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California Energy Commission

COMMISSION REPORT

2017-2018 Investment Plan Update for the Alternative and Renewable Fuel and Vehicle Technology Program

California Energy Commission

Edmund G. Brown Jr., Governor

May 2017 | CEC-600-2016-007-CMF

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ABSTRACT

The *2017-2018 Investment Plan Update for the Alternative and Renewable Fuel and Vehicle Technology Program* guides the allocation of program funding for fiscal year 2017-2018. This *2017-2018 Investment Plan Update* covers the ninth year of the program and reflects laws, executive orders, and policies to reduce greenhouse gas emissions, petroleum dependence, and criteria emissions. It details how the California Energy Commission determines the goal-driven priorities of the program by incorporating input from stakeholders and the program 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 *2017-2018 Investment Plan Update* establishes recommended funding allocations based on the identified needs and opportunities of a variety of alternative fuels and vehicle technologies. As an update, the *2017-2018 Investment Plan Update* relies on the narrative and analyses developed in previous investment plans, most recently the *2016-2017 Investment Plan Update.*

This Energy Commission report represents the final step in the development of the *2017-2018 Investment Plan Update*, following the draft staff report, revised staff report, and lead commissioner report that were published in October 2016, January 2017, and March 2017, respectively. This report was adopted at the April 12, 2017 Energy Commission business meeting.

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

California has adopted several aggressive goals for reducing greenhouse gas (GHG) emissions, including:

- A near-term goal of reducing GHG emissions to 1990 levels by 2020.
- An interim goal of reducing GHG emissions to 40 percent below 1990 levels by 2030.
- A long-term goal of reducing GHG emissions to 80 percent below 1990 levels by 2050.

Achieving these goals will require significant technological and market changes within the transportation sector, which accounts for 37 percent of state greenhouse gas emissions. Both California and the U.S. federal government have also established numerous goals and mandates 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 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 provides up to $100 million per year for projects that will "transform California's fuel and vehicle types to help attain the state's climate change policies." The statute also emphasizes "develop[ing] and deploy[ing] technology and alternative and renewable fuels in the marketplace, without adopting any one preferred fuel or technology." Assembly Bill 8 (Perea, Chapter 401, Statutes of 2013) subsequently extended the collection of fees that support the ARFVTP through January 1, 2024.

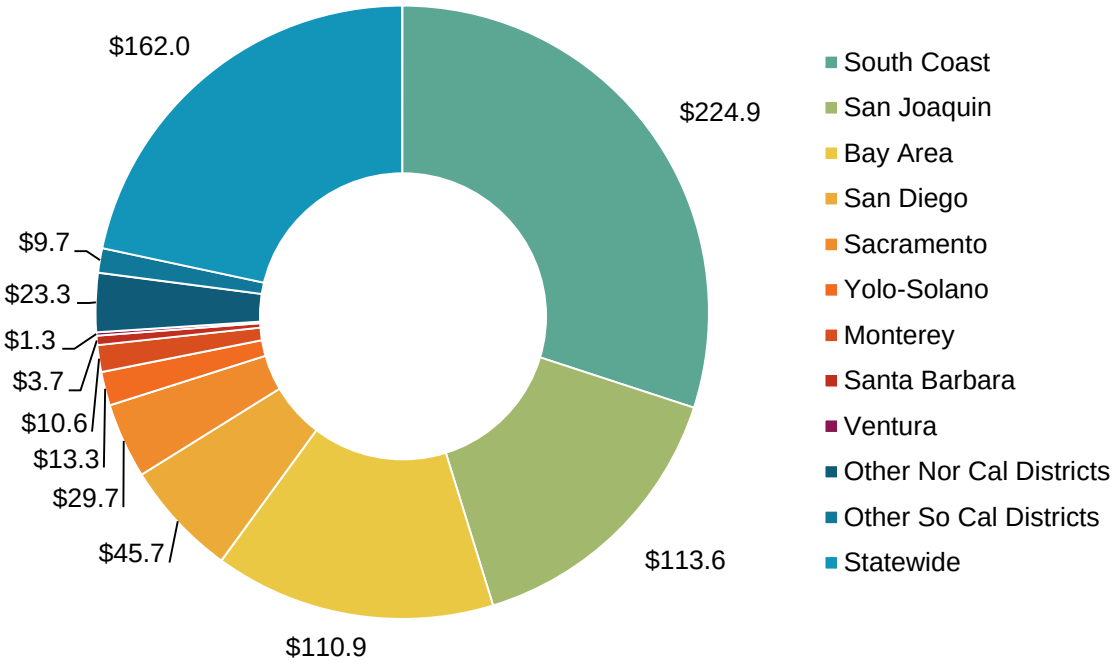
As part of the ARFVTP, the Energy Commission prepares and adopts an annual investment plan update that identifies the funding priorities for the coming fiscal year. The funding allocations reflect the potential for each alternative fuel and vehicle technology to contribute to the goals of the program; the anticipated barriers and opportunities associated with each fuel or technology; the effect of other entities' investments, policies, programs, and statutes; and a portfolio-based approach that avoids adopting any preferred fuel or technology. This Energy Commission report of the *2017-2018 Investment Plan Update* is the final version of the document.

Context of the 2017-2018 Investment Plan Update

The *2017-2018 Investment Plan Update* builds on the analyses and recommendations contained in previously adopted investment plans and investment plan updates. Since the first investment plan, the Energy Commission has invested more than $748 million in projects that support the advancement and deployment of alternative and renewable fuels and advanced vehicle technologies. These projects provide direct feedback on how the ARFVTP can maximize value in reducing near-term greenhouse gas emissions while

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. Figure ES-1 shows the distribution of ARFVTP funding throughout the state, by air district. The projects funded by the ARFVTP are summarized in Table ES-1 and support a broad portfolio of fuel types, supply chain phases, and commercialization phases.

Figure ES-1: ARFVTP Funding by Air District (in Millions)



Source: California Energy Commission

Table ES-1: Previous ARFVTP Awards as of March 1, 2017

Category	Funded Activity	Cumulative Awards to Date (in millions)*	# of Projects or Units
Alternative Fuel Production	Biomethane Production	$59.5	20 Projects
	Gasoline Substitutes Production	$32.4	14 Projects
	Diesel Substitutes Production	$75.1	25 Projects
Alternative Fuel Infrastructure	Electric Vehicle Charging Infrastructure**	$80.1	7,796 Charging Stations
	Hydrogen Refueling Infrastructure	$128.2	64 Fueling Stations
	E85 Fueling Infrastructure	$13.7	158 Fueling Stations
	Upstream Biodiesel Infrastructure	$4.0	4 Infrastructure Sites
	Natural Gas Fueling Infrastructure	$21.9	64 Fueling Stations
Alternative Fuel and Advanced Technology Vehicles	Natural Gas Vehicle Deployment***	$65.8	3,148 Vehicles
	Propane Vehicle Deployment	$6.0	514 Trucks
	Light-Duty Electric Vehicle Deployment	$25.1	10,700 Cars
	Medium- and Heavy-Duty Electric Vehicle Deployment	$4.0	150 Trucks
	Medium- and Heavy-Duty Vehicle Technology Demonstration and Scale-Up	$129.4	49 Demonstrations
Related Needs and Opportunities	Manufacturing	$46.5	21 Manufacturing Projects
	Emerging Opportunities	†	†
	Workforce Training and Development	$30.7	96 Recipients
	Fuel Standards and Equipment Certification	$3.9	1 Project
	Sustainability Studies	$2.1	2 Projects
	Regional Alternative Fuel Readiness and Planning	$9.0	40 Regional Plans
	Centers for Alternative Fuels	$5.8	5 Centers
	Technical Assistance and Program Evaluation	$5.5	n/a
Total		**$748.7**	

Source: California Energy Commission. Sum of cumulative awards may not equal total because of rounding. *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. **Includes $15.3 million for an agreement with the Center for Sustainable Energy 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 encumbered funds for future incentives. †Previous awards have been reclassified by project type into other rows.

The funding recommendations in this draft are guided by, and complementary to, energy policies and regulations including the Low-Carbon Fuel Standard administered by the California Air Resources Board (CARB), the Renewable Fuels 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. 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*, for instance, articulates these market transformation goals as applicable for zero-emission vehicles and calls for developing infrastructure networks and community readiness plans for both 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.

For fiscal year 2016-2017, the state Legislature allocated $363 million from the Greenhouse Gas Reduction Fund (GGRF) to CARB for low-carbon transportation projects. In its joint funding plan for both its Air Quality Improvement Program and Low Carbon Transportation Investments, the CARB discussed project allocations for deployment incentives for light-duty