preapplication and prebid workshops to explain requirements for grant and contract funding opportunities, answer questions, and encourage networking and partnering among potential applicants.
- Providing debriefings to help funding applicants understand evaluation processes and how to submit stronger project proposals.

Proposal Selection

The statutes that established the ARFVTP provide several directives and preferences that the Energy Commission uses to evaluate and select prospective projects for funding. These include petroleum and GHG emission reductions, market transformation, technology advancement, sustainability, air quality benefits, economic development, and benefit-cost assessments. In competitive solicitations, the ARFVTP considers these criteria when evaluating potential projects for funding by using a series of weighted scoring factors. The extent to which these scoring factors are applied to each solicitation varies, depending on the characteristics of each technology area.

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13 *2018-2019 Actualización del Plan de Inversión para el Programa de Tecnologías Alternativas y Renovables para Combustibles y Vehículos – Informe de la Comisión* . Published May 25, 2018. Publication # CEC-600-2017-010-CMF-Spanish. Available at https://efiling.energy.ca.gov/getdocument.aspx?tn=223585.

14 The CalEnviroScreen 3.0 tool is available online from the California Office of Environmental Health Hazard Assessment at https://oehha.ca.gov/calenviroscreen/report/calenviroscreen-30.

AB 8 also added the GHG benefit-cost score to the list of policy and scoring preferences for ARFVTP. It is defined as "…a project's expected or potential greenhouse gas emissions reduction per dollar awarded by the Commission to the project."[15] AB 8 also directs the Energy Commission to "give additional preference to funding those projects with higher benefit-cost scores."[16] Energy Commission staff applies the benefit-cost preference when evaluating proposals for similar types of projects during funding solicitations.

Benefit-cost measurements and scoring are incorporated into the development of solicitations and the review of proposals for the ARFVTP. The "benefit" is calculated as the amount of conventional fuel displaced per year by the resulting alternative fuel or technology, multiplied by the carbon intensity of that fuel or technology relative to conventional fuel. The "cost" is based on the requested ARFVTP funding amount. Dividing the "benefit" by the "cost" produces a benefit-cost ratio that staff uses in ranking similar proposals within a competitive solicitation. The benefit-cost ratio is typically given greater scoring weight in solicitations that focus on technologically mature and commercially established project types. In recent solicitations, this preference has also been incorporated as part of the general scoring criteria and as a potential tie-breaker in the event of proposals receiving equal scores.

Summary of Program Funding

As of September 2018, the Energy Commission has approved more than $789 million in ARFVTP funding. A summary of these agreements by fuel type is provided in Figure 2, and a more detailed listing of ARFVTP awards to date is shown in Table 2. The agreements support a broad portfolio of fuel types, supply chain phases, and commercialization phases. In many cases, projects are in progress, with ongoing siting, installation, construction, and demonstrations. Major highlights of the ARFVTP funding portfolio through September 1, 2018, include:

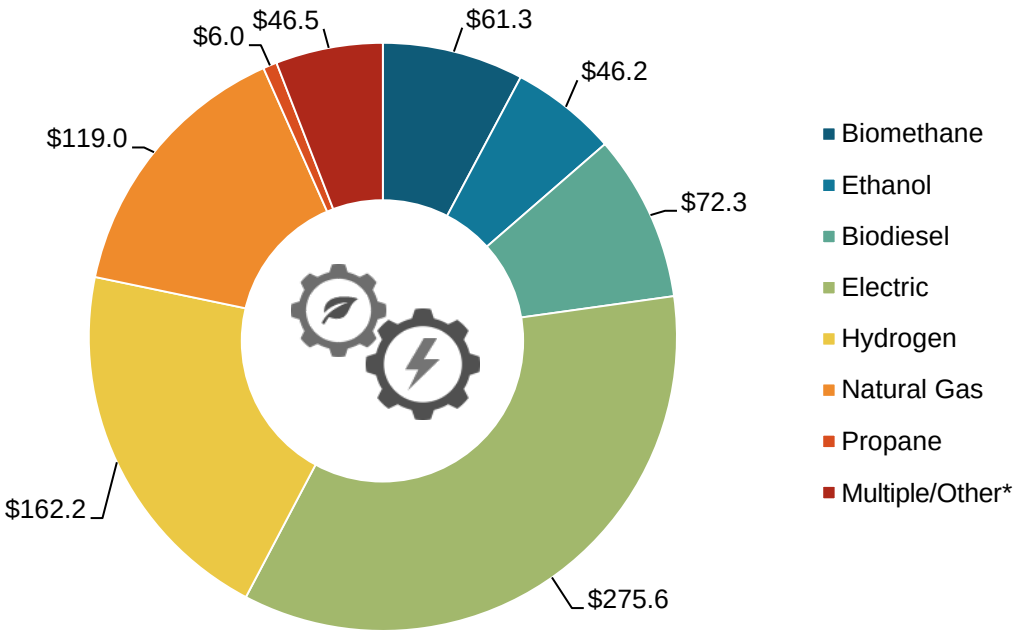
- 60 projects to promote the production of sustainable, low-carbon alternative fuels within California, with a cumulative annual production capacity equivalent to more than 130 million gallons of diesel fuel. Most will use waste-based feedstocks, which have some of the lowest carbon intensity pathways recognized under the Low Carbon Fuel Standard.
- 8,832 installed or planned charging connectors for plug-in electric vehicles, including 3,936 private charging connectors at homes, 107 fleet, and 442 workplaces; 3,194 public Level 2 charging connectors; and 808 public direct current (DC) fast chargers.

15 California Health and Safety Code, Sec. 44270.3(a).

16 California Health and Safety Code, Sec. 44272(d).

- 64 new or upgraded hydrogen refueling stations that will help serve an emerging population of fuel cell electric vehicles, plus the development of retail fueling standards to enable hydrogen sales on a per-kilogram basis. Once built, these stations will represent two-thirds of the initial network of 100 hydrogen refueling stations called for by AB 8.
- 48 projects to demonstrate zero- and near-zero-emission advanced technologies and alternative fuels in a variety of medium- and heavy-duty vehicle applications. This number includes five projects at major California seaports to support Governor Edmund G. Brown Jr.'s executive order on sustainable freight, which will deploy a variety of zero- and near-zero-emission freight vehicles.
- More than 3,000 natural gas vehicles operating or soon to be operating in a variety of applications.
- 65 natural gas fueling stations to support a growing population of natural gas vehicles. These include at least six stations that will incorporate low-carbon biomethane into some, if not all, of the dispensed fuel. Twenty-eight of these stations are at California school districts and will help provide air quality benefits to children and local communities.
- $24.5 million to fund incentives for all-electric and plug-in hybrid electric vehicles via the California Air Resources Board Clean Vehicle Rebate Project (CVRP).
- More than 20 manufacturing projects that support in-state economic growth while reducing the supply-side barriers for alternative fuels and advanced technology vehicles, primarily in electric drive-related components and vehicles.
- Workforce training for 17,440 trainees and 277 businesses that translate clean technology investments into sustained employment opportunities.
- Five centers for alternative fuels and advanced vehicle technologies, located throughout the state, which are dedicated to expanding the role of alternative fuels and advanced vehicle technologies in California.
- More than 50 alternative fuels readiness planning and implementation grants to help regions plan for alternative fuel vehicle deployment, new fueling infrastructure, and permit streamlining.

Figure 2: ARFVTP Awards by Fuel Type as of September 1, 2018 (in Millions)



Source: California Energy Commission. As of September 1, 2018. *Some agreements, such as those for multifuel, regional readiness plans, or workforce training, cannot be readily categorized by fuel type.

Table 2: ARFVTP Awards as of September 1, 2018

Funded Activity	Cumulative Awards to Date (in Millions)*	# of Projects or Units
Alternative Fuel Production		
Biomethane Production	$61.3	21 Projects
Gasoline Substitutes Production	$29.5	14 Projects
Diesel Substitutes Production	$68.3	24 Projects
Renewable Hydrogen Production	$4.0	1 Project
Alternative Fuel Infrastructure		
Electric Vehicle Charging Infrastructure**	$94.9	8,832 Charging Connectors
Hydrogen Refueling Infrastructure	$140.6	64 Fueling Stations
E85 Fueling Infrastructure	$13.7	59 Fueling Stations
Upstream Biodiesel Infrastructure	$4.0	4 Infrastructure Sites
Natural Gas Fueling Infrastructure	$22.0	64 Fueling Stations
Alternative Fuel and Advanced Technology Vehicles		
Natural Gas Vehicle Deployment***	$82.8	3,127+ Vehicles
Propane Vehicle Deployment	$6.0	514 Trucks
Hybrid and ZEV Deployment (Including CVRP, HVIP, and low-income mobility incentives)	$32.0	10,700 Cars and 150 Trucks
Advanced Technology Freight and Fleet Vehicles****	$126.3	48 Demonstrations
Related Needs and Opportunities		
Manufacturing	$43.6	21 Manufacturing Projects
Workforce Training and Development	$31.5	17,440 Trainees
Fuel Standards and Equipment Certification	$3.9	1 Project
Sustainability Studies	$2.0	2 Projects
Regional Alternative Fuel Readiness	$11.4	52 Regional Plans
Centers for Alternative Fuels	$5.6	5 Centers
Technical Assistance and Program Evaluation	$5.7	n/a
Total	**$789.2**	

Source: California Energy Commission. *Includes all agreements that have been approved at an Energy Commission business meeting, or are expected for business meeting approval following a notice of proposed award. For canceled and completed projects, includes only funding received from ARFVTP, which may be smaller than initial award. Due to rounding, "total" may not match sum of rows. **Includes $38.8 million for the California Electric Vehicle Infrastructure Project to provide EV incentives throughout California, which will fund a yet-to-be-determined number of EV chargers. ***Funding includes both completed and pending vehicle incentives, as well as funds reserved for future incentives. ****Includes projects from the former Medium- and Heavy-Duty Vehicle Technology Demonstration category.

The geographic distribution of ARFVTP funding is shown in Table 3, sorted by air district.

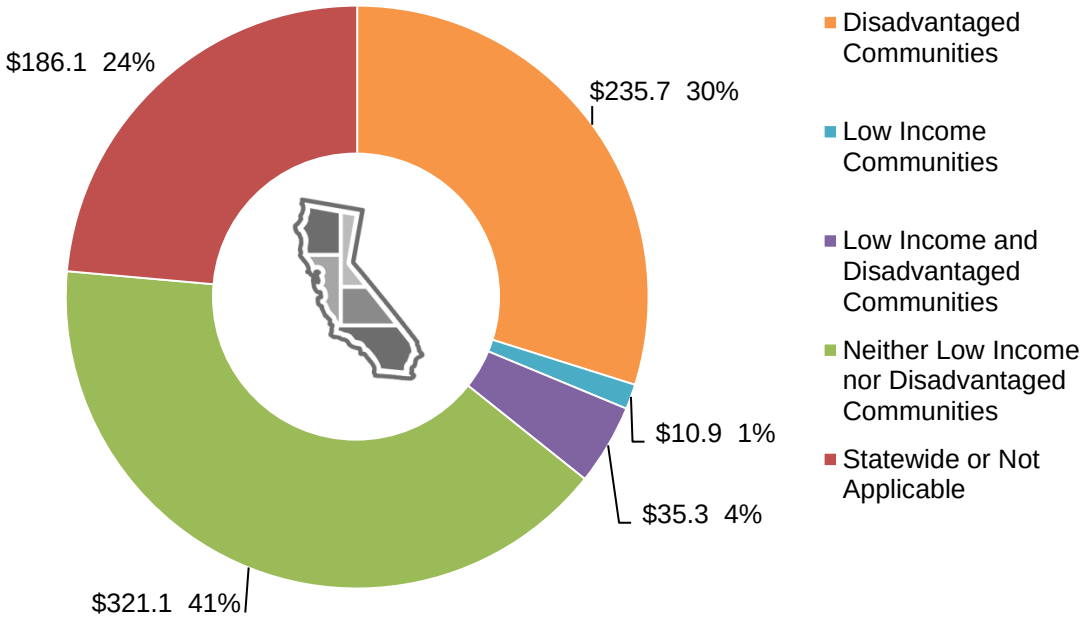
Table 3: ARFVTP Awards by Air District as of September 1, 2018

Air District	Cumulative Awards (in Millions)	Cumulative Number of Projects Sites*
San Joaquin	$113.2	103
Bay Area	$110.7	441
Sacramento	$29.6	99
Yolo-Solano	$15.7	58
Monterey	$7.6	49
Other Northern California Districts	$24.4	125
South Coast	$262.6	563
San Diego	$41.7	270
Other Southern California Districts	$17.4	150
Statewide	$166.2	60
Total	**$789.2**	**1,918**

Source: California Energy Commission. Due to rounding, "total" may not match sum of rows. *Each agreement has one or more project site; each project site is a distinct geographic location where agreement work is conducted.

The Energy Commission also seeks to increase the participation of disadvantaged and underrepresented communities from a diverse range of geographical regions in implementing the ARFVTP. As depicted in Figure 3, about 34 percent of ARFVTP project funding has gone into disadvantaged communities as defined by CalEnviroScreen. When excluding ARFVTP projects that occur statewide or without an applicable site address, this funding share is closer to 45 percent.

Figure 3: ARFVTP Funding Toward Disadvantaged Communities (in Millions)



Source: California Energy Commission. As of September 1, 2018.

The proposed funding allocations for FY 2019-2020 are outlined in Table 4, and the funding allocations of the two most recent investment plan updates are outlined in Table 5. In the event that a different amount of funding is available, the allocations in this document may be revised in subsequent versions or amended after final adoption.

Beginning with FY 2017-2018, the ARFVTP is now required to fund program support costs from the motor vehicles registration fees that provide funding for the program. Historically, these program support costs were paid from a different funding source that was supported by commercial and residential utility surcharges. These program support costs are now reflected in the funding allocations.

Table 4: Proposed Investment Plan Allocations for FY 2019-2020 (in Millions)

Category	Funded Activity	2019-2020
Zero-Emission Vehicle Infrastructure	Electric Vehicle Charging Infrastructure	$32.7
	Hydrogen Refueling Infrastructure	$20
	Manufacturing and Workforce Development	$5
Advanced Technology and Alternative Fuel Vehicle Support	Advanced Freight and Fleet Technologies	$17.5
	Natural Gas Vehicles and Infrastructure	-
Alternative Fuel Production	Low-Carbon Fuel Production and Supply	$20
	Total	**$95.2**

Source: California Energy Commission.

Table 5: Most Recent Approved Investment Plan Allocations (in Millions)

Funded Activity	2017-2018	2018-2019	Unencumbered Funds*
Electric Vehicle Charging Infrastructure	$16.6	$94.2	$95.3
Hydrogen Refueling Infrastructure	$19.4	$20	$21.1
Manufacturing	$4.9	$8.5	$16.8
Workforce Training and Development	$3.4		
Emerging Opportunities	$0.4**	-	-
Advanced Freight and Fleet Technologies	$17.5	$17.5	$17.5
Low-Carbon Fuel Production and Supply	$22.9**	$25***	$25
Natural Gas Vehicles	$9.7	-	-
Natural Gas Fueling Infrastructure	$2.4	-	-
Total	**$97.2**	**$165.2**	**$175.7**

Source: California Energy Commission. *Unencumbered funds include funding from FY 2017-2018 and FY 2018-2019 that has not yet been reserved for a funding solicitation or dedicated to a specific agreement. This funding is accurate as of September 1, 2018, and is available for new agreements, including grants, contracts, and incentives. Energy Commission staff is continuously developing new funding solicitations and agreements that will use this funding. Unencumbered funds are highest at the start of each fiscal year when new funds are made available and gradually decline throughout the fiscal year as the funds are used. **The Energy Commission modified the funding allocations for FY 2017-2018 at the January 17, 2018, business meeting. A total of $3,517,715 was reallocated from the Emerging Opportunities allocation to the Biofuel Production and Supply allocation. ***Funding for Low-Carbon Fuel Production and Supply for
FY 2018-2019 includes $12.5 million from the Greenhouse Gas Reduction Fund and $12.5 million from the Alternative and Renewable Fuel and Vehicle Technology Fund.

ARFVTP Benefits and Evaluation

The Energy Commission periodically reviews and evaluates its implementation of the ARFVTP to improve program efficiency, identify future funding needs, and select higher-quality projects. Much of this is performed in-house by reviewing previous investment plans, reviewing funding solicitations, comparing past awards, visiting sites, surveying ARFVTP grantees, and performing other program analyses.

National Renewable Energy Laboratory Program Benefits Guidance Report

The Energy Commission has worked with the National Renewable Energy Laboratory (NREL) to develop an approach for quantifying the petroleum displacement, GHG reduction, and air quality benefits of projects funded by the ARFVTP, which is required by Assembly Bill 109 (Núñez, Chapter 313, Statutes of 2008). In 2014, NREL issued a *Program Benefits Guidance* draft report that describes its method for categorizing and assessing a series of benefit categories.[17] The methods and results of this report are discussed in the *2014 Integrated Energy Policy Report (IEPR) Update*, and the assessment was subsequently updated in the *2015* and 2017 *IEPRs*. The most current and thorough discussion of the benefits report for the ARFVTP can be found in Appendix D of the *2017 IEPR*.[18]

For 2017, NREL analyzed updated ARFVTP project data for projects totaling $622.4 million, consisting of all ARFVTP projects with directly quantifiable benefits and equal to 83 percent of all ARFVTP-funded projects through June 2017. In reviewing the ARFVTP, NREL analyzed two categories of benefits: expected benefits and market transformation benefits.

Expected benefits are defined as the benefits most likely to occur from ARFVTP projects being executed successfully, assuming a one-to-one substitution of existing fuel or technology with a new fuel or technology. *Market transformation benefits* correspond to the core mission of ARFVTP to transform the California transportation system into a low-carbon, low-emission system of alternative fuel and vehicle technologies. Market transformation benefits are more challenging to quantify because they are assessments of how ARFVTP-funded projects will contribute to reducing the barriers of future alternative fuel and technology markets. Because of the greater uncertainty from this type of benefit, NREL incorporated "high case" and "low case" assumptions. The

17 Melaina, Marc, Ethan Warner, Yongling Sun, Emily Newes, and Adam Ragatz (National Renewable Energy Laboratory). 2014. *Program Benefits Guidance: Analysis of Benefits Associated With Projects and Technologies Supported by the Alternative and Renewable Fuel and Vehicle Technology Program.* CEC-600-2014-005-D. Available at http://www.energy.ca.gov/2014publications/CEC-600-2014-005/CEC-600-2014-005-D.pdf.

18 California Energy Commission Staff. *2017 Integrated Energy Policy Report*. February 2018. Publication Number: CEC-100-2017-001-CMF. Available at https://efiling.energy.ca.gov/getdocument.aspx?tn=223205.

expected benefits from NREL's 2017 assessment can be found in Table 6, and the estimated market transformation benefits can be found in Table 7.

Table 6: Expected Annual Petroleum Fuel and GHG Emission Reduction Benefits

Project Type	Petroleum Displacement (Million Gallons)			Greenhouse Gas Emission Reductions (Thousand Tonnes[19] CO_2e)		
	2020	2025	2030	2020	2025	2030
Fuel Production						
Biomethane	6.3	11.0	11.0	103.1	193.5	193.5
Diesel Substitutes	81.5	111.3	111.3	894.1	1,228.3	1,228.3
Gasoline Substitutes	4.4	15.6	15.6	737.5	161.1	161.1
Fuel Production Subtotal	*92.2*	*137.9*	*137.9*	*1,734.7*	*1,582.9*	*1,582.9*
Fueling Infrastructure						
Biodiesel	8.5	8.5	8.5	73.8	73.8	73.8
E85	11.1	11.2	11.2	33.7	33.8	33.8
Electric Vehicle Charging	2.8	2.6	2.6	20.9	20.0	20.0
Hydrogen	13.6	14.3	15.5	107.7	113.8	123.2
Natural Gas	35.3	35.3	35.6	87.1	87.8	87.8
Fueling Infrastructure Subtotal	*71.3*	*71.9*	*73.4*	*323.2*	*329.2*	*338.6*
Vehicles						
Electric Commercial Trucks	0.4	0.3	-	3.1	2.1	-
Light Duty BEVs & PHEVs	1.5	1.1	0.9	11.3	8.4	6.5
Manufacturing	65.1	108.8	97.8	543.8	919.7	841.6
Medium- & Heavy-Duty Trucks	0.9	1.2	1.0	7.1	8.5	6.9
Natural Gas Trucks	5.4	4.6	3.1	14.7	12.5	8.5
Vehicles Subtotal	*73.3*	*116.0*	*102.8*	*580*	*951.2*	*863.5*
Total	**236.8**	**325.8**	**314.1**	**2,637.9**	**2,863.3**	**2,785.0**

Source: NREL. Based on a sample size of ARFVTP projects awarded through June 2017

19 *Tonne* is a unit of mass equal to 1,000 kilograms or 2,204.6 pounds.

Table 7: Expected Annual Market Transformation Benefits in 2030

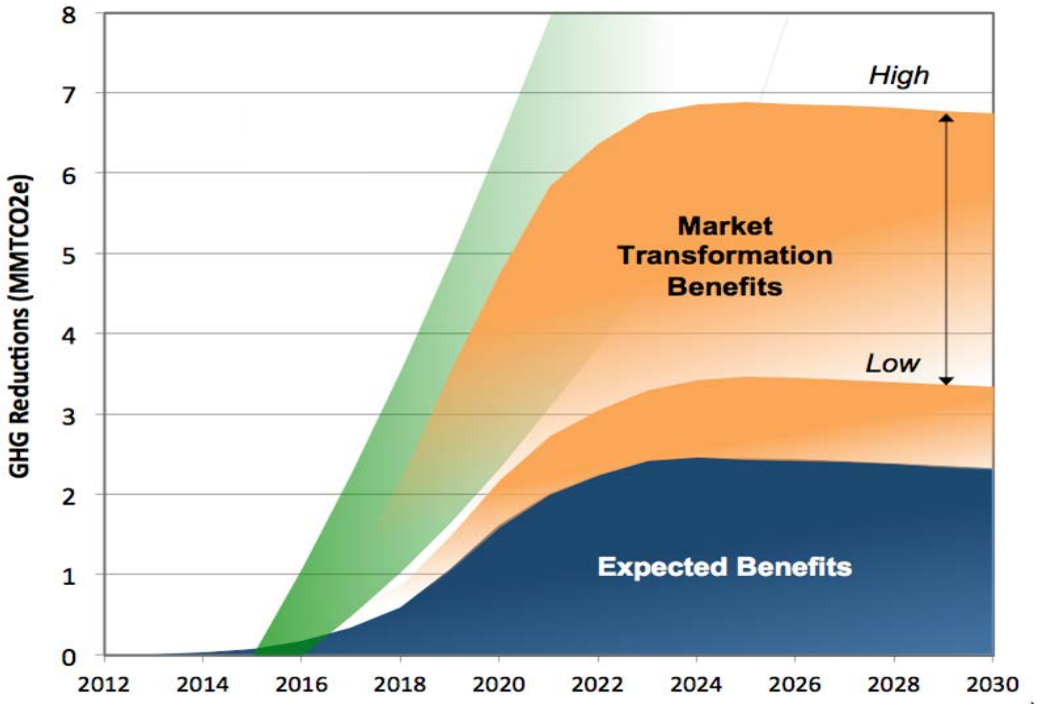
Market Transformation Influence	Case	Petroleum Displacement (Million Gallons)	Greenhouse Gas Emission Reductions (Thousand Tonnes CO_2e)
Vehicle Price Reductions	High	104.4	865.5
	Low	45.0	371.2
ZEV Industry Experience	High	10.9	83.4
	Low	9.6	71.1
Next-Generation Trucks	High	257.8	1,513.0
	Low	10.2	70.7
Next-Generation Fuels	High	286.6	2,032.5
	Low	71.7	508.1
Total	High	659.7	4,494.4
	Low	136.5	1,021.1

Source: NREL

By 2030, the expected benefits for all project classes total about 2.79 million metric tons of carbon dioxide equivalent greenhouse gases ($MMTCO_2e$) reduced per year. The market transformation benefits for 2030 range from 1.02 $MMTCO_2e$ in the low case to 4.49 $MMTCO_2e$ in the high case. Combining this range of market transformation benefits with the expected benefits category yields an annual GHG reduction range of 3.81 $MMTCO_2e$ to 7.28 $MMTCO_2e$ by 2030. Combined petroleum reductions for expected and market transformation benefits range from 450.6 million to 973.8 million gallons per year by 2030.

Figure 4 depicts the expected GHG reductions per year from both expected benefits and market transformation benefits. In this figure, the expected benefits are shown in blue, and the market transformation low and high cases are shown in orange. The green segment represents the needed trajectory for the California transportation sector to meet long-term GHG reduction goals. More information on expected ARFVTP benefits can be found in the *2017 IEPR*.

Figure 4: GHG Reductions From Expected and Market Transformation Benefits in Comparison to Required Market Growth Benefits



Source: NREL

NREL also examined the expected tailpipe emission reduction of oxides of nitrogen (NO_X) and fine particulate matter ($PM_{2.5}$) from ARFVTP projects. This analysis was limited to fuel and vehicle types recognized under the California Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (CA-GREET) and VISION models, which includes electricity and hydrogen. A summary of the expected annual air pollution emission reduction benefits can be found in Table 8.

Table 8: Expected Annual Air Pollution Emission Reduction Benefits

Project Type		NO_X Reductions (Tonnes/Year)			$PM_{2.5}$ Reductions (Tonnes/Year)		
		2020	2025	2030	2020	2025	2030
Fuel Infrastructure	Electric Chargers	1.89	1.57	1.57	0.19	0.19	0.07
	Hydrogen	9.31	8.51	9.25	0.94	1.05	0.43
Vehicles	CVRP & HVIP Support	7.06	6.44	1.83	0.11	0.09	0.05
	Medium- & Heavy-Duty	7.52	12.43	11.52	0.23	0.25	0.22
	Manufacturing	537.17	1,126.14	1,201.45	7.55	19.68	28.13
Total		**562.95**	**1,155.09**	**1,225.62**	**9.02**	**21.26**	**28.90**

Source: NREL

Related Policies and Programs

AB 32, SB 32, and the Greenhouse Gas Reduction Fund

Assembly Bill 32 (Núñez, Chapter 488, Statutes of 2006), also known as the Global Warming Solutions Act of 2006, required CARB to adopt a statewide GHG emission limit for 2020 equivalent to the statewide GHG emission levels in 1990. Executive Order S-3-05 also set an objective of reducing emissions to 80 percent below 1990 levels by 2050, which is consistent with an Intergovernmental Panel on Climate Change analysis of the emissions trajectory that would stabilize atmospheric GHG concentrations at 450 parts per million CO_2e and reduce the danger of catastrophic climate change.

Senate Bill 32 (Pavley, Chapter 249, Statutes of 2016) amended the Global Warming Solutions Act of 2006 to extend the emission targets of AB 32. The amendment set a statewide GHG emission limit for 2030 equivalent to 40 percent below emission levels in 1990. In September 2018, Governor Brown issued Executive Order B-15-18 establishing a new target to achieve carbon neutrality by 2045. AB 32 and SB 32 directed CARB to develop a climate change scoping plan to describe the approach that California will take to reduce GHG emissions and achieve the state's climate change goals. *California's 2017 Climate Change Scoping Plan*, published by CARB in November 2017, helped inform and guide the development of this investment plan update.[20]

As part of its regulation, CARB developed a Cap-and-Trade Program that set a limit on the amount of permissible GHG emissions from entities in regulated sectors. The Cap-and-Trade Program includes an auction system where tradable permits, or allowances, can be purchased from the state at quarterly auctions. A portion of the proceeds from these auctions are deposited in the Greenhouse Gas Reduction Fund (GGRF). The Governor and Legislature enact GGRF appropriations for state agencies to implement a variety of programs that reduce greenhouse gases. Assembly Bill 398 (Garcia, Chapter 135, Statutes of 2017) extended California's Cap-and-Trade Program through 2030.

Executive Orders on Zero-Emission Vehicles

In March 2012, Governor Brown issued Executive Order B-16-12, which set a target of 1.5 million zero-emission vehicles on the road by 2025 and tasked various state agencies with specific actions needed to support this goal.[21] Subsequently, in January 2018, Governor Brown issued Executive Order B-48-18, which set an expanded target of 5 million zero-emission vehicles on the road by 2030, as well as a network of 200 hydrogen refueling stations and 250,000 electric vehicle charging stations, including

20 California Air Resources Board. November 2017. *California's 2017 Climate Change Scoping Plan.* Available at https://www.arb.ca.gov/cc/scopingplan/scoping_plan_2017.pdf.

21 Available at https://www.gov.ca.gov/news.php?id=17472.

10,000 DC fast chargers, installed or constructed by 2025.[22] These executive orders have guided the electric vehicle charging and hydrogen refueling infrastructure investments of the ARFVTP to date.

The Governor's Interagency Working Group on Zero-Emission Vehicles (ZEVs) developed the *ZEV Action Plan*, issued in 2013 and subsequently updated in 2016, to identify actions that support the state's ZEV goals.[23] Some actions in the *ZEV Action Plan* that are particularly relevant to the ARFVTP include ensuring ZEVs are accessible to a broad range of Californians and making ZEV technologies commercially viable in the medium- and heavy-duty and freight sectors. Many recommendations in the *ZEV Action Plan* have been captured in the ARFVTP since the inception of the program and continue to be priorities in the ARFVTP. The Electric Vehicle Charging Infrastructure, Hydrogen Refueling Infrastructure, and Advanced Freight and Fleet Technologies sections of this investment plan update discuss proposed ARFVTP activities that will help achieve the goals of the *ZEV Action Plan*.

In addition, the Governor's Office of Planning and Research released the *Zero-Emission Vehicles in California: Community Readiness Guidebook* in 2013.[24] This guidebook helps local planning and permitting agencies familiarize themselves with ZEVs and support these vehicles in their communities. The guidebook includes an overview of ZEV technologies, specific suggestions for how these agencies can better prepare for ZEVs, as well as a collection of tools that can help streamline ZEV infrastructure permitting, prepare for increased electricity demand, and develop ZEV-friendly building codes.

Charge Ahead California Initiative

Senate Bill 1275 (De León, Chapter 530, Statutes of 2014) established the Charge Ahead California Initiative, administered by CARB in consultation with the Energy Commission and related agencies. This statute establishes a goal of placing 1 million zero-emission and near-zero-emission vehicles in service by January 1, 2023, as well as increased access to these vehicles for disadvantaged, low-income, and moderate-income communities and consumers. In implementing the initiative, CARB must include a three-year funding forecast for near-zero- and zero-emission vehicles. CARB released the first of these forecasts, the *Fiscal Year 2016-17 Funding Plan for Low Carbon Transportation*

22 Executive Order B-48-18 available at https://www.gov.ca.gov/2018/01/26/governor-brown-takes-action-to-increase-zero-emission-vehicles-fund-new-climate-investments.

23 Governor's Interagency Working Group on Zero-Emission Vehicles. October 2016. *2016 ZEV Action Plan: An Updated Roadmap Toward 1.5 Million Zero-Emission Vehicles on California Roadways by 2025*. Available at https://www.gov.ca.gov/docs/2016_ZEV_Action_Plan.pdf.

24 California Governor's Office of Planning and Research. 2013. *Zero-Emission Vehicles in California: Community Readiness Guidebook*. Available at http://opr.ca.gov/docs/ZEV_Guidebook.pdf.

and Fuels Investments and the Air Quality Improvement Program[25] in 2016. CARB also adopted revisions to the Clean Vehicle Rebate Project to phase down rebate levels based on cumulative sales, limit eligibility based on income, and consider other methods of incentives.

CPUC Transportation Electrification Activities

In 2014, the California Public Utilities Commission (CPUC) adopted Decision 14-12-079 to allow the consideration of utility ownership of electric vehicle charging stations and infrastructure on a case-specific basis. Subsequently, the CPUC approved 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 7,500, 3,500, and 1,500 charging stations, respectively.[26] The utility programs for light-duty infrastructure are described further in the Electric Vehicle Charging Infrastructure section in Chapter 3 of this report.

The CPUC is also working to implement the transportation electrification provisions of Senate Bill 350 (De León, Chapter 547, Statutes of 2015) by directing the six investor-owned electric utilities under the CPUC's jurisdiction to propose portfolios of transportation electrification programs and investments that can be implemented over the next five years. The three major investor-owned utilities submitted more than $1 billion in applications to the CPUC for electric vehicle charging infrastructure projects, with $780 million of these projects approved in January and May 2018. These projects include roughly $592 million for medium- and heavy-duty vehicle infrastructure and $171 million for light-duty vehicle infrastructure. The projects for medium- and heavy-duty electric vehicle infrastructure are discussed further in the Advanced Freight and Fleet Technologies section in Chapter 4 of this report.

In addition, the remaining three investor-owned electric utilities, including PacifiCorp, Liberty Utilities, and Bear Valley Electric Service, filed applications with the CPUC in June 2017 for projects within their service territories. PG&E, SCE, and SDG&E have also begun providing customer incentives for plug-in electric vehicles as part of the utility implementation of the Low Carbon Fuel Standard program.

Volkswagen Diesel Emissions Settlement

Beginning with its 2009 model year, Volkswagen sold 2.0- and 3.0-liter diesel vehicles in the United States, including in California, which violated federal and state law by using illegal devices to defeat emission tests. To remedy the harm caused by the use of these

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25 California Air Resources Board. May 2016. *Fiscal Year 2016-2017 Funding Plan for Low Carbon Transportation and Fuels Investments and the Air Quality Improvement Program.* Available at https://www.arb.ca.gov/msprog/aqip/fundplan/proposed_fy16-17_fundingplan_full.pdf.

26 California Public Utilities Commission, Decisions (D.)16-01-023, D.16-01-045, and D.16-12-065. Available at http://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=6442454831.

defeat devices, California entered into a series of settlement agreements with Volkswagen. From these agreements, California will receive about $423 million from a national Environmental Mitigation Trust for projects to fully mitigate the lifetime excess NO_X emissions caused by the illegal devices. In May 2018, CARB approved a Beneficiary Mitigation Plan outlining how these funds will be spent.[27] The plan targetsa minimum of 50 percent of funding for the benefit of low-income or disadvantaged communities. Project funding will be available starting in 2019. California will also receive $25 million for vehicle replacement programs for low-income consumers and $153.8 million in civil penalties.[28] In addition, Volkswagen will invest $800 million in ZEV-related projects in the state and must offer and sell additional battery electric vehicle models in California between 2019 and 2025.

Volkswagen's ZEV investments will occur over a 10-year period, and eligible projects include fueling infrastructure for plug-in electric vehicles and hydrogen fuel cell electric vehicles, consumer awareness campaigns, and car-sharing programs. Volkswagen will submit four ZEV investment plans, each of which will cover 30 months and total $200 million, to CARB for approval. The first of these plans was approved in July 2017. The ZEV infrastructure funding is expected to complement ARFVTP investments in electric vehicle charging infrastructure and hydrogen refueling infrastructure. In addition, CARB allocated $10 million from the Environmental Mitigation Trust for light-duty zero-emission vehicle infrastructure projects. The Energy Commission will monitor the development of the Volkswagen settlement investment plans to ensure that investments are coordinated. Details from the first Volkswagen settlement investment plan are discussed in the Electric Vehicle Charging Infrastructure section in Chapter 3 of this report.[29]

Air Quality Improvement Program and Low Carbon Transportation Investments

In addition to the ARFVTP, AB 118 also created the Air Quality Improvement Program (AQIP), which is administered by CARB. While the ARFVTP emphasizes achieving state GHG reduction goals within the transportation sector, the AQIP is responsible primarily for reducing air pollutants from the transportation sector. Since 2009, the AQIP has provided deployment incentives for light-duty electric vehicles through the CVRP, deployment incentives for alternative medium- and heavy-duty vehicles through the

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27 California Air Resources Board. June 2018. "Beneficiary Mitigation Plan for the Volkswagen Environmental Mitigation Trust." Available at https://www.arb.ca.gov/msprog/vw_info/vsi/vw-mititrust/documents/bmp_jun2018.pdf.

28 California Air Resources Board. July 20, 2017. "California to Receive $153M in Final Settlement With Volkswagen." Release #17-48. Available at https://ww2.arb.ca.gov/news/california-receive-153m-final-settlement-volkswagen.

29 Information on CARB activities associated with the VW Environmental Mitigation Trust is available at https://www.arb.ca.gov/msprog/vw_info/vsi/vw-mititrust/vw-mititrust.htm.

Hybrid and Zero-Emission Truck and Bus Voucher Inventive Project (HVIP), as well as funding for other advanced emission reduction technologies for vehicles. Before the availability of appropriations from the GGRF, the ARFVTP provided $49.1 million in funding to backfill CVRP needs, as well as an additional $4 million for HVIP incentives.

CARB also distributes GGRF funding through its Low Carbon Transportation Investments (LCTI) program to reduce greenhouse gas emissions and advance the purposes of AB 32 and SB 32. Projects that were originally funded by the AQIP, such as the CVRP, are now funded by the LCTI program because demand has exceeded available funding from the AQIP. The LCTI provides incentives for light-duty vehicle and transportation equity projects, as well as heavy-duty vehicle and off-road equipment projects.

In October 2018, CARB approved the *Proposed FY 2018-2019 Funding Plan for Clean Transportation Incentives* that includes funding totaling $483 million for LCTI and AQIP projects.[30] A summary of the funding allocations can be found in Table 9.

Table 9: Proposed FY 2018-2019 CARB Clean Transportation Incentives Allocations

Project Category	Proposed Allocation (millions)		
	Light-Duty Vehicle and Transportation Equity Investments	Heavy-Duty and Off-Road Equipment Investments	AQIP-Funded Heavy-Duty Investments
Clean Vehicle Rebate Project	$200		
Transportation Equity Projects	$75		
Clean Truck and Bus Vouchers		$125	
Freight Equipment Advanced Demonstration and Pilot Commercial Deployment Project		$55	
Truck Loan Assistance Program			$25.6
Diesel Particulate Filter Retrofit Replacements			$3
Total	**$275**	**$180**	**$28.6**

Source: California Air Resources Board.

30 California Air Resources Board. September 21, 2018. "Proposed Fiscal Year 2018-19 Funding Plan for Clean Transportation Incentives." Available at https://www.arb.ca.gov/msprog/aqip/fundplan/proposed_1819_funding_plan.pdf.

Many project categories listed above have particular importance to the goals and strategies of the ARFVTP and are further discussed in the Advanced Freight and Fleet Technologies section of Chapter 4 in this investment plan update.

State Implementation Plans and Mobile Source Strategy

The federal Clean Air Act of 1970 (42 U.S.C. 7401) authorizes the U.S. Environmental Protection Agency (U.S. EPA) to establish National Ambient Air Quality Standards (NAAQS) to protect public health. To achieve these standards, the Clean Air Act directs states to develop State Implementation Plans (SIPs) that describe how an area will attain the NAAQS. CARB, in coordination with local air quality districts, is the state agency responsible for developing the California SIPs and for controlling emissions from cars, trucks, other mobile sources, and consumer products. In March 2017, CARB adopted the State SIP strategy with a commitment to achieve the emission reductions from mobile sources and consumer products necessary to meet the NAAQS for ozone throughout California. In October 2018, CARB adopted a supplement to the State SIP strategy to address the PM2.5 standards in the San Joaquin Valley.

The State SIP strategy is one of several planning elements based on the 2016 *Mobile Source Strategy* which outlines an integrated strategy to meet air quality standards, achieve state greenhouse gas emission targets, minimize exposure to toxic air contaminants, reduce petroleum use by up to 50 percent by 2030, and increase energy efficiency and renewable electricity generation. Many of the actions recommended in the strategy, such as increasing the use of ZEVs and renewably sourced alternative fuels, complement the activities of the ARFVTP.

CARB reports that 12 million Californians live in communities that exceed the ozone and particulate matter standards set by the U.S. EPA, and that the South Coast and San Joaquin Valley are the only two areas in the nation in extreme nonattainment for the federal ozone standard.[31] The actions described in the State SIP strategy intend to resolve these problems and are expected to result in up to an 80 percent reduction in smog-forming emissions and a 45 percent reduction in diesel particulate emissions by 2031.[32] Since exposure to elevated levels of air pollutants causes significant health and economic impacts in the state, reducing emissions of criteria and toxic air pollutants will have corresponding benefits for Californians.

ARFVTP investments frequently provide significant air quality benefits by replacing conventional gasoline- and diesel-fueled vehicles with near-zero and zero-emission vehicles, as well as by providing the fueling infrastructure required for these vehicles to operate. These ARFVTP-funded vehicle and infrastructure projects complement and

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31 California Air Resources Board. March 7, 2017. *Revised Proposed 2016 State Strategy for the State Implementation Plan.* Available at https://www.arb.ca.gov/planning/sip/2016sip/rev2016statesip.pdf.

32 California Air Resources Board. *Mobile Source Strategy*. May 2016. Available at https://www.arb.ca.gov/planning/sip/2016sip/2016mobsrc.pdf.

assist other California efforts to achieve the goals of the federal Clean Air Act. Air quality benefits from ARFVTP projects are further discussed in Chapters 3, 4, and 5 of this report.

Executive Order on Sustainable Freight

Executive Order B-32-15, issued by Governor Brown in 2015, ordered the development of an integrated action plan to improve freight efficiency, transition to zero-emission technologies, and increase the competitiveness of California's freight system.[33] The resulting *California Sustainable Freight Action Plan* was released in 2016 and identifies state policies, programs, and investments to achieve these targets.[34]

The plan was developed as a combined effort by the California State Transportation, California Environmental Protection, and California Natural Resources Agencies, including the Energy Commission, CARB, the California Department of Transportation, and the Governor's Office of Business and Economic Development, in partnership with the public and stakeholders. In addition, the executive order directs the Energy Commission and other state agencies to initiate work on corridor-level freight pilot projects within the state primary trade corridors that integrate advanced technologies, alternative fuels, freight and fuel infrastructure, and local economic development opportunities.

In response to this executive order, the Energy Commission released three solicitations for advanced freight vehicle and infrastructure projects between 2015 and 2017. These solicitations awarded $60 million to eight projects demonstrating advanced technology vehicles and infrastructure in the Ports of Los Angeles, Long Beach, and San Diego. These projects will deploy 90 zero- and near-zero-emission vehicles, including yard trucks, drayage trucks, gantry cranes, top handlers, and forklifts, as well as install charging and refueling infrastructure for electric and hydrogen vehicles. Moreover, the Energy Commission regularly engages with seaports in California through the Ports Energy Collaborative, which provides a forum for the Energy Commission and the ports to come together to discuss important energy issues, mutual challenges, and opportunities for transitioning to alternative and renewable energy technologies.

School Bus Replacement Program

In the November 2012 California general election, voters approved Proposition 39 to improve energy efficiency and expand clean energy generation in schools and community colleges. This proposition provides up to $550 million annually for five fiscal years for these purposes, beginning with FY 2013-2014. Senate Bill 110 (Committee on Budget and Fiscal Review, Chapter 55, Statutes of 2017) allocates the available remaining funds from the implementation of Proposition 39 to improve energy

33 Available at https://www.gov.ca.gov/news.php?id=19046.

34 Available at http://www.casustainablefreight.org/theplan.html.

efficiency at California schools. The energy efficiency measures in SB 110 include one-time funding of $75 million for the retrofit or replacement of school buses.

This funding will be administered by the Energy Commission, and priority will be given to school districts operating the oldest and most polluting diesel school buses, as well as to school buses operating in disadvantaged and low-income communities. The Energy Commission has developed strong relationships with every local education agency in California through the successful implementation of Proposition 39 and will use these established relationships to expedite the replacement of school buses statewide. The $75 million in funding provided by SB 110 will be used exclusively for the purchase of battery-electric school buses, and this amount will be supplemented with up to $13 million in ARFVTP funds to provide the necessary charging infrastructure to operate the buses. For circumstances in which battery-electric propulsion is not feasible, up to $3.7 million in Natural Gas Vehicles funds and up to $2.4 million in Natural Gas Fueling Infrastructure funds from previous fiscal years will be made available for natural gas-powered school buses and necessary fueling infrastructure.

Low Carbon Fuel Standard

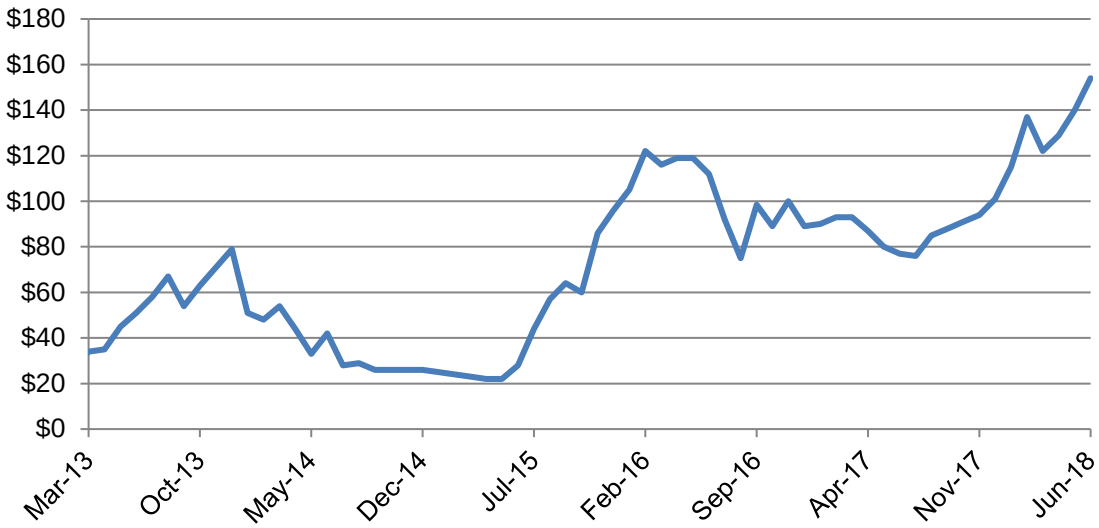
CARB adopted the Low Carbon Fuel Standard (LCFS) regulation in April 2009 with a goal of reducing the overall carbon intensity of fuel within the transportation sector by 10 percent by 2020. In September 2018, CARB set a further goal of reducing carbon intensity by 20 percent by 2030. The LCFS sets a carbon intensity standard (or benchmark) that declines each year.Providers of low carbon fuels earn credits under the LCFS by producing fuels with a carbon intensity below the annual carbon intensity standard. These credits can be used or sold to offset deficits caused by high carbon fuels that exceed the annual carbon intensity standard. Through this mechanism, the LCFS allows the market to determine what mix of fuels will be used to achieve the program carbon intensity reduction goals.

LCFS credits and deficits are denominated in metric tons of CO_2e Credit prices reached all-time highs in 2017 and 2018, as shown in Figure 5, ranging from a low of $22 in May 2015 to a high of $154 in June 2018.[35] As of March 2018, 459 certified transportation fuel pathways were available for use under the LCFS, and 255 parties were registered for transactions under the LCFS, including oil refiners, biofuel producers, and electric and natural gas utilities.[36]

35 California Air Resources Board. July 11, 2018. *LCFS Monthly Credit Price and Transaction Volumes July 2018 Spreadsheet*. Available at https://www.arb.ca.gov/fuels/lcfs/dashboard/creditpriceserieswithoutargusopis.xlsx.

36 California Air Resources Board. March 2018. *Staff Report: Initial Statement of Reasons for the Proposed Amendments to the Low Carbon Fuel Standard Regulation.* Available at https://www.arb.ca.gov/regact/2018/lcfs18/lcfs18.htm.

Figure 5: Average Monthly Low-Carbon Fuel Standard Credit Prices



Source: California Energy Commission. Data from the LCFS Monthly Credit Price and Transaction Volumes July 11, 2018. Spreadsheet is available at https://www.arb.ca.gov/fuels/lcfs/dashboard/creditpriceserieswithoutargusopis.xlsx.

The LCFS has significance for the ARFVTP in several ways. Most important, the Energy Commission frequently relies on LCFS-derived carbon intensity numbers in numerous phases of ARFVTP implementation. This reliance is due to the LCFS program life-cycle analysis of GHG emissions, the specificity of the analysis to California, and the consistent method of calculation across multiple fuel pathways. The life-cycle GHG emission numbers are used in assessing the opportunities from different alternative fuels within the investment plan update, estimating the GHG reduction potential from applicants during solicitations, and analyzing ARFVTP benefits.

The LCFS also provides a direct financial incentive per gallon, kilowatt-hour, therm, or kilogram to the producers and distributors of low-carbon alternative fuels. At the recent 12-month average price of about $111 per credit, the LCFS value of an alternative fuel offering a 50 percent GHG emission reduction compared to gasoline would be $0.60 per gasoline gallon equivalent (GGE).[37] This complements the investments of the ARFVTP by creating market incentives for near-term GHG reductions, allowing the ARFVTP to focus more resources on longer-term market transformation goals.

In September 2018, CARB also adopted changes to the LCFS regulations that will benefit the deployment of ZEVs and ZEV infrastructure. The amendments will allow hydrogen refueling stations to earn hydrogen refueling infrastructure credits based on the capacity of the station. The amendments will also provide credits for DC fast charging equipment based on the equipment's power rating. On the vehicles side, the amendments also restructure the existing approach for providing PEV rebates thorugh

37 LCFS credit value derived from the CARB LCFS Credit Price Calculator Version 1.2, available at https://www.arb.ca.gov/fuels/lcfs/dashboard/creditpricecalculator.xlsx.

utilities, so as to create create a statewide rebate that would be offered at the dealership, funded through LCFS credit proceeds.

Renewable Fuel Standard

The federal Energy Policy Act of 2005 established the Renewable Fuel Standard (RFS) Program, which was revised under the Energy Independence and Security Act of 2007 into the RFS2. The RFS2 mandates 36 billion gallons of renewable fuel to be blended into transportation fuels nationwide by 2022. Within this volume, the RFS2 also establishes four categories of renewable fuel, each with a target for 2022. These categories include cellulosic, biomass-based diesel, advanced biofuel, and total renewable fuels.

Renewable fuels are assigned renewable identification numbers (RINs) to track trading and record compliance with the RFS. The U.S. EPA establishes annual RIN requirements in consideration of the expected available volumes of renewable fuels. The projected volumes and proposed percentages for renewable fuels to be used under the RFS program are summarized in Table 10.[38]

Table 10: Proposed and Final RFS Fuel Volumes for 2018-2020

Category	Volume Standards		
	2018	2019	2020
Cellulosic Biofuel	288 million	381 million*	n/a
Biomass-Based Diesel	2.1 billion	2.1 billion	2.43 billion*
Advanced Biofuel	4.29 billion	4.88 billion*	n/a
Total Renewable Fuels	19.29 billion	19.88 billion*	n/a

Source: U.S. EPA. All volume is reported in ethanol-equivalent gallons, except for biomass-based diesel, which is in U.S. gallons. *Proposed volume requirements as of July 17, 2018

As with the LCFS, the RFS provides a per-gallon subsidy for alternative fuels through saleable RINs. This subsidy complements the goals of the ARFVTP by encouraging credit-generating and regulated parties to invest in the lowest-cost means of increasing alternative fuel use. The market value of these RINs can be volatile. Pricing depends on the category of RIN and, for the first half of 2018, ethanol RINs have averaged $0.44 and biodiesel RINs have averaged $0.66, with one RIN representing the energy content of a gallon of ethanol.[39] This volatility affects the income of biofuel producers and can negatively affect investments in projects.

38 United States Environmental Protection Agency. July 10, 2018. *Renewable Fuel Standard Program: Standards for 2019 and Biomass-Based Diesel Volume for 2020.* Available at https://www.gpo.gov/fdsys/pkg/FR-2018-07-10/pdf/2018-14448.pdf.

39 Based on analysis from California Energy Commission Energy Assessments Division, with data from the Oil Price Information Service.

CHAPTER 3:
Zero-Emission Vehicle Infrastructure

Electric Vehicle Charging Infrastructure

Electric vehicles are a key component of achieving zero-emission vehicle deployment goals, greenhouse gas reduction targets, petroleum reduction goals, and air quality standards in California. ARFVTP investments in electric vehicle charging infrastructure are guided in part by Executive Order B-48-18, which set goals of deploying 250,000 electric vehicle chargers, including 10,000 DC fast chargers, by 2025 and 5 million ZEVs by 2030. Other legislation and mandates guide the state government's transportation electrification policies and investments as well. These include SB 1275, which established a target of 1 million ZEVs and near-ZEVs in California by 2023, and Executive Order B-16-2012, which calls for 1.5 million ZEVs on California roads by 2025. The majority of the initial ZEVs in the state are expected to be plug-in electric vehicles (PEVs), as CARB manufacturer surveys forecast that 47,200 hydrogen fuel cell electric vehicles will be on California roads in 2024.[40]

Cumulative sales of ZEVs, which include battery-electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs), are steadily growing in California, with annual sales increasing 29 percent in 2017 and more than 470,000 sold through October 2018.[41] This accounts for half of the vehicles sold in the United States, due in part to funding in zero-emission vehicle infrastructure. Furthermore, the Energy Commission forecasts that between 1.5 million and 2.4 million ZEVs will be in the state by 2025, setting California on track to meet or exceed the state ZEV deployment goals for 2025.[42] A convenient, reliable network of public electric vehicle charging stations (EVCS) will be critical to continue supporting the expansion of PEV ownership in California and to ensure state ZEV deployment goals are realized.

Technology Overview

Charging infrastructure is typically categorized into three power ratings: Level 1, Level 2, and direct current (DC) fast charging. More than 90 percent of charging connectors funded to date by the ARFVTP are Level 2 chargers, which use alternating current

40 California Air Resources Board. *2018 Annual Evaluation of Fuel Cell Electric Vehicle Deployment & Hydrogen Fuel Station Network Development.* July 2018. Available at https://www.arb.ca.gov/msprog/zevprog/ab8/ab8_report_2018_print.pdf.

41 Veloz. October 5, 2018. *Detailed Monthly Sales Chart.* Available at https://www.veloz.org/wp-content/uploads/2018/10/9_sept_2018_Dashboard_PEV_Sales_veloz-1.pdf.

42 California Energy Commission Staff. February 2018. *2017 Integrated Energy Policy Report.* Publication Number: CEC-100-2017-001-CMF. Available at https://efiling.energy.ca.gov/getdocument.aspx?tn=223205.

electricity to charge a PEV at 240 volts and can provide about 12 to 30 miles of range per hour of charging.[43] Fewer than 3 percent of charging connectors funded by the ARFVTP have been Level 1 chargers, which use alternating current electricity at 120 volts to provide about 5 miles or less of range per hour of charging.[44] Finally, DC fast charging uses DC electricity at 480 volts to recharge a BEV to 80 percent capacity in about 30 minutes, though the time required depends on the size of the vehicle battery and the power level of the charger.[45]

In addition to varying by charging rate, charging infrastructure varies by location type. Residential projects account for 45 percent of the Level 2 charging connectors funded by the ARFVTP to date, with the majority installed at single-family homes. These chargers were funded through FY 2011-2012 and, as at-home Level 2 chargers became readily available and affordable, the Energy Commission discontinued funding for private-use residential charging stations. Shared-use residential charging stations, which are predominantly used in multifamily housing, still face barriers that impede PEV adoption. Projects at multifamily housing have been historically underrepresented by applicants despite efforts to target incentives toward EVCS installations at these locations.

Workplace and public charging stations are another major component of the state's portfolio of charging stations. Public chargers include charging locations at stores, parking garages, universities, municipal governments, curbside locations, and other common, publicly accessible destinations. When residents of multifamily housing are unable to charge at home, having an available site to charge at work or access to other public locations can serve as an alternative. If located far from home, workplace and public charging can also help BEV owners extend their range and PHEV owners increase their electric miles driven. Open access to public chargers in California is ensured by the Electric Vehicle Charging Stations Open Access Act, which prohibits requiring subscription fees or memberships as a condition of use for publicly accessible chargers.[46]

The majority of charging at public locations is expected to occur during the daytime, which is likely to create opportunities for electricity demand management at these sites. Electric vehicle charging with demand-side management can reduce electricity use during peak times and shift use to periods of excess electricity supply. As more

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43 Center for Sustainable Energy. *The ABCs of EVs: Technology Overview*. Accessed August 25, 2017. Available at https://cleanvehiclerebate.org/eng/ev/technology/electric-car-fueling-options.

44 Ibid.

45 Center for Sustainable Energy. *The ABCs of EVs: Technology Overview*. Accessed August 25, 2017. Available at https://cleanvehiclerebate.org/eng/ev/technology/electric-car-fueling-options.

46 Senate Bill 454 (Corbett, Chapter 418, Statutes of 2013).

intermittent renewable energy is available to the electricity grid, such as solar and wind, the electricity supply available during the day will increase and possibly result in overgeneration. Vehicle-to-grid technologies and daytime PEV charging, especially at workplace and public charging stations, have the opportunity to reduce the negative effects of overgeneration.

When located along major interregional routes, DC fast chargers can enable long-distance travel by BEVs. Fast charger plazas, which consist of two or more fast chargers at a single location, can charge multiple PEVs quickly and simultaneously. These plazas can alleviate charger congestion in areas with large PEV populations. Fast chargers can also provide a quicker alternative to charging at destinations or at home or serve the needs of drivers without access to charging at home, such as those living in multifamily housing. Next-generation BEVs with higher-capacity batteries will require higher-powered fast chargers than what is adequate for first-generation BEVs. Energy Commission staff is considering how to best apply ARFVTP funding to meet the anticipated infrastructure needs of future vehicles.

In an attempt to quantify the number of charging stations needed to service the growing number of PEVs in California, the Energy Commission and NREL developed the Electric Vehicle Infrastructure Projections (EVI-Pro) model. EVI-Pro estimates the number of charging connectors that will be needed at the local level while accounting for differing charger power levels, location types, and PEV adoption rates. This model allows the Energy Commission to estimate where local and regional gaps exist in charging station deployment, how many electric vehicle chargers will be needed to meet the goals of the *ZEV Action Plan*, how much this infrastructure will cost, and how differences in travel behavior and housing types will affect PEV charging demand. Energy Commission staff is using the EVI-Pro model to estimate the number of chargers needed to support PEVs in the state.

Medium- and heavy-duty vehicles with electric powertrains may have charging infrastructure requirements that are incompatible with those of light-duty vehicles. These vehicles may require charging infrastructure with specialized connectors or higher voltage and power levels than what is typically provided for light-duty PEVs. In addition, heavy-duty vehicle operators may need to locate chargers in areas that are inaccessible to the public for security and safety reasons. Energy Commission staff expects that some portion of the funding from this allocation or the Advanced Freight and Fleet Technologies allocation will be used to support the deployment of charging infrastructure specifically for medium- and heavy-duty PEVs.

New mobility services, including car and ride sharing, autonomous connected vehicles, and wireless charging, present other opportunities to expand the use of PEVs. Thus far, PEV use has been limited largely to those who have the means to purchase a new vehicle. Dedicated PEV car- and ride-sharing services, however, can provide zero-emission transportation options for drivers and passengers that would otherwise have no alternatives to conventional automobiles. To advance ZEV adoption, the Energy

Commission may provide funding from this category to purchase and install charging infrastructure for demonstration PEV car- and ride-sharing services. These demonstrations may be targeted in disadvantaged and rural communities to provide further benefits to Californians who lack adequate transportation options. The $46 million CARB is investing in car- and ride-sharing in disadvantaged communities with its Low Carbon Transportation funding would further complement ARFVTP investments in this area.

ARFVTP Funding to Date

The Energy Commission has led state efforts in ZEV infrastructure deployment and has supported the rollout of PEVs by awarding nearly $95 million in ARFVTP funding for electric vehicle charging infrastructure. Due in part to these investments, California has the largest network of publicly accessible electric vehicle chargers in the nation.

ARFVTP investments have funded EVCS at many types of locations, as detailed in Table 11. More than half of these Level 2 charging stations were installed at homes to support the early deployment of the first PEVs in the state. The residential, fleet, workplace, multifamily housing, and public charging connectors, as reported in Table 11, consist entirely of Level 1 and Level 2 charging stations. The corridor charging stations consist mostly of fast chargers, but many sites also include some Level 2 charging stations.

Table 11: Charging Connectors Funded by ARFVTP as of September 1, 2018

Status	Private Access			Publicly Accessible			Total
	Residential	Fleet	Workplace	Multifamily Housing	Public	Corridor	
Installed	3,936	107	342	341	2,944	185	**7,855**
Planned	-	-	100	4	250	623	**977**
Total	**3,936**	**107**	**442**	**345**	**3,194**	**808**	**8,832**

Source: California Energy Commission. Does not include connectors that have yet to be approved at an Energy Commission business meeting, or connectors that have yet to be funded under CALeVIP.

In September 2018, Senate Bill 1000 (Lara, Chapter 368, Statutes of 2018) was signed by Governor Brown. The legislation will require the Energy Commission, in consultation with CARB, to assess whether electric vehicle charging station infrastructure is disproportionately deployed. As used in the legislation, "disproportionate" refers to population density, geographical area, or income level. If the infrastructure is found to be disproportionately deployed, the Commission must use ARFVTP funding to more proportionately deploy new charging station infrastructure, unless the Energy Commission finds the disproportionate deployment reasonable and in furtherance of

state energy or environmental policy goals.[47] An analysis of disproportionate deployment of charging infrastructure will be included in a subsequent version of this *2019-2020 Investment Plan Update* before adoption at an Energy Commission business meeting.

In December 2017, the Energy Commission introduced the California Electric Vehicle Infrastructure Project (CALeVIP) to provide streamlined ARFVTP incentives for electric vehicle charging infrastructure. The incentives provided through CALeVIP simplify the funding process and accelerate charger deployment compared to the previously used grant solicitations. Each CALeVIP project provides incentives for infrastructure in specific regions throughout the state, with funding targeted at regions that have low rates of infrastructure deployment or lack adequate incentives from utilities and other sources. The CALeVIP has an initial budget of $39 million for charger rebates, and the Energy Commission may make up to $200 million available through this funding mechanism depending on demand, project performance, and funding availability. As of September 2018, CALeVIP is providing incentives to businesses and public agencies in Fresno County for Level 2 chargers and in Los Angeles, Orange, Riverside, and San Bernardino Counties for DC fast chargers. The availability of funding is expected to steadily expand to additional regions and project types in 2019 and 2020.

The Energy Commission, through the ARFVTP, has undertaken additional efforts to ensure adequate charging infrastructure for future PEVs in California, such as allowing funding recipients to purchase maintenance plans lasting up to five years using ARFVTP funds. By providing prepaid maintenance from a designated service provider, charger downtime can be minimized in the event of equipment damage or malfunction. Site owners have also voiced concern over charging stations that are no longer functional because of equipment failure, damage, or vandalism. The owners of these charging stations may not be able to pay for repairs and choose instead to leave the infrastructure non-operational. In situations such as these, the Energy Commission may fund maintenance and repair to return these charging stations to service.

As the market for PEVs becomes more developed, financing for electric vehicle charging stations will eventually need to shift from government incentives to private sector lending. Electric vehicle chargers, however, may require innovative business models because of uncertain long-term payoff and risk, and these may reduce the willingness of lenders to fund EVCS with competitive financing terms. To validate the profitability and feasibility of financing EVCS, the ARFVTP funded the Electric Vehicle Charging Station Financing Program, which is administered by the California Pollution Control Financing Authority. Because potential borrowers have shown limited interest in this demonstration-scale financing program, Energy Commission staff expects to reevaluate and modify this program to best meet the needs for charging infrastructure

47 Senate Bill 1000 (Lara, Chapter 368, Statutes of 2018).

development in the state. Other advanced financing mechanisms may also be considered as EVCS markets continue to mature.

Other Sources of Funding for PEV Infrastructure

In 2014, the CPUC adopted Decision (D.) 14-12-079, which permits utility ownership of electric vehicle charging infrastructure, contingent upon an examination of the utility program through a balancing test.[48] A prior CPUC decision had prohibited utility ownership of charging infrastructure; however, utilities may now apply for ownership approval on a case-specific basis. Each of the three major investor-owned utilities applied to install electric vehicle chargers or supporting infrastructure for light-duty vehicles in their respective service territories, and these proposals were approved by the CPUC in 2016.

Southern California Edison (SCE) launched Phase 1 of its "Charge Ready" pilot program in 2016, which provided roughly $22 million over a one-year period to install an estimated 1,500 site host-owned charging stations at multifamily housing, workplaces, and other public locations.[49] San Diego Gas & Electric (SDG&E) launched its "Power Your Drive" pilot program in 2017, which provides up to $45 million over three years to install an estimated 3,500 SDG&E-owned charging stations at multifamily housing and workplaces.[50] Pacific Gas and Electric Company (PG&E) began projects under its "EV Charge Network" pilot program in 2017, which will provide up to $130 million over three years to install an estimated 7,500 site-owned and PG&E-owned charging stations at multifamily housing and workplaces.[51] In addition, in June 2017, Bear Valley Electric Service, Liberty Utilities, and PacifiCorp filed applications with the CPUC to support transportation electrification through charging infrastructure installation and rebates, as well as outreach and education.

The three major investor-owned utilities each submitted applications to the CPUC for additional light-duty electric vehicle charging infrastructure projects, including $141 million for residential charging infrastructure and $30 million for public DC fast charging infrastructure. These projects were approved in January and May 2018 and, once implemented, will increase charging options for PEV drivers within the utility service territories. Energy Commission staff expects that ARFVTP funding opportunities

48 California Public Utilities Commission. December 18, 2014. *CPUC Takes Steps to Encourage Expansion of Electric Vehicles*. Available at http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M143/K627/143627882.PDF.

49 Southern California Edison. "Charge Ready Program." Accessed August 25, 2017. Available at https://www.sce.com/wps/portal/home/business/electric-cars/Charge-Ready.

50 San Diego Gas & Electric Company. "Power Your Drive." Accessed August 25, 2017. Available at https://www.sdge.com/clean-energy/electric-vehicles/poweryourdrive.

51 Pacific Gas and Electric Company. "PG&E's Electric Vehicle (EV) Charge Network." Accessed August 25, 2017. Available at https://www.pge.com/en_US/residential/solar-and-vehicles/options/clean-vehicles/charging-stations/ev-charging-infrastructure-program.page?WT.mc_id=Vanity_evcharge.

and investor-owned utility projects will complement one another within each utility service territory.

Other organizations have also committed to providing substantial funding for light-duty charging infrastructure deployment in California. EVgo installed 200 fast chargers and is expected to install electrical infrastructure to support nearly 10,000 Level 2 chargers by December 2018 as part of the energy crisis settlement reached between the CPUC and NRG Energy, Inc.[52] Volkswagen, through its subsidiary Electrify America, has also agreed to invest $800 million over 10 years for ZEV infrastructure, education, and access in California as part of a settlement with CARB. For the first 30-month cycle of the settlement, Electrify America is expected to invest roughly $45 million in community chargers in major metropolitan areas and $75 million in a highway fast charging network throughout the state.[53] Energy Commission staff will continue to monitor and coordinate with other EVCS deployment projects to ensure the strategic deployment of electric vehicle infrastructure and to avoid duplication of efforts. As more funding sources become available, all agencies, utilities, and companies providing EVCS funding will need to coordinate to expedite expansion of the charging network and to avoid duplication.

Publicly owned utilities have historically used the value of LCFS credits to support the installation of charging infrastructure within their territories; recent LCFS amendments adopted by CARB in September 2018 will require publicly owned utilities to contribute a portion of their LCFS credit value toward a statewide electric vehicle rebate fund. The amendments also establish fast charging infrastructure credits that will further incentivize the deployment of fast chargers. These credits are generated on the basis of the nameplate capacity of the fast charging equipment. In the event that fast charging infrastructure credits reach a certain threshold within the LCFS, the amendments also include provisions that require a diversity of charging connectors and connector protocols.

Related State Policy

Senate Bill 350 requires CARB, in consultation with the Energy Commission, to develop and release a study on the barriers faced by low-income customers in adopting zero-emission and near-zero-emission transportation options. As a result, in April 2017, CARB released a draft guidance document titled *Low-Income Barriers Study, Part B: Overcoming Barriers to Clean Transportation Access for Low-Income Residents.* CARB subsequently issued the final guidance document in February 2018 after incorporating

52 EVgo Services LLC. January 5, 2018. *Settlement Year 5 – Fourth Quarter Progress Report to the California Public Utilities Commission.* Available at http://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=6442455980.

53 Volkswagen Group of America. March 8, 2017. *California ZEV Investment Plan: Cycle 1.* Available at https://www.arb.ca.gov/msprog/vw_info/vsi/vw-zevinvest/documents/vwinvestplan1_031317.pdf.

comments received on the draft.[54] The guidance document cited affordability, awareness, and a lack of permanent, long-term funding sources as barriers to increasing access to clean transportation and mobility options in underserved and disadvantaged communities. Energy Commission staff will take these barriers and the recommendations to overcome them into account when developing future funding opportunities.

In September 2018, Governor Brown signed Assembly Bill 2127 (Ting, Chapter 365, Statutes of 2018). The legislation requires the Energy Commission, working with CARB and the CPUC, to prepare and biennially update a statewide assessment of the electric vehicle charging infrastructure needed to support levels of electric vehicle adoption required for the state to meet its goals of at least 5 million vehicles on California roads by 2030 and of reducing emissions of greenhouse gases to 40 percent below 1990 levels by 2030. The Energy Commission will regularly seek data and input from stakeholders relating to electric vehicle charging infrastructure, and will update the assessment at least once every two years.[55]

Summary

In January 2018, Governor Brown issued Executive Order B-48-18, which set a directive to install 250,000 zero-emission vehicle chargers, including 10,000 DC fast chargers, in California by 2025. To help achieve this goal, Energy Commission staff proposes a $32.7 million allocation for electric vehicle charging infrastructure for FY 2019-2020. This funding will complement the efforts made by the private sector and electric utilities by increasing statewide investments and funding projects not covered by the geographic area or scope of other programs. Energy Commission staff expects funding from this allocation will also be invested in infrastructure specifically for the growing number of medium- and heavy-duty electric vehicles in the state. These significant investments in electric vehicle charging infrastructure from multiple sources will be necessary to keep pace with expected deployment of PEVs in the state and meet the goals of Executive Order B-48-18.

Hydrogen Refueling Infrastructure

Fuel cell electric vehicles (FCEVs) using hydrogen fuel offer another zero-emission transportation option for Californians. Like electricity, hydrogen can be produced from a variety of pathways, including renewable sources of energy. When produced with one-third renewable energy, the hydrogen for a passenger FCEV can reduce GHG emissions by about 50 to 70 percent compared to a conventional gasoline vehicle, and this is

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54 California Air Resources Board. February 21, 2018. “Low-Income Barriers Study, Part B: Overcoming Barriers to Clean Transportation Access for Low-Income Residents.” Available at https://ww2.arb.ca.gov/sites/default/files/2018-08/sb350_final_guidance_document_022118.pdf.

55 Assembly Bill 2127 (Ting, Chapter 365, Statutes of 2018).

comparable to the GHG emissions benefits of BEVs that use electricity from the power grid.[56] FCEVs can also travel farther and be refueled more quickly than BEVs. Fuel cells enable electrification of a broad range of vehicles, including passenger cars, light-duty trucks and SUVs, transit buses, and heavy-duty trucks and can complement BEVs by offering zero-emission vehicles to drivers who need more range or faster refueling.

Technology Overview

Several automakers have launched FCEVs for lease or sale in California. Hyundai became the first automaker to offer a production model FCEV, the Tucson Fuel Cell, for lease in 2014. Toyota subsequently released the Mirai FCEV in 2015, Honda released its production Clarity FCEV in 2016, and Hyundai released its Nexo FCEV in 2018. Kia is also expected to release a new FCEV model by 2020, and in September 2017, Mercedes-Benz presented a preproduction model of the hybrid GLC F-Cell, which combines hydrogen fuel cell and plug-in battery-electric powertrains.

Analyses conducted by CARB determined that open-retail hydrogen refueling stations are critical to enabling FCEV sales in California, and that expanding the network of stations increases the marketability of FCEVs. CARB also conducts annual automaker surveys to inform FCEV deployment efforts and analyses in California, and these surveys suggest that FCEV deployment can be accelerated if the rate of station construction is increased. To these ends, the Energy Commission is working with hydrogen station developers to create a network of stations needed to support the initial deployment of hydrogen FCEVs from Hyundai, Toyota, Honda, and other manufacturers.

To identify areas of the state with the greatest need for hydrogen refueling infrastructure, CARB developed the California Hydrogen Infrastructure Tool (CHIT). CHIT is a geospatial analysis tool used to analyze locations where potential refueling demand is not met with sufficient hydrogen refueling coverage or capacity. The most recent ARFVTP hydrogen refueling infrastructure solicitation, GFO-15-605, used CHIT as part of the proposal evaluation to determine the project coverage, capacity, and market viability.

The Energy Commission, through the ARFVTP, has supported the development of hydrogen refueling regulations and test procedures, hydrogen refueling infrastructure test equipment, and regional readiness plans for FCEV and refueling station deployment. The Energy Commission also provides data on ARFVTP-funded hydrogen refueling infrastructure to the NREL Technology Validation Program. NREL combines these data with other nationally sourced data to assess hydrogen refueling systems and components under real-world conditions, analyze the availability and performance of existing hydrogen fueling stations, and provide feedback regarding capacity, use, station

56 Based on a range of potential hydrogen fuel pathways established by the LCFS. This includes an energy economy ratio of for 2.5 FCEVs and a range of 65.87-130.12 grams CO2e/megajoule (MJ) for hydrogen with one-third renewable content. Source: CARB. *LCFS Fuel Pathway Table.* July 10, 2017. Available at https://www.arb.ca.gov/fuels/lcfs/fuelpathways/pathwaytable.htm.

build time, maintenance, fueling, and geographic coverage. The technology validation analyses help inform state and national hydrogen refueling infrastructure deployment.

Companies are also producing or are planning to produce heavy-duty vehicles with hydrogen fuel cell electric powertrains, including transit buses and tractor-trailer trucks. These vehicles, and the fleets that operate them, may require dedicated refueling infrastructure to ensure the safety, security, and fuel supply of the vehicles. Energy Commission staff expects that some portion of ARFVTP funding will be used to support the construction and installation of hydrogen refueling infrastructure specifically for medium- and heavy-duty FCEVs, either from the Advanced Freight and Fleet Technologies allocation or from this allocation.

ARFVTP Funding to Date

As of September 2018, 35 hydrogen refueling stations were operational in California, and an additional 4 stations are expected to be operational in 2018. Through the ARFVTP, the Energy Commission has provided funding to install or upgrade 64 publicly available hydrogen stations capable of light-duty vehicle refueling. The most recent completed funding solicitation issued by the ARFVTP for hydrogen refueling stations was GFO-15-605, which made awards for 16 stations in February 2017. Thirteen applicants submitted proposals to install hydrogen refueling stations at 111 locations. The solicitation prioritized hydrogen refueling stations that filled gaps in coverage and capacity throughout California. The Energy Commission provided $33.4 million in grants for this solicitation with funds from multiple fiscal years.

As with previous awards, the 16 stations funded under GFO-15-605 will provide at least 33 percent of the hydrogen from renewable sources. Four hydrogen refueling stations previously funded by the ARFVTP will provide 100 percent of the hydrogen from renewable resources, and overall, stations funded by the ARFVTP are expected to dispense fuel with an average of 37 percent renewable hydrogen content. The renewable hydrogen from these agreements is typically derived from either renewable electricity via electrolysis or biomethane via steam methane reformation at central production plants. Of the 64 stations that have received ARFVTP funding, 5 are planned to use on-site electrolysis to generate hydrogen. Energy Commission staff may consider providing ARFVTP funds to support additional on-site renewable hydrogen production at refueling stations. Larger-scale, off-site renewable hydrogen production is discussed in the Low-Carbon Fuel Production and Supply section in Chapter 5 of this report.

In addition to funding for infrastructure development, the Energy Commission recognizes the need for operations and maintenance (O&M) funding for the initial network of hydrogen refueling stations. This funding provides ongoing support to station developers who build and operate stations before the mass introduction of FCEVs and is meant to sustain the stations until enough vehicles are on the roads to be profitable. O&M support, however, reduces the amount of capital funding that the Energy Commission can provide for new hydrogen station development.

Since 2014, the Energy Commission offered as much as $100,000 per year for up to five years' worth of O&M funding for each existing or planned station, once operational. As of September 2018, 34 stations have been eligible for this funding, and 10 of these stations have billed for the maximum allowable amount of $300,000. Stations that operate without O&M support can face an average annual operating loss of up to $218,000, and this must be paid with private capital to keep the station operational. In the long term, station operators must increase hydrogen fuel sales to eliminate operating loses, and this is possible only through greater FCEV deployment by automakers.

Other Sources of Project Support

In September 2018, CARB adopted Resolution 18-34 that modifies the LCFS to allow hydrogen refueling stations to earn hydrogen refueling infrastructure (HRI) credits based on the capacity of the hydrogen station, in addition to credits earned for the fuel dispensed.[57, 58] These credits will provide a subsidy to hydrogen refueling station owners that can supplant Energy Commission O&M funding, thereby increasing the amount of ARFVTP funding available for new station construction. The expected value of these proposed HRI credits and the duration of the incentive exceed what can be offered through the ARFVTP, and this should have the effect of reducing investment risk and providing a stable source of operating capital. The Energy Commission will continue discussions with CARB and stakeholders to ensure that all available funding for hydrogen refueling is used in the most effective manner for encouraging early FCEV adoption.

The California Fuel Cell Partnership (CaFCP) has supported the growth of hydrogen as a transportation fuel since the partnership's inception in 1999. Members of the CaFCP have worked with local fire departments and the California Office of the State Fire Marshal to develop emergency response guides for hydrogen vehicles. The CaFCP has also trained first responders since 2002 on how to respond to fuel cell electric vehicles and hydrogen stations. In addition, to keep FCEV drivers informed of the real-time availability of the hydrogen fueling network, the CaFCP developed the Station Operational Status System mobile Web application.[59] This application provides status information for hydrogen refueling stations to consumers, allowing them to avoid stations with insufficient fuel or offline equipment.

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57 California Air Resources Board resolution 18-34 information is available at https://www.arb.ca.gov/fuels/lcfs/rulemakingdocs.htm

58 This modification to the LCFS provides credits to hydrogen refueling station owners for 15 years, with the credits being calculated based on the nameplate capacity of the station not to exceed 1,200 kilograms of hydrogen per day, and the availability (or uptime) of the station relative to the permitted hours of operation. The amount of dispensed hydrogen is subtracted from the calculation of HRI credits so that credits are not double-earned.

59 The Station Operational Status System is available at https://m.cafcp.org/.

Related State Policy

Assembly Bill 8 requires CARB to evaluate the need annually for additional publicly available hydrogen fueling stations. This evaluation includes the quantity of fuel needed for the actual and projected number of hydrogen-fueled vehicles (based on DMV registrations and automaker projections), geographic areas where fuel will be needed, and station coverage. Based on this evaluation, CARB reports to the Energy Commission the number of stations, geographic areas where additional stations will be needed, and minimum operating standards, such as number of dispensers, filling protocols, and pressure. CARB determines station and fuel cell electric vehicle projections for up to six years in the future, based on mandatory survey information provided by vehicle manufacturers for the next three model years and voluntary information for an additional three following model years.

CARB released the *2018 Annual Evaluation of Fuel Cell Electric Vehicle Deployment & Hydrogen Fuel Station Network Deployment* report in July 2018 to comply with the requirements of Assembly Bill 8.[60] In this latest assessment, CARB found that California's hydrogen refueling network is continuing to mature with sustained growth in the number of operational refueling stations, and that recent station development progress has remained almost completely on schedule. Manufacturer surveys project 47,200 FCEVs will be on California roads by the end of 2024. CARB also conducted a scenario analysis for the report, which looked at the station deployment needed through 2030 to ensure up to 1 million FCEVs can be deployed in California, providing at least basic coverage to all communities and a capacity sufficient to meet projected FCEV deployment.

In December 2017, the Energy Commission and CARB released the *Joint Agency Staff Report on Assembly Bill 8: 2017 Annual Assessment of Time and Cost Needed to Attain 100 Hydrogen Refueling Stations in California.*[61] This annual joint report evaluates progress in establishing a network of 100 hydrogen refueling stations, the factors affecting timely station development, the time and public funding needed to reach the 100-station milestone in the *2016 ZEV Action Plan*, and the ability of the hydrogen refueling network to serve the anticipated 37,400 FCEVs projected by the end of 2023.

The joint report found that overall hydrogen refueling station development time has decreased from an average of more than four years for stations funded in 2009 to less than two years for the stations funded in 2013. In addition, the costs for hydrogen refueling stations have decreased from an average of $8,700 per kilogram of installed hydrogen refueling capacity in 2014 to $6,400 in 2016. Based on the analysis conducted

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60 California Air Resources Board. July 2018. 2018 *Annual Evaluation of Fuel Cell Electric Vehicle Deployment & Hydrogen Fuel Station Network Development*. Available at https://www.arb.ca.gov/msprog/zevprog/ab8/ab8_report_2018_print.pdf.

61 Baronas, Jean, Gerhard Achtelik, et al. 2017. *Joint Agency Staff Report on Assembly Bill 8: 2017 Annual Assessment of Time and Cost Needed to Attain 100 Hydrogen Refueling Stations in California.* California Energy Commission and California Air Resources Board. Publication Number: CEC-600-2017-011. Available at http://www.energy.ca.gov/2017publications/CEC-600-2017-011/CEC-600-2017-011.pdf.

for the report, Energy Commission and CARB staff expects that the *2016 ZEV Action Plan* goal to build an initial network of 100 hydrogen refueling stations can be achieved with an additional ARFVTP investment of $70 million. Achieving the 200 station goal set by Executive Order B-48-18, however, will require significant additional funding.

Summary

As the market for hydrogen fuel matures and station developers become more experienced, the percentage of the total cost of hydrogen station capital expenses needed to be paid for by the ARFVTP may decrease. Capital expenses may also decrease as more stations are installed and equipment manufacturers are able to achieve economies of scale. To maximize the effectiveness of ARFVTP funding, the Energy Commission may alter the requirements and funding structure of future solicitations, such as offering incentives for higher-capacity and more cost-effective stations. The Energy Commission may also consider alternative financing mechanisms and options to encourage private investment as the market for hydrogen fuel matures. Legacy stations with outdated or inoperable equipment may also be eligible for upgrade funding to return the stations to full usability.

For FY 2019-2020, Energy Commission staff proposes a $20 million allocation for hydrogen refueling infrastructure, which is the maximum allocation allowable under current law.[62] With this funding restriction, Energy Commission staff analysis predicts that the ARFVTP will be able to fund a statewide network of up to 110 hydrogen refueling stations that will be operational by the end of 2024. These stations are expected to be able to provide fueling for between 46,900 and 59,300 FCEVs, which should be adequate to support the number of FCEVs that CARB predicts will be on the roads in 2024.

Manufacturing and Workforce Development

New and emerging technologies can simplify, accelerate, and reduce the cost of the state's deployment of zero-emission vehicle infrastructure. These new technologies often face a long path to commercialization, beginning with research and development, progressing to prototyping, advancing to demonstrations, and finally achieving commercialization and technological maturity. In later stages, product commercialization requires substantial capital to sustain low-volume production. During this time, the technology must gain market acceptance by consumers, and the production process must attain financial margins capable of sustaining business operations and growth. Moreover, companies must also address their workforce needs while scaling growth to bring products and services forward.

In May 2018, the Energy Commission hosted a discussion roundtable focused on zero-emission infrastructure manufacturing. The discussion centered on actions that California state and local government could take to expand or recruit California-based

62 California Health and Safety Code Section 43018.9.

manufacturing into the ZEV infrastructure supply chain. Subsequently, in August 2018, the Energy Commission hosted a public technology merit review workshop to highlight lessons learned from previous ARFVTP funding awards. The workshop also explored challenges and opportunities faced by ZEV manufacturers, ZEV infrastructure manufacturers, and ZEV supply chain component manufacturers in California. Participants also discussed as the workforce development needs relating to existing and future ARFVTP manufacturing projects.[63]

Manufacturing Overview

Funding support is critical at all stages of product, manufacturing, and business development to successfully bring emerging technologies to market. The Energy Commission, through the ARFVTP, has provided significant support to expand the in-state manufacturing capacity of zero-emission vehicles and components. California leads the nation in venture capital funding for clean transportation technologies, with 87 percent of these investments nationwide being made in California in 2016.[64] Grant funding from the ARFVTP and the CARB Low Carbon Transportation Investments continues to support demonstration and deployment of alternative fuel vehicles, technologies, and infrastructure.

Despite the financial and technical support available to advanced transportation technology manufacturers, early stage companies often struggle to transition from producing demonstration products to achieving full commercialization. This challenge is often because of low volume sales and a lack of available capital to support growth from the private and public sectors, commonly referred to as the commercialization "Valley of Death."[65] At this stage, companies have demonstrated the technical validity and viability of their products but now must prove that the manufacturing process is economical and viable. To do this requires significant capital, which traditional investors and financiers may be unwilling to provide because of the high-risk nature of early commercial technologies. Additional sources of funding, such as ARFVTP grants, can help reduce this risk and encourage lenders and investors to invest as well.

The Energy Commission has invested more than $43 million in 21 in-state manufacturing projects that support the goals of the ARFVTP. These investments often encourage the siting or expansion of manufacturing plants in California, creating jobs, and supporting the in-state production of zero- and near-zero-emission vehicles and vehicle components. The most recent manufacturing solicitation, PON-14-604, was

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63 More information on these workshops is available at http://www.energy.ca.gov/altfuels/2015-MISC-04/documents/.

64 Thornberg, Christopher, Hoyu Chong, and Adam Fowler (Beacon Economics). 2017. *California Green Innovation Index 9th Edition*. NEXT 10.

65 Bloomberg New Energy Finance. *Crossing the Valley of Death*. June 21, 2010.

issued in 2015 and focused on advanced vehicle technology manufacturing and proposed awards totaling $10 million for factories that produce complete vehicles or vehicle components.

ChargePoint, Inc. is an example of a zero-emission vehicle infrastructure manufacturing project that received ARFVTP support. The company received a $1.1 million grant from the Energy Commission to develop hardware, software, and manufacturing methods for a communications processor for electric vehicle charging stations. The processor provides smart grid and peak load management functions to reduce GHG emissions by regulating the electricity demand load of the charger, which also reduces the cost of charging by charging at the most economical time. ChargePoint placed the communications processor in commercial production after completing the project.

Workforce Overview

The Energy Commission has also provided significant investments for the training and development of California's alternative fuel workforce through the ARFVTP. Workforce efforts funded by the ARFVTP have grown in size and scope with expanded programs from partner agencies, as well as efforts from new partner agencies. Demand for workforce training and development in alternative transportation remains robust across many technology types, and Energy Commission staff is continuing to engage new organizations and industry partners through the ARFVTP to train, develop, and support a qualified alternative transportation workforce.

Beginning in 2009, the Energy Commission partnered with the Employment Development Department, Employment Training Panel, and the California Community Colleges Chancellor's Office (CCCCO) with the intent of providing for and better understanding the state's alternative transportation workforce needs. In addition to growing work within those agencies, the Energy Commission contracted with the Advanced Transportation and Logistics Initiative (ATL Initiative; formerly the Advanced Transportation and Technology Energy Centers), an initiative of CCCCO. The ATL Initiative is hosted by California community college districts that serve the alternative transportation needs for community colleges across the state. The first ATL Initiative agreement, hosted by the San Diego Community College District, awarded multiple California community colleges with funds to purchase specialty equipment required for essential hands-on training and advanced technical training for instructors and trainers to stay at the forefront of ever-evolving technologies. The second ATL Initiative agreement, with the Cerritos Community College District, focuses on developing a high school clean transportation career pilot program for underserved communities.

The CCCCO, in coordination with Mission College, is working on internships, preapprenticeships, and apprenticeships for transit agency programs using ARFVTP funding. This new transit training apprenticeship model is designed to meet the growing demand for transit workers with alternative fuel and vehicle expertise. The California Workforce Development Board proposes the development of a transferable model that will be available across California's multiple local Workforce Development Boards. These

efforts benefit greatly from leveraged funding through the Governor's Office to the colleges for a strong workforce initiative.

Summary

For FY 2019-2020, Energy Commission staff proposes a $5 million allocation for this category, based on the projected need for funding to support manufacturing and workforce development of the zero-emission vehicle infrastructure industry in California. This allocation will complement the efforts of other government programs that focus on manufacturing and workforce for zero-emission vehicles. Manufacturing projects funded under this allocation are expected to produce components and infrastructure that directly achieve the air quality, greenhouse gas emission, and petroleum use reduction goals of the ARFVTP. This funding can also provide incentives for companies to expand manufacturing projects in California and cultivate a California-based supply chain for advanced technology and zero-emission vehicle infrastructure products. Energy Commission staff will also continue to coordinate with workforce agencies, companies, and new workforce partners to determine the most beneficial and effective use of this funding.

Supporting Project Types

The Energy Commission has provided funding to other project types that can indirectly achieve the goals of the ARFVTP, including emerging opportunities projects and regional alternative fuel readiness plans. The Emerging Opportunities allocation was created to fund project types that were not anticipated during the development of the investment plan, as well as to provide matching funds for projects seeking federal funding. The Regional Alternative Fuel Readiness Planning allocation provided a funding source for planning efforts that prepare for and expedite the deployment of alternative fuel infrastructure and vehicles.

The Energy Commission has provided 11 grants and contracts totaling $19.5 million through the Emerging Opportunities category. These agreements include a variety of projects, such as the research and development of innovative renewable fuel production methods and the development and demonstration of unique zero-emission vehicle types. In addition, Emerging Opportunities funding has been used to augment solicitations, such as the intelligent transportation systems activities funded under solicitation GFO-15-604 for freight transportation projects at California seaports.

The Energy Commission has also conducted six grant solicitations for regional readiness planning, providing $11.4 million for 52 agreements to prepare for and expedite the deployment of alternative fuel infrastructure and vehicles. Since the first regional readiness planning projects were approved in 2011, the zero-emission vehicle sector has matured significantly. Most regions in California have developed regional readiness plans because of this funding, and the plans have aided the deployment of the first generation of zero-emission vehicles and the continued deployment of charging and

refueling infrastructure. The need for these planning grants, however, has diminished because of the initial statewide success of ZEV deployment.

Education and outreach are also important for driving consumer demand for zero-emission vehicles and increasing awareness of charging and refueling infrastructure. The Energy Commission has provided funding for education and outreach projects directly through past investments in centers for alternative fuels and advanced vehicle technology and indirectly through support for regional alternative fuel readiness planning grants. Continuing education and outreach are undertaken by automakers, charging and refueling station operators, and industry groups through advertising and community engagement efforts.

Most recently, the Energy Commission released solicitation GFO-17-604 to provide grant funding for the EV Ready Communities Challenge competition. GFO-17-604 is the first phase of an expected two-phase effort that provided funds to develop replicable planning blueprints that identify the actions needed to accelerate the deployment of electrified transportation at the regional level. Twenty organizations applied for funding under GFO-17-604, and the Energy Commission provided a total of $2 million in grants to nine recipients. The organizations that successfully complete blueprints are expected to be able to apply for funding to implement the blueprints under the second phase of the EV Ready Communities Challenge.

For FY 2019-2020, Energy Commission staff does not propose dedicated funding for Emerging Opportunities or Regional Alternative Fuel Readiness Planning projects. These types of projects may be funded through the electric vehicle charging infrastructure or hydrogen refueling infrastructure allocations, if the need arises.

Summary of Zero-Emission Vehicle Infrastructure Allocations

Table 12: Proposed FY 2019-2020 Funding for Zero-Emission Vehicle Infrastructure

Electric Vehicle Charging Infrastructure Relevant Policy Goals: – GHG Reduction – Petroleum Reduction – Low-Carbon Fuel Standard – Air Quality – ZEV Regulations – Environmental Equity	$32.7 Million	$61.5 million decrease relative to FY 2018-2019*
Hydrogen Refueling Infrastructure Relevant Policy Goals: – GHG Reduction – Petroleum Reduction – Low-Carbon Fuel Standard – Air Quality – ZEV Regulations	$20 Million	No change relative to FY 2018-2019*
Manufacturing and Workforce Development Relevant Policy Goals: – GHG Reduction – Petroleum Reduction – Air Quality – Equitable Economic Development	$5 Million	$3.5 million decrease relative to FY 2018-2019
Total	**$57.7 Million**	

Source: California Energy Commission. *The FY 2018-2019 funding allocations for Electric Vehicle Charging Infrastructure and Hydrogen Refueling Infrastructure were most recently modified at an Energy Commission business meeting on October 3, 2018.

CHAPTER 4: Advanced Technology and Alternative Fuel Vehicle Support

Advanced Freight and Fleet Technologies

Freight and fleet vehicles serve as a pillar to the California economy, providing indispensable functions for domestic goods movement, international trade, public transit, and other essential services. ARFVTP funding in this sector has historically focused on medium- and heavy-duty vehicles, defined here as vehicles with a gross vehicle weight rating above 10,000 pounds. These vehicles represent a small share of California registered vehicle stock, accounting for about 1 million out of 31 million vehicles, or 3 percent; however, this small number of vehicles is responsible for about 23 percent of on-road GHG emissions in the state because of comparatively low fuel efficiency and high number of miles traveled per year.[66,67] Medium- and heavy-duty vehicles additionally account for nearly 60 percent of NO_X and 52 percent of $PM_{2.5}$ emissions from on-road transportation in California.[68] For these reasons, medium- and heavy-duty vehicles represent a significant opportunity to reduce GHG emissions and criteria emissions while focusing on a small number of vehicles. Nonroad freight vehicles, such as forklifts and other cargo handlers, have similar or supporting purposes and potential for emission reductions.

Technology Overview

Providing zero- and near-zero-emission options for freight and fleet vehicles can be challenging because the fuel and technology must be closely matched to the needs of the particular vehicle duty cycle and vocation. For example, low-emission solutions such as hybrid- or full battery-electric systems might be appropriate for urban delivery trucks with many stops and starts, but might not provide sufficient utility to long-haul trucks. Similarly, a battery-electric system might be appropriate for a vehicle that can regularly recharge, such as school buses or public transit buses, and may possess lower cost of ownership than a conventional fuel option. However, with present technology limitations, battery-electric systems may be inappropriate for trucks that have unpredictable operating hours or travel routes. Providing the right solution for the right

66 Based on analysis from California Energy Commission Energy Assessments Division, with data from the California Department of Motor Vehicles.

67 California Air Resources Board. June 22, 2018. *California Greenhouse Gas Inventory for 2000-2016.* Available at https://www.arb.ca.gov/cc/inventory/data/tables/ghg_inventory_scopingplan_sum_2000-16.pdf.

68 California Air Resources Board. "Almanac Emission Projection Data." Accessed August 17, 2018. https://www.arb.ca.gov/app/emsinv/2017/emssumcat_query.php?F_YR=2012&F_DIV=-4&F_SEASON=A&SP=SIP105ADJ&F_AREA=CA#7.

duty cycle is, therefore, a key element in reducing GHG emissions from this vehicle sector.

While these advanced technology vehicles are expected to provide significant GHG emission reductions and public health benefits, the vehicles have much higher differential costs than conventional gasoline or diesel vehicles. Public funding for these higher costs is justified not only by the per-unit emission reductions, but because supporting advanced technology vehicles at these early development stages increases the likelihood of further development. As these vehicle technologies and markets mature, owners and operators will be able to undertake larger demonstration and deployment projects. Eventually, the most promising and suitable vehicle technologies will reach commercial maturity, allowing the vehicles to have a significant impact on statewide GHG emissions and air pollution.

In 2015, the Energy Commission hosted a Lead Commissioner Technology Merit Review Workshop for medium- and heavy-duty vehicles. Manufacturers and assemblers of alternative fuel vehicles and components participated in the workshop, providing overviews of ARFVTP-funded projects and discussing the key elements of project success. The discussion indicated that many alternative-fueled vehicle types have progressed from the proof-of-concept phase to an early adopter phase of development, permitting sales to a larger market. This progression suggests that manufacturers have sufficiently developed these vehicles to move beyond small-scale demonstrations and have proceeded with larger deployment projects.

Many alternative-fueled freight and fleet vehicles also require specialized refueling infrastructure. While light-duty PEVs use standard Level 1, Level 2, or DC fast chargers, medium- and heavy-duty electric vehicles can require charging systems that provide significantly higher voltage and power levels. Medium- and heavy-duty PEV manufacturers have not yet agreed to standardize electric vehicle chargers, and some use specialized charging systems that can be significantly more expensive than light-duty counterparts. In addition, fleets may require dedicated refueling infrastructure in areas that cannot provide public access because of security or safety concerns. This specialized and dedicated electric charging refueling infrastructure can add significant cost and affect the financial viability of alternatively fueled vehicle projects.

Nonpropulsion projects, such as intelligent transportation systems, congestion mitigation strategies, and autonomous vehicles, may also present opportunities to significantly reduce GHG emissions and air pollution from freight and fleet vehicles. Such projects can reduce emissions and fuel use without requiring alternative fuel systems or be paired with alternative fuels and vehicles for an even greater impact.

ARFVTP Funding to Date

The Energy Commission has provided more than $125 million in ARFVTP funding for a wide variety of alternative fuel and advanced technology powertrains that can be incorporated into California trucks and buses. Table 13 summarizes the portfolio of

advanced technology freight and fleet vehicle and infrastructure projects supported through the ARFVTP.

Table 13: Advanced Freight and Fleet Vehicle Projects Supported by ARFVTP

Vehicle/Technology Type	# of Vehicles	ARFVTP Funding (in Millions)
Medium-Duty Hybrids, PHEVs and BEVs	132	$13.1
Heavy-Duty Hybrids, PHEVs and BEVs	78	$48.2
Electric Buses	35	$14.2
Natural Gas Trucks	51	$19.1
Fuel Cell Trucks and Buses	13	$14.5
Vehicle-to-Grid	6	$7.7
Off-Road Hybrids	2	$4.5
E85 Hybrids	1	$3.0
Intelligent Transportation Systems	110	$2.0
Total	**428**	**$126.3**

Source: California Energy Commission

The most recent solicitation for advanced freight and fleet technology demonstration projects, GFO-17-603, was released in December 2017. The solicitation provided more than $23 million to three projects that will install electric vehicle charging infrastructure or hydrogen refueling infrastructure for freight vehicles at California seaports, regional warehouses, and freight distribution centers. Four additional qualifying proposals requesting $24.9 million were received but not funded.

The large power sources in medium- and heavy-duty battery and fuel cell electric vehicles may be able to serve as a vehicle-to-grid asset for load balancing and disaster response. To assess the economic and technical viability of PEVs participating in vehicle-to-grid services, the Energy Commission funded a vehicle-to-grid demonstration project at the Los Angeles Air Force Base. The demonstration project converted a portion of the nontactical vehicle fleet to PEVs that are capable of optimizing vehicle-grid interactions to capitalize on demand response and ancillary services markets. Data collected from this project will support the vehicle-to-grid use of PEVs and associated technologies in California.

With a growing awareness of the economic and environmental challenges facing California's ports, the Energy Commission formed the Ports Energy Collaborative to engage with various ports throughout California as they develop and implement sustainable practices. Participants include the Ports of Hueneme, Long Beach, Los Angeles, Oakland, and San Diego. The Ports Energy Collaborative gives port representatives and Energy Commission staff the opportunity to coordinate collectively and share lessons learned from clean transportation projects. Participants work on key

projects in areas including energy conservation and efficiency measures; renewable generation; and zero- and near-zero emission vehicles and equipment.

Other Sources of Funding

Other state programs provide funding for the vehicle types discussed in this section, though often at different stages of commercialization and at different scales. The Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP), administered by CARB, provides deployment incentives for hybrid, battery-electric, fuel cell, and low-NO_X trucks and buses. Since 2010, CARB has allocated over $300 million in incentives. Through June 2018, HVIP has provided vouchers to help California fleets purchase 1,264 zero-emission trucks and buses, 2,392 hybrid trucks, and 1,015 vehicles with low-NO_X engines. [69] CARB's approved *FY 2018-2019 Funding Plan Clean Transportation Incentive*s includes an additional $125 million allocation for clean truck and bus vouchers through HVIP, with continuing funding for hybrid, battery-electric, fuel cell, and low-NO_X engines. The approved 2018-19 funding plan also includes a $55 million allocation for Freight Equipment Advanced Demonstration and Pilot Commercial Deployment Projects. The $55 million will be used to fund additional projects from the oversubscribed $150 million Zero- and Near Zero-Emission Freight Facilities Project competitive solicition held in 2018 using fiscal year 2017-18 funds. Investments from the ARFVTP and the Clean Transportation Incentives complement each other to help achieve the state's greenhouse gas emission reduction targets in the freight and fleet vehicles sectors.

Senate Bill 350 (De León, Chapter 547, Statutes of 2015) established new goals to reduce greenhouse gas emissions and air pollution for 2030 and beyond. This legislation tasked the CPUC with directing investor-owned utilities to submit applications to support widespread transportation electrification. PG&E, SCE, and SDG&E submitted more than $790 million in proposals for a variety of infrastructure projects for medium- and heavy-duty vehicles and equipment, and in January and May 2018, the CPUC approved $592 million of these proposals. The resulting projects are expected to support the electrification of at least 15,000 medium- and heavy-duty vehicles at transit agencies, ports, and warehouses. [70] Though this is a significant investment, the total funding needed in this sector to attain state air quality and climate change goals is far greater.

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69 California Air Resources Board. September 21, 2018. *Proposed Fiscal Year 2018-2019 Funding Plan for Clean Transportation Incentives.* Available at: https://www.arb.ca.gov/msprog/aqip/fundplan/proposed_1819_funding_plan.pdf.

70 California Public Utilities Commission. May 31, 2018. *Summary of Decision on Transportation Electrification Program Proposals from the Investor-Owned Utilities.* Available at http://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=6442457607.

The Ports of Long Beach and Los Angeles estimate that more than $1.5 billion in infrastructure investments will be needed to fully electrify their freight terminals.[71]

Related State Policy

Executive Order B-32-15, issued by Governor Brown in 2015, noted the effects that freight transportation has on GHG emissions and air quality and ordered the development of the *California Sustainable Freight Action Plan*. The plan, released in 2016, discusses potential statewide actions to improve freight efficiency, transition to zero-emission technologies, and increase the competitiveness of the California freight system. The Energy Commission is also working in collaboration with six ports throughout California to identify and implement transportation project concepts that will help attain California's climate and clean air goals while meeting the needs of the ports. This category is expected to be the primary source of Energy Commission funding support for *Sustainable Freight Action Plan* strategies and ports collaborative activities.

Summary

To meet state GHG and air quality goals, this sector will need to transition to zero- and near-zero-emission technologies, and the resources required for this transition far exceed available funding. Energy Commission staff expects an increasing demand for dedicated charging and refueling infrastructure for alternative fuel and advanced technology freight and fleet vehicles funded through this category and by other state incentives programs. As the state's lead agency for fueling infrastructure deployment, the Energy Commission will take into account the need to develop this infrastructure alongside the vehicles.

For FY 2019-2020, Energy Commission staff proposes a $17.5 million allocation for this category to continue to support the demonstration and deployment of advanced technology freight and fleet vehicles and infrastructure. Staff intends to balance the need to continue vehicle demonstration projects while taking into account similar funding available from other sources and an increasing need for charging and refueling infrastructure. Staff expects that funding from this category will also be necessary to address Energy Commission-specific actions outlined in the *California Sustainable Freight Action Plan* and to help achieve GHG and air pollution reduction goals. These projects may include propulsion and nonpropulsion aspects, such as alternative-fueled vehicles, infrastructure, and other advanced freight technologies.

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71 EnSafe Inc. July 2017. *San Pedro Bay Ports Clean Air Action Plan 2017 Preliminary Cost Estimates for Select Clean Air Action Plan Strategies*. Available at http://www.cleanairactionplan.org/documents/clean-air-action-plan-costing-report-final.pdf.

Natural Gas Vehicles and Infrastructure

Natural gas vehicles and fueling infrastructure are commercially mature alternative transportation technologies, and a significant number of these vehicles have already been deployed in California. Nearly 19,000 medium- and heavy-duty natural gas vehicles operate in California, making this fuel type the most common alternative fuel vehicle in each of these vehicle classes.[72] California leads the nation in the number of compressed natural gas (CNG) and liquefied natural gas (LNG) fueling stations, with 328 public or private CNG stations and 46 public or private LNG stations.[73] Low-carbon biomethane and the latest natural gas engine emission control technologies can also provide substantial reductions in greenhouse gas and criteria pollutant emissions compared to a conventional diesel truck.

Technology Overview

In 2015, CARB readopted the LCFS, which included a switch from the California Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation Model (CA-GREET) 1.8b to CA-GREET 2.0. As part of the revised calculations in CA-GREET 2.0, the carbon intensity values for conventional natural gas increased because of higher pipeline energy intensity, higher methane leakage estimates, and higher tailpipe emissions.[74] Using the CA-GREET 2.0 model, conventional natural gas offers modest GHG reductions of about 14 percent compared to gasoline and diesel.[75]

The life-cycle GHG emissions of natural gas vehicles can be significantly reduced with the use of biomethane, which has some of the lowest carbon intensity values established by the LCFS. Biomethane from wastewater biogas offers life-cycle GHG emission reductions of as much as 92 percent compared to diesel, while biomethane derived from high-solids anaerobic digestion can reduce life-cycle GHG emissions by upward of 125 percent.[76] Biomethane derived from dairy biogas has the lowest carbon intensity

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72 Based on analysis from the California Energy Commission Energy Assessments Division, with data from the California Department of Motor Vehicles.

73 U.S. Department of Energy Alternative Fuels Data Center. "Alternative Fuel Station Locator." Accessed August 20, 2018. Available at http://energy.gov/maps/alternative-fueling-station-locator.

74 CA-GREET 1.8b lists EER-adjusted (0.9 EER for spark-ignition natural gas) carbon intensity values of 98.03 gCO_2e/MJ for ultra-low-sulfur diesel and 75.57 gCO_2e/MJ for North American CNG. Data obtained from the California Air Resources Board's "CA-GREET 1.8b versus 2.0 CI Comparison Table," available at http://www.arb.ca.gov/fuels/lcfs/lcfs_meetings/040115_pathway_ci_comparison.pdf.
CA-GREET 2.0 lists EER-Adjusted (0.9 EER for spark ignition natural gas) carbon intensity values of 102.01 gCO_2e/MJ for ultra-low-sulfur diesel and 87.08 gCO_2e/MJ for North American CNG. Data obtained from the "Low Carbon Fuel Standard Final Regulation Order," available at https://www.arb.ca.gov/regact/2015/lcfs2015/finalregorderlcfs.pdf.

75 Ibid.

76 California Air Resources Board. 2015. "Low Carbon Fuel Standard Final Regulation Order (Table 6)." Available at http://www.arb.ca.gov/regact/2015/lcfs2015/finalregorderlcfs.pdf.

approved under the LCFS; approximately 255 grams of carbon dioxide equivalent greenhouse gases per megajoule.[77] Use of biomethane as a transportation fuel has steadily increased, averaging 67 percent of the total reported natural gas volume under the LCFS for 2017.[78]

The potential of biomethane as a transportation fuel may ultimately be limited, however, because of the finite amount that can be produced from waste-based feedstocks. A 2017 analysis conducted by the Union of Concerned Scientists suggests that capturing biomethane from all potential sources of organic waste in California may be able to supply roughly 3 percent of the state's total demand for natural gas, or supplant 15 percent of diesel fuel use in California.[79] Other past analyses have determined a similar or greater potential for biomethane production in the state. Given that the supply of this very-low-carbon fuel is limited, the associated carbon reduction benefits can be maximized by prioritizing the use of this fuel in transportation and other applications for which no alternative is available.

Natural gas vehicles may also offer the opportunity for reducing criteria pollution emissions. In 2013, CARB adopted an optional reduced-NO_X emission standard for heavy-duty vehicles that can encourage engine manufacturers to demonstrate their emission reductions. The standard includes NO_X levels that are 50, 75, and 90 percent lower than the current 0.20 grams per brake horsepower-hour emission standard.

In 2015, Cummins Westport Inc. became the first natural gas engine manufacturer to receive emission certifications from both the U.S. EPA and CARB at a level of 0.02 grams NO_X per brake horsepower-hour, which is equal to a 90 percent reduction in NO_X emissions compared to existing emission standards.[80] These engines, referred to as low-NO_X engines, are now available for purchase and have the potential to support the market deployment of near-zero-emission medium- and heavy-duty natural gas trucks. By using biomethane and low-NO_X engines, natural gas trucks have the potential to reduce life-cycle criteria pollutant and GHG emissions to levels near those of BEVs and FCEVs.

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77 California Air Resources Board. October 31, 2018. *LCFS Pathway Certified Carbon Intensities.* Available at https://www.arb.ca.gov/fuels/lcfs/fuelpathways/pathwaytable.htm.

78 California Air Resources Board. July 31, 2018. *LCFS Quarterly Data Spreadsheet.* Available at http://www.arb.ca.gov/fuels/lcfs/lrtqsummaries.htm.

79 Union of Concerned Scientists. May 2017. *The Promises and Limits of Biomethane as a Transportation Fuel.* Available at https://www.ucsusa.org/sites/default/files/attach/2017/05/Promises-and-limits-of-Biomethane-factsheet.pdf.

80 Cummins Westport Inc. October 5, 2015. *ISL G Near Zero Natural Gas Engine Certified to Near Zero - First MidRange Engine in North America to Reduce NO_X Emissions by 90% From EPA 2010.* Available at http://www.cumminswestport.com/press-releases/2015/isl-g-near-zero-natural-gas-engine-certified-to-near-zero.

The differential upfront costs for natural gas engines vary significantly by engine size and supplier and can be up to tens of thousands of dollars. As a result, natural gas engines are most economical in vehicle applications where fuel costs constitute a higher share of overall vehicle costs, such as heavy-duty trucks that travel tens of thousands of miles per year. To offset the additional upfront costs, natural gas must be obtained at a lower price than gasoline or diesel fuel. When natural gas is significantly cheaper than diesel fuel, as was the case in 2014, the payback period for investing in a natural gas powered vehicle can be two years or less. Lower relative petroleum fuel prices, however, can extend the payback period or make natural gas a more expensive option. Extended volatility in diesel fuel prices has often resulted in a low, and at times unfavorable, price difference for natural gas, and this impacts the cost-effectiveness of natural gas vehicles. As a result, vehicle owners may be less likely to shift to CNG, while the price of petroleum fuels remains low. Fleets, however, may be able to obtain significantly lower CNG prices than those offered at retail stations by contracting directly with local natural gas providers.[81]

The cost of a natural gas fueling station depends on many factors, including compressor size, storage capacity, and liquefied natural gas (LNG) or compressed natural gas (CNG) dispensing capabilities. Costs generally range from as little as $500,000 for smaller CNG-only stations to several million dollars for larger fueling stations or combined LNG-CNG stations. Particularly in the case of private stations for fleets, the cost of installing a natural gas fueling station can be built into the long-term fuel savings that result from switching to natural gas vehicles, assuming natural gas can be obtained at a lower price than gasoline or diesel fuel. Other financing methods, such as the Compression Services Tariff offered by the Southern California Gas Company (SoCalGas), are also available. This tariff allows SoCalGas to plan, design, procure, construct, own, operate, and maintain compression equipment on customer premises in exchange for a fee on natural gas dispensed. Because the cost of compressors can range from 25 to 50 percent of the total station cost, financing methods such as this may be a viable solution to pay for station costs.

ARFVTP Funding to Date

The ARFVTP has provided significant support for the deployment of natural gas vehicles, as summarized in Table 14. Two large awards for natural gas vehicle deployment came from the ARFVTP cost-sharing of successful projects under the American Recovery and Reinvestment Act of 2009. Subsequently, the Energy Commission released three solicitations (PON-10-604, PON-11-603, and PON-13-610) that offered first-come, first-served buydown incentives for the sale of natural gas cars and trucks. Vehicle incentives were tailored to vehicle weight classes, to reflect the increasing incremental costs of natural gas vehicles as gross vehicle weight (GVW)

81 U.S. Department of Energy. April 2018. *Clean Cities Alternative Fuel Report.* Available at https://www.afdc.energy.gov/uploads/publication/alternative_fuel_price_report_april_2018.pdf.

increases. As a result, these investments favored heavier-duty vehicle classes (both in terms of numbers and funding), which offer the largest per-vehicle opportunities for petroleum displacement.

Beginning in 2015, the Energy Commission provided ARFVTP incentives for the purchase of natural gas vehicles through the Natural Gas Vehicle Incentive Project (NGVIP), which is administered by the Institute of Transportation Studies at the University of California, Irvine. Similar to prior solicitations, the NGVIP provides incentives on a first-come, first-served basis at varying levels, depending on the gross vehicle weight. Unlike previous incentive programs, however, the NGVIP provides the incentives directly to vehicle purchasers. Of the $21.8 million available for incentives, about $18.3 million of incentive funds were paid by September 2018, with the remaining $3.5 million reserved.

In May 2018, the Energy Commission awarded $8 million each to the San Joaquin Valley Unified Air Pollution Control District and the South Coast Air Quality Management District to support existing incentive programs for natural gas vehicles. Energy Commission staff expects these incentives will support the purchase of at least 220 natural gas vehicles.

Table 14: ARFVTP Funding for Natural Gas Vehicle Deployment

Funding Agreement or Solicitation	Vehicle Type	# of Vehicles	ARFVTP Funding (in Millions)
Federal Cost-Sharing Projects (ARV-09-001 and ARV-09-002)	Heavy-duty trucks	334	$15.4
Buydown Incentives (PON-10-604, PON-11-603, and PON-13-610)	Up to 8,500 GVW	362	$0.9
	8,501-16,000 GVW	437	$4.9
	16,001-26,000 GVW	136	$2.1
	26,001-33,000 GVW	53	$1.5
	33,001 GVW and up	746	$20.2
Natural Gas Vehicle Incentive Project*	Up to 8,500 GVW	0	$0.0
	8,501-16,000 GVW	64	$0.4
	16,001-26,000 GVW	64	$0.7
	26,001-33,000 GVW	17	$0.3
	33,001 GVW and up	694	$17.4
	TBD	TBD	$3.0
California Air District Natural Gas Vehicles (GFO-17-605)	TBD	220	$16.0
Total		**3,127+**	**$82.8**

Source: California Energy Commission. *Total budget for NGVIP agreement is $23.7 million, including administrative costs.

To date, the ARFVTP has provided nearly $22 million toward the installation or upgrade of about 64 natural gas fueling stations. Of this, about $11.3 million (51 percent) will go toward 31 stations in disadvantaged communities. The most recent solicitation for natural gas fueling infrastructure projects, GFO-16-602, made $3.5 million available to public K-12 school districts in California. This solicitation was undersubscribed, as the Energy Commission received four applications, and only three were eligible and awarded a total of $1.5 million.

Other Sources of Funding

CARB funds low-NO_X natural gas vehicles through its Low Carbon Transportation Investments. The approved *FY 2018-2019 Funding Plan for Clean Transportation Incentives* includes low-NO_X natural gas vehicles as well as zero-emission and hybrid vehicles as an eligible powertrain under the Clean Truck and Bus Voucher project, for which CARB staff proposes allocating $125 million. As of June 2018, CARB has provided an incentives for 1015 low-NO_X vehicles.[82]

Incentives for natural gas vehicles are also provided by the Carl Moyer Memorial Air Quality Standards Attainment program, which is administered by local California air districts. Funding priorities for the Carl Moyer program are determined by each air district, and the amount spent on natural gas vehicle projects varies by year. In the period covering FY 2010-2011 through FY 2016-2017, California air districts provided an average of about $1 million annually for natural gas vehicles through the Carl Moyer program.[83]

Related State Policy

In response to growing supply and demand for natural gas, the Legislature passed Assembly Bill 1257 (Bocanegra, Chapter 749, Statutes of 2013), also referred to as the Natural Gas Act. This law tasks the Energy Commission with developing a report to "identify strategies to maximize the benefits obtained from natural gas, including biomethane…, as an energy source, helping the state realize the environmental costs and benefits afforded by natural gas."[84] These strategies include the use of natural gas as a fuel within the transportation sector. The Energy Commission held two workshops in 2015 to seek comments on how natural gas and biomethane will affect the

82 California Air Resources Board. June 1, 2018. *Fiscal Year 2018-19 Funding Plan for Clean Transportation Incentives Discussion Document*. Available at https://www.arb.ca.gov/msprog/aqip/fundplan/060118_discussion_doc.pdf.

83 Based on analysis from California Air Resources Board MSCD Incentives and Technology Advancement Branch.

84 California Public Resources Code Section 25303.5(b).

transportation sector, as well as development of the 2015 AB 1257 report in general.[85] The first of these reports was completed 2015, and the report will be updated every four years thereafter.

CARB is in the process of developing low-NO_X engine standard for medium- and heavy-duty vehicles with an effective date of 2023.[86] More information about this possible new standard, as well as a CARB board hearing, is expected in 2019. The new standard, if adopted, may result in an increase in demand and a self-sustaining market for low-NO_X natural gas vehicles and other powertrains capable of achieving the emission standard.

Summary

For FY 2019-2020, Energy Commission staff does not propose allocating ARFVTP funding for natural gas vehicle incentives or infrastructure projects. Incentives for natural gas vehicles are available through the CARB Clean Truck and Bus Voucher Project and various California air district programs, and additional ARFVTP incentives for these vehicles would be redundant with these other funding sources. Potential applicants have also shown weak demand for natural gas fueling infrastructure funding in recent solicitations.

85 Presentations, comments, and the transcript from this workshop are available at http://www.energy.ca.gov/2014_energypolicy/documents/#06232014.

86 California Air Resources Board. March 7, 2017. *Revised Proposed 2016 State Strategy for the State Implementation Plan.* Available at https://www.arb.ca.gov/planning/sip/2016sip/rev2016statesip.pdf.

Summary of Advanced Technology and Alternative Fuel Vehicle Support Allocations

Table 15: Proposed FY 2019-2020 Funding for Advanced Technology and Alternative Fuel Vehicle Support

Advanced Freight and Fleet Technologies Relevant Policy Goals: – GHG Reduction – Air Quality – Petroleum Reduction – Low-Carbon Fuel Standard – Sustainable Freight Action Plan	$17.5 Million	No change relative to FY 2018-2019
Natural Gas Vehicles and Infrastructure Relevant Policy Goals: – Petroleum Reduction – Air Quality (with use of low-NO_X engines) – Low-Carbon Fuel Standard – GHG Reduction (with incorporation of biomethane)	-	No change relative to FY 2018-2019
Total	**$17.5 Million**	

Source: California Energy Commission

CHAPTER 5:
Alternative Fuel Production

Low-Carbon Fuel Production and Supply

The California transportation sector depends largely on petroleum, which accounts for 89 percent of ground transportation fuel used in the state.[87] Any low-carbon substitute fuel that can displace the roughly 14 billion gallons of petroleum-based gasoline and 3.3 billion gallons of petroleum-based diesel used per year in California can provide an immediate and long-term opportunity to reduce GHG emissions and petroleum use.[88] Biofuels – defined in this document as nonpetroleum diesel substitutes, gasoline substitutes, and biomethane – represent the largest existing stock of alternative fuel in the California transportation sector.[89] In addition, production of and demand for renewable hydrogen are expected to increase in the coming years as more hydrogen fuel cell electric vehicles are sold.

The carbon intensity of renewable fuels can vary significantly depending on the pathway, which accounts for the specific feedstock and production process of the fuel. CARB provides carbon intensity values for most transportation fuels as part of the LCFS. The carbon intensity value accounts for the life-cycle GHG emissions of the fuel, including production, transportation, and consumption, and is reported in grams of carbon dioxide equivalent greenhouse gases per megajoule (gCO_2e/MJ).[90] California reformulated gasoline and ultra-low-sulfur diesel have carbon intensities of 99.78 and 102.01 gCO_2e/MJ, respectively.[91] Maximizing renewable fuel production from the lowest carbon pathways represents a key opportunity to reduce near-term GHG emissions in combustion engines and fuel cell electric vehicles. Biofuels derived from waste-based feedstocks typically have the lowest carbon intensity of all transportation fuels.

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87 Based on analysis from California Energy Commission Energy Assessments Division, with data from the California Department of Motor Vehicles.

88 Ibid.

89 The term *gasoline substitutes* refers to any liquid fuel that can directly displace gasoline in internal combustion engines, including ethanol and renewable drop-in gasoline substitutes. The term *diesel substitutes* refers to any liquid fuel that can significantly displace diesel fuel, including biodiesel, renewable diesel, and renewably derived dimethyl ether (assuming fuel system modifications). These definitions differ from similar terms used by CARB under the LCFS, which are broader and include fuels such as electricity, natural gas, and hydrogen.

90 Consult the glossary for the definition of *megajoule*.

91 California Air Resources Board. August 18, 2017.*LCFS Fuel Pathway Table*. Available at https://www.arb.ca.gov/fuels/lcfs/fuelpathways/pathwaytable.htm.

Fuel Type Overview

Renewable Diesel and Biodiesel

In 2017, renewable diesel was the most common diesel substitute in California with 335 million gallons used, the majority of which was supplied through overseas imports.[92] Two renewable diesel production facilities are operating in California and produced 33 million gallons of renewable diesel fuel in 2017.[93] Renewable diesel that meets the fuel specification requirements of ASTM International Standard D975 is fungible, or interchangeable, with conventional diesel fuel and can be used in existing diesel engines and fuel infrastructure.

Biodiesel is another diesel substitute; however, unlike renewable diesel, it is not fully fungible with conventional diesel fuel. Many modern diesel vehicles can use biodiesel in concentrations ranging from 5 to 20 percent, depending on the requirements and limitations of the engine, without special modifications to the vehicle. CARB's Alternative Diesel Fuel Regulation allows biodiesel blends up to 5 percent to be sold without restriction. For biodiesel blends in excess of 5 percent, the regulation requires additional action, such as blending with additives, due to concerns with higher oxides of nitrogen (NO_X) emissions. Higher blends of biodiesel are commercially available; however, these may not be compatible with all retail infrastructure and may interfere with vehicle warranty provisions. In 2017, California biodiesel production plants produced 41 million gallons of biodiesel, and 171 million gallons of biodiesel were registered with the LCFS.[94, 95] Renewable diesel and biodiesel have carbon intensities up to 92 percent lower than diesel fuel, depending on the pathway used.[96] Together, renewable diesel and biodiesel accounted for about 44 percent of LCFS credits in 2017, increasing from 9 percent of LCFS credits in 2011.[97]

Some low-carbon fuels, such as biodiesel, require separate terminal blending, storage, and handling infrastructure to dispense fuel for delivery to wholesale and retail

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92 California Air Resources Board. July 31, 2018.*LCFS Quarterly Data Spreadsheet.* Available at http://www.arb.ca.gov/fuels/lcfs/lrtqsummaries.htm.

93 California Air Resources Board. April 25, 2018. *Share of Liquid Biofuels Produced In-State by Volume 2017.* Available at https://www.arb.ca.gov/fuels/lcfs/dashboard/figure10_042518.xlsx.

94 Ibid.

95 California Air Resources Board. July 31, 2018. *LCFS Quarterly Data Spreadsheet.* Available at http://www.arb.ca.gov/fuels/lcfs/lrtqsummaries.htm.

96 Compared to California diesel (102.01 gCO2e/MJ), with biodiesel carbon intensity as low as 8.63 gCO2e/MJ and renewable diesel carbon intensity as low as 16.89 gCO2e/MJ. Based on data from the LCFS Fuel Pathway Table (July 31, 2018), available at https://www.arb.ca.gov/fuels/lcfs/fuelpathways/current-pathways_all.xlsx.

97 California Air Resources Board. July 31, 2018. *LCFS Quarterly Data Spreadsheet.* Available at http://www.arb.ca.gov/fuels/lcfs/lrtqsummaries.htm.

customers. Industry stakeholders have noted that roughly 30 percent of existing bulk fuel storage racks and blending terminals in California are capable of blending biodiesel, and increasing the number of facilities able to blend alternative fuels with petroleum-based fuels will remove a significant barrier to distribution and use.[98] Energy Commission staff may consider funding opportunities for these types of infrastructure, as permitted by the funding source, to reduce market barriers for low-carbon fuel distribution.

Ethanol and Renewable Gasoline

Ethanol is the only widely available gasoline substitute, and it is used primarily as a fuel additive with gasoline. California limits ethanol blends in conventional gasoline to 10 percent, although the U.S. Environmental Protection Agency does permit blends of up to 15 percent. Though ethanol continues to be the largest volume alternative fuel used in California, in-state ethanol use has not substantially changed since 2011. California has the capacity to produce about 220 million gallons of ethanol per year within the state, using primarily corn as a feedstock.[99]

Flex-fuel vehicles (FFVs) are capable of running on higher blends of up to 85 percent ethanol and 15 percent gasoline, referred to as E85. About 1.8 million FFVs are registered in California, which, during 2017, used 23.9 million gallons of E85.[100] While sales of E85 continue to increase, E85 accounts for only about 1 percent of the total fuel used by FFVs and about 1 percent of total ethanol consumption in the state.[101]

Renewable gasoline is a potential gasoline substitute, although it is undergoing research and development and is not commercially available. Similar to renewable diesel, it will need to conform to relevant ASTM International standard specifications to operate in unmodified spark ignition (for example, gasoline) engines. The petroleum and GHG reduction potential from a low-carbon renewable gasoline would be enormous and has the potential to contribute significantly to the environmental and energy goals of the state. Similarly, renewable crude oil products can serve as a fully fungible substitute for petroleum crude oil at refineries. Renewable crude oil is in the research and development phase and, if developed into a commercially viable product, may contribute significantly to California's environmental and energy goals.

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98 Based on comments submitted by California Biodiesel Alliance to Energy Commission Docket 17-ALT-01, TN 221800. November 17, 2017.

99 Nebraska Energy Office. June 2018. *Ethanol Facilities Capacity by State and Plant.* Accessed August 17, 2018. Available at http://www.neo.ne.gov/statshtml/122.htm.

100 Based on analysis from the California Energy Commission Energy Assessments Division.

101 Ibid.

Biomethane

Biomethane is a commercially mature biofuel that serves as a low- or negative-carbon substitute for conventional natural gas. According to the most recently listed LCFS carbon intensity values, biomethane from anaerobic digestion of wastewater sludge can reduce GHG emissions by as much as 92 percent below diesel, and biomethane derived from high-solids anaerobic digestion of prelandfill food and green wastes possesses a negative carbon intensity roughly 125 percent below diesel.[102] Biomethane derived from dairy biogas has the lowest carbon intensity approved under the LCFS; approximately 255 grams of carbon dioxide equivalent greenhouse gases per megajoule.[103]

For gaseous fuels, such as biomethane, producers may have difficulty finding purchasers for the fuel, as biomethane cannot be economically transported by truck or rail, and the complexities and regulations associated with pipeline injection often make this option uneconomical for all but the largest projects. Most often, biomethane fuel must be distributed to vehicles at or very near the site of production, which can limit the potential of this fuel, especially in rural areas that lack infrastructure and existing natural gas vehicle fleets.

The Legislature passed SB 1383 with the intent to, among other things, support policies that improve the cost-effectiveness and environmentally beneficial uses of biomethane derived from solid waste. As part of this legislation, the CPUC is directing natural gas utilities to undertake at least five pilot projects to demonstrate pipeline injection of biomethane at California dairies. These pilot projects are expected to demonstrate the feasibility of these project types and provide a model to increase the use of biomethane fuel in California.

Renewable Hydrogen

Renewable hydrogen is a relatively new transportation fuel, as hydrogen fuel cell electric vehicles (FCEVs) have only recently become commercially available. The production methods, however, are commercially mature, and the fuel can be produced most commonly through steam reformation of biomethane or through electrolysis using water and renewable electricity. According to the California Independent System Operator, increasing amounts of renewable power generation may result in electricity oversupply as California renewable power requirements grow from 33 percent to 50 percent.[104] Renewable hydrogen production is being investigated as a viable technology for beneficial use of this surplus renewable energy. Several ARFVTP projects

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102 California Air Resources Board. 2015. *Low Carbon Fuel Standard Final Regulation Order (Table 6).* Available at http://www.arb.ca.gov/regact/2015/lcfs2015/finalregorderlcfs.pdf.

103 California Air Resources Board. October 31, 2018. *LCFS Pathway Certified Carbon Intensities.* Available at https://www.arb.ca.gov/fuels/lcfs/fuelpathways/pathwaytable.htm.

104 California Independent System Operator. April 29, 2016. *Flexible Resources to Help Renewables - Fast Facts.* Available at http://www.caiso.com/Documents/FlexibleResourcesHelpRenewables_FastFacts.pdf.

already use electrolysis to generate modest volumes of hydrogen at fueling stations. Potential renewable hydrogen production projects may include using renewable energy to produce large volumes of renewable hydrogen through electrolysis, or commercial-scale steam reformation plants that exclusively use biomethane as a feedstock.

Feedstock Availability

Feedstock availability must also be considered when determining the potential of biofuels. In 2016, the U.S. Department of Energy released Volume I of the *2016 Billion-Ton Report*, which assesses potential available biomass resources in the United States and analyzes associated economic and technological characteristics.[105] The report determined that California has the second highest available volume of any state of forest biomass, with 2.05 billion short tons across 32 million acres, though the majority is only moderately economically viable. Compared to other states, the report also identified the potential economic availability in California as high for waste resources and microalgae, low for dedicated biomass energy crops, and mixed for various crop residues. Volume II of the report, released in January 2017, addresses the environmental sustainability of various feedstock and processing scenarios.

ARFVTP Funding to Date

To date, the Energy Commission has awarded more than $160 million to 60 low-carbon fuel production projects. These awards are summarized by fuel type in Table 16.

Table 16: Summary of Low-Carbon Fuel Production Awards to Date

Fuel Type	Qualifying Proposals* Submitted	Funds Requested by Qualifying Proposals* (in Millions)	Awards Made	Funds Awarded (in Millions)
Gasoline Substitutes	25	$58.8	14	$29.5
Diesel Substitutes	56	$162.2	24	$68.3
Biomethane	45	$139.5	21	$61.3
Renewable Hydrogen	3	$11.9	1	$4.0
Total	**129**	**$372.4**	**60**	**$163.1**

Source: California Energy Commission. *Qualifying proposals refers to proposals that received at least a passing score.

The most recently completed solicitation for low-carbon fuel production projects, GFO-15-606, was released in 2016 and was open to community-scale and commercial-scale advanced biofuel production projects. The solicitation used a two-phase scoring process in which applicants were required to score at least 70 percent on a preapplication to be considered for funding. The Energy Commission received 50

105 The *2016 Billion-Ton Report: Advancing Domestic Resources for a Thriving Bioeconomy* is available at http://energy.gov/eere/bioenergy/downloads/2016-billion-ton-report-advancing-domestic-resources-thriving-bioeconomy.

preapplication proposals requesting $148.1 million. Twenty-one of these preapplications received a passing score, and 11 of these were selected for funding in Phase Two of the solicitation to receive a total of $38.5 million in awards.

Low life-cycle GHG emissions, as well as other sustainability considerations, have been a primary factor in determining ARFVTP funding for renewable fuel production projects. Table 17 shows a selection of the commercial-scale projects by fuel type that either received or are proposed to receive ARFVTP funding. While the pathway used for these projects may not have the lowest carbon intensity, the technologies used are sufficiently developed to allow for considerable annual production of at least several hundred thousand gallons of fuel per year.

Table 17: GHG Emission Reduction Potential of Commercial-Scale ARFVTP Projects

Fuel Type	Feedstock Descriptions	Average GHG Emission Reduction[106]	# of Projects	Range of Annual Capacity for Individual Projects	Total Annual Capacity Increase
Biomethane	Dairy manure; fats, oils, & grease; food, green, yard, & municipal waste	166%	10	140,000 – 2,870,000 DGE	8.5 Million DGE per Year
Diesel Substitutes	Waste oils* (various)	83%	15	1,928,311 – 20,000,000 DGE	106.4 Million DGE per Year
Gasoline Substitutes	Sugar beets; grain sorghum	47%	4	2,600,000 – 26,000,000 GGE	34.6 Million GGE per Year
Renewable Hydrogen	Renewable electricity & water	100%	1	750,000 GGE	0.7 Million GGE per Year

Source: California Energy Commission. *Several diesel substitute production projects will use a mixture of waste-based oils and conventional vegetable oils (for example, canola or soy).

ARFVTP low-carbon fuel production solicitations have also funded precommercial projects. Though these projects do not yet produce as much fuel as commercial-scale projects, precommercial projects focus on transformative technology solutions that have the potential to increase yields, productivity, or cost-effectiveness of low-carbon fuel production. The Energy Commission funds these pilot and demonstration projects with the expectation that, after successful operations at this scale, the technology will be suitable for commercial use. These precommercial projects are focused on advanced new technologies and approaches that can subsequently be expanded into wider markets. A sample of ARFVTP precommercial low-carbon fuel production projects is

106 Compared to California diesel (102.01 gCO2e/MJ) for biomethane and diesel substitutes and California gasoline (99.78 gCO2e/MJ) for ethanol. All GHG emission reductions will vary depending on the specific feedstock and production process used by each project. Based on a mix of established LCFS values and applicants' LCFS-derived estimates.

shown in Table 18, including pathways and greenhouse gas emission reduction potential.

Table 18: Sample of Precommercial ARFVTP Projects

Fuel Type	Pathway Description	Estimated GHG Emission Reduction[107]	# of Projects	Annual Capacity for Individual Projects (DGE)
Biomethane	Anaerobic codigestion of wastewater; manure; or food, beverage, or green waste	89% - 150%	4	57,000 – 328,000
Diesel Substitutes	Esterification or trans-esterification[108] of algae, manure, or food waste	45% - 55%	2	Nominal
Diesel Substitutes	Gasification of green waste or manure	67%	2	Nominal – 365,000
Gasoline Substitutes	Fermentation of cellulosic or agricultural residues*	76% - 85%	6	Nominal

Source: California Energy Commission. *Agricultural residues include woodchips and forest biomass.

Past funding solicitations have taken various approaches to biofuel types, either combining all biofuel projects into one category or separating projects by fuel type or commercialization stage. Upcoming solicitations may continue to use the combined category approach when scoring applications to maximize cost-effectiveness per dollar of state funding. As such, this investment plan will retain the single allocation for all low-carbon fuels as used in previous years to allow greatest flexibility for funding solicitations.

In 2015, the Energy Commission hosted a Lead Commissioner Technology Merit Review workshop for biofuels and biomethane. Biofuel producers and experts presented examples of ARFVTP-funded projects and discussed key elements for project success. The workshop discussion indicated that some biofuel business models are evolving to incorporate new revenue streams that don't depend on government subsidies. Many biofuel producers, however, noted a need for biofuel production incentives to stabilize and expand in-state biofuel production.

The need for production incentives stems largely from extended volatility in the price of petroleum fuels. Alternative fuels are linked in price to those of gasoline, diesel fuel,

107 Ibid.

108 *Esterification and transesterification* are defined in this context as a chemical reaction between oil and alcohol to produce esters, which are the primary component of biodiesel.

and conventional natural gas because they are substitutes for those fuels. During times of low petroleum prices or high feedstock prices, producers of alternative fuels may have no choice but to sell at a loss. Alternative fuel producers can reduce potential losses by selling LCFS and RFS credits, and Energy Commission staff has considered production incentives for low-carbon fuels as a remedy for these problems. Staff determined, however, that the amount of funding necessary for these incentives far exceeds the limited amount available under the ARFVTP, when accounting for funding needs from other fuel types and technologies. As such, alternative fuel production incentives are not viable under the ARFVTP.

Other Sources of Funding

Other state and federal programs also provide support and incentives to low-carbon fuel producers. The California Department of Resources Recycling and Recovery (CalRecycle) Organics Grant Program conducted three grant cycles in 2014, 2017, and 2018 and through these awarded $32.9 million to nine biomethane-producing projects. In addition, the California Department of Food and Agriculture awarded $35.2 million in October 2017 for anaerobic digesters at dairies through the Dairy Digester Research and Development Program and plans to allocate up to $80 million for additional dairy digester projects in 2018. The Energy Commission will work with these agencies to ensure future funding awards are complementary rather than duplicative. In addition, the LCFS and RFS requirements can support low-carbon fuel producers by creating markets for carbon credits and renewable fuels.

The incentives earned through the LCFS provide steady financial support to low-carbon fuel producers, distributors, and blenders in California. In 2017, 86 percent of LCFS credits were granted for biofuels including biomethane, ethanol, biodiesel, and renewable diesel.[109] These credits equate to an incentive of more than $750 million for biofuel producers and retailers, if sold at the average credit price of $88 for 2017.[110] CARB and Energy Commission staff expects that the LCFS will serve as the state's primary source of financial support for low-carbon fuel production and distribution.

Related State Policy

Energy Commission staff expects the availability of organic waste feedstocks suitable for prelandfill biomethane production to increase as a result of Assembly Bill 341 (Chesbro, Chapter 476, Statutes of 2011) and Senate Bill 1383 (Lara, Chapter 395, Statutes of 2016). AB 341 set a state goal of reducing, recycling, or composting

109 California Air Resources Board. July 31, 2018. *LCFS Quarterly Data Spreadsheet*. Available at http://www.arb.ca.gov/fuels/lcfs/lrtqsummaries.htm.

110 California Air Resources Board. July 11, 2018. *LCFS Monthly Credit Price and Transaction Volumes July 2018 Spreadsheet*. Available at https://www.arb.ca.gov/fuels/lcfs/dashboard/creditpriceserieswithoutargusopis.xlsx.

75 percent of solid waste by 2020, and SB 1383 set additional goals to reduce statewide disposal of organic waste from 2014 levels by 50 percent by 2020 and 75 percent by 2025. CARB also notes in the *Short-Lived Climate Pollutant Reduction Strategy* that the state must have sufficient organics processing capacity to handle this additional diverted organic waste.[111] Low-carbon fuel production projects that reduce methane emissions, such as biomethane production facilities, can help achieve the state's short-lived climate pollutant reduction goals. Given these state goals and the corresponding need for organic waste processing infrastructure, future funding opportunities will exclude landfill gas projects from consideration and instead limit biomethane production projects to those that use prelandfill organic waste.

Summary

Given the enormous petroleum and GHG emission reduction potential of any low-carbon, drop-in gasoline or petroleum replacement, future solicitations under this category may emphasize renewable gasoline, renewable crude oil, and similar products in an attempt to accelerate development. In addition, given the ultimately limited quantities of common feedstocks such as waste vegetable oil and food waste, future solicitations may also emphasize underused and emerging feedstocks such as woody biomass or agricultural residue. Recent drought and other effects of climate change have accelerated a decline in the health of California forests and resulted in increased tree mortality. The potential supply of woody biomass feedstock from dead trees exceeds that of any other source of waste material in the state, and the sustainable harvesting and use of this biomass can avoid carbon emissions from wildfire and decomposition. Energy Commission staff seeks to attract technologies that can economically convert this feedstock into low-carbon biofuels.

Some fuel types and pathways have shown minimal improvement in carbon intensity or cost-effectiveness in recent funding solicitations, which may indicate that the technology or process has fully matured. The Energy Commission may evaluate renewable fuel types and production pathways to determine when state incentives are no longer necessary. To this end, incentives may be reduced or altered by placing a higher emphasis on using cost-effectiveness scoring criteria or pathway efficiency, or requiring increased benefits from repeat applicants. As the market for low-carbon fuels continues to develop, the Energy Commission may also consider alternative funding mechanisms, such as revolving loan or loan guarantee programs, which may be more suitable for large projects and developed industries. For FY 2019-2020, Energy Commission staff proposes a $20 million allocation for Low Carbon Fuel Production and Supply. This funding will be used to continue Energy Commission support for biofuel and renewable hydrogen production facilities in California.

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111 California Air Resources Board. 2017. *Short Lived Climate Pollutant Reduction Strategy*. Available at https://www.arb.ca.gov/cc/shortlived/meetings/03142017/final_slcp_report.pdf.

Summary of Alternative Fuel Production Allocations

Table 19: Proposed FY 2019-2020 Funding for Alternative Fuel Production and Supply

Low-Carbon Fuel Production and Supply Relevant Policy Goals: – GHG Reduction – Short-Lived Climate Pollutant Reduction – Petroleum Reduction – In-State Low-Carbon Fuel Production – Low Carbon Fuel Standard	$20 Million	$5 million decrease relative to FY 2018-2019
Total	**$20 Million**	

Source: California Energy Commission

CHAPTER 6:
Summary of Funding Allocations

Proposed funding allocations for FY 2019-2020 are summarized in Table 20. In the event that a different amount of funding is available, the allocations in this document may be revised in subsequent versions or amended after final adoption. For details on each allocation, please see the relevant section of the preceding chapters.

Table 20: Summary of Proposed Funding Allocations for FY 2019-2020

Category	Funded Activity	Funding Allocation
Zero-Emission Vehicle Infrastructure	Electric Vehicle Charging Infrastructure	$32.7 million
	Hydrogen Refueling Infrastructure	$20 million
	Manufacturing and Workforce Development	$5 million
Advanced Technology and Alternative Fuel Vehicle Support	Advanced Freight and Fleet Technologies	$17.5 million
Alternative Fuel Production	Low-Carbon Fuel Production and Supply	$20 million
	Total	**$95.2 million**

Source: California Energy Commission.

GLOSSARY

AIR POLLUTANT – Amounts of foreign or natural substances occurring in the atmosphere that may result in adverse effects to humans, animals, vegetation, or materials or any combination thereof.

ANAEROBIC DIGESTION – A biological process in which biodegradable organic matter is broken down by bacteria into biogas, which consists of methane (CH_4), carbon dioxide (CO_2), and trace amounts of other gases. The biogas can be further processed into a transportation fuel or combusted to generate heat or electricity.

BATTERY-ELECTRIC VEHICLE – A type of electric vehicle that derives power solely from the chemical energy stored in rechargeable batteries.

BIODIESEL – A transportation fuel for use in diesel engines that is produced through the transesterification of organically derived oils or fats. Transesterification is a chemical reaction between oil and alcohol that forms esters (in this case, biodiesel) and glycerol.

BIOMETHANE – A pipeline-quality gas that is fully interchangeable with conventional natural gas and can be used as a transportation fuel to power natural gas engines. Biomethane is most commonly produced through an anaerobic digestion or gasification process using various biomass sources. Also known as renewable natural gas (RNG).

BRITISH THERMAL UNIT (Btu) – A unit of heat energy. One Btu is equal to the amount of energy required to raise the temperature of one pound of water by one degree Fahrenheit at sea level. One Btu is equivalent to 252 calories, 778 foot-pounds, 1,055 joules, or 0.293 watt-hours.

CARBON DIOXIDE EQUIVALENT – A measure used to compare emissions from various greenhouse gases based upon their global warming potential. The carbon dioxide equivalent for a gas is derived by multiplying the mass of the gas by the associated global warming potential.

CARBON INTENSITY – A measure of greenhouse gas emissions by weight per unit of energy. A common measure of carbon intensity is grams of carbon dioxide equivalent greenhouse gases per megajoule of energy (gCO_2e/MJ).

CRITERIA AIR POLLUTANT – An air pollutant for which acceptable levels of exposure can be determined and for which the U.S. Environmental Protection Agency has set an ambient air quality standard. Examples include ozone (O_3), carbon monoxide (CO), nitrogen oxides (NO_X), sulfur oxides (SO_X), and particulate matter (PM_{10} and $PM_{2.5}$).

DIRECT-CURRENT FAST CHARGER – Equipment that provides charging through a direct-current plug, typically at a rate of 50 kilowatts or higher.

ELECTRIC VEHICLE – A vehicle that uses an electric propulsion system. Examples include battery-electric vehicles, hybrid electric vehicles, and fuel cell electric vehicles.

ELECTROLYSIS – A process by which a chemical compound is broken down into associated elements by passing a direct current through it. Electrolysis of water, for example, produces hydrogen and oxygen.

ETHANOL – A liquid that is produced chemically from ethylene or biologically from the fermentation of various sugars from carbohydrates found in agricultural crops and cellulosic residues. Used in the United States as a gasoline octane enhancer and oxygenate, or in higher concentration (E85) in flex-fuel vehicles.

FEEDSTOCK – Any material used directly as a fuel or converted into fuel. Biofuel feedstocks are the original sources of biomass. Examples of biofuel feedstocks include corn, crop residue, and waste food oils.

FLEX-FUEL VEHICLE – A vehicle that uses an internal combustion engine that can operate on alcohol fuels (methanol or ethanol), regular unleaded gasoline, or any combination of the two from the same fuel tank.

FUEL CELL – A device capable of generating an electrical current by converting the chemical energy of a fuel (for example, hydrogen) directly into electrical energy.

FUEL CELL ELECTRIC VEHICLE – A type of electric vehicle that derives power from an onboard fuel cell.

GREENHOUSE GAS – Any gas that absorbs infrared radiation in the atmosphere. Common examples of greenhouse gases include water vapor, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), halogenated fluorocarbons (HCFCs), ozone (O_3), perfluorinated carbons (PFCs), and hydrofluorocarbons (HFCs).

HYBRID VEHICLE – A vehicle that uses two or more types of power, most commonly using a combustion engine together with an electric propulsion system. Hybrid technologies typically expand the usable range of electric vehicles beyond what an electric vehicle can achieve with batteries alone, and increase fuel efficiency beyond what an internal combustion engine can achieve alone.

INTELLIGENT TRANSPORTATION SYSTEM – The application of advanced information and communications technology to surface transportation to achieve enhanced safety, efficiency, and mobility while reducing environmental impact.

INVESTOR-OWNED UTILITY – A private company that provides a utility, such as water, natural gas, or electricity, to a specific service area. Investor-owned utilities that operate in California are regulated by the California Public Utilities Commission.

LANDFILL GAS – Gas generated by the natural degradation and decomposition of municipal solid waste by anaerobic microorganisms in sanitary landfills. The gases produced, carbon dioxide and methane, can be collected by a series of low-level pressure wells and can be processed into a medium Btu gas that can be further processed into a transportation fuel or combusted to generate heat or electricity.

LEVEL 1 CHARGER – Equipment that provides charging through a 120 volt alternative-current plug.

LEVEL 2 CHARGER – Equipment that provides charging through a 240 volt (typical in residential applications) or 208 volt (typical in commercial applications) alternative-current plug. This equipment requires a dedicated 40-amp circuit.

MEGAJOULE – One million joules. A joule is a unit of work or energy equal to the amount of work done when the point of application of force of 1 newton is displaced 1 meter in the direction of the force. One British thermal unit is equal to 1,055 joules.

METHANE – A light hydrocarbon that is the main component of natural gas. It is the product of the anaerobic decomposition of organic matter or enteric fermentation in animals and is a greenhouse gas. The chemical formula is CH_4.

MICROMETER – One millionth of a meter, equal to roughly 0.00004 inches.

NATURAL GAS – A hydrocarbon gas found in the earth composed of methane, ethane, butane, propane, and other gases.

NO_X – Oxides of nitrogen, a chief component of air pollution that is commonly produced by the burning of fossil fuels.

OVERGENERATION – A condition that occurs when total electricity supply exceeds total electricity demand. This condition may negatively affect the reliable operation of the regional, state, or interstate electrical grid.

PARTICULATE MATTER – Any material, except pure water, that exists in a solid or liquid state in the atmosphere. The size of particulate matter can vary from coarse, wind-blown dust particles to fine particle combustion products.

PATHWAY – A descriptive combination of three components including feedstock, production process, and fuel type.

PLUG-IN ELECTRIC VEHICLE – A type of vehicle that is equipped with a battery than can be recharged from an external source of electricity. It may or may not also have an internal combustion engine.

PLUG-IN HYBRID ELECTRIC VEHICLE – A type of hybrid vehicle that is equipped with a larger, more advanced battery that can be recharged from an external source of electricity. This larger battery allows the vehicle to be driven on battery power alone, gasoline fuel alone, or a combination of electricity and gasoline.

ZERO-EMISSION VEHICLE – A vehicle that produces no pollutant emissions from the onboard source of power.

APPENDIX A: LIST OF ACRONYMS

AB	Assembly Bill
AQIP	Air Quality Improvement Program
ARFVTP	Alternative and Renewable Fuel and Vehicle Technology Program
ARPA-E	Advanced Research Projects Agency – Energy
ATL Initiative	Advanced Transportation and Logistics Initiative
BEV	battery-electric vehicle
CaFCP	California Fuel Cell Partnership
CA-GREET	California Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation Model
CALeVIP	California Electric Vehicle Infrastructure Project
CalRecycle	California Department of Resources Recycling and Recovery
CARB	California Air Resources Board
CCCCO	California Community Colleges Chancellor's Office
CHIT	California Hydrogen Infrastructure Tool
CNG	compressed natural gas
CO_2e	carbon dioxide-equivalent greenhouse gases
CPUC	California Public Utilities Commission
CVRP	Clean Vehicle Rebate Project
DC	direct current
DGE	diesel gallon-equivalent
EPIC	Electric Program Investment Charge
EVs	electric vehicles
EVCS	electric vehicle charging station
EVI-Pro	Electric Vehicle Infrastructure Projections
FCEV	fuel cell electric vehicle
FFV	flex-fuel vehicle
FY	fiscal year
GFO	grant funding opportunity
GGE	gasoline gallon-equivalent
GGRF	Greenhouse Gas Reduction Fund
gCO_2e/MJ	grams of carbon dioxide-equivalent greenhouse gases per megajoule
GVW	gross vehicle weight
GHG	greenhouse gas
HVIP	Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project
HRI	hydrogen refueling infrastructure
IEPR	*Integrated Energy Policy Report*

LCFS	Low Carbon Fuel Standard
LCTI	Low Carbon Transportation Investments
LNG	liquefied natural gas
MJ	megajoule
$MMTCO_2e$	million metric tons of carbon dioxide-equivalent greenhouse gases
NAAQS	National Ambient Air Quality Standards
NGVIP	Natural Gas Vehicle Incentive Project
NO_X	oxides of nitrogen
NOPA	notice of proposed award
NREL	National Renewable Energy Laboratory
O&M	operations and maintenance
$PM_{2.5}$	particulate matter, 2.5 micrometers and smaller
PEV	plug-in electric vehicle
PG&E	Pacific Gas and Electric Company
PHEV	plug-in hybrid electric vehicle
PON	program opportunity notice
RFS	Renewable Fuel Standard
RIN	renewable identification number
SB	Senate Bill
SCE	Southern California Edison
SDG&E	San Diego Gas & Electric Company
SIP	State Implementation Plan
SoCal Gas	Southern California Gas Company
U.S. EPA	United States Environmental Protection Agency
ZEV	zero-emission vehicle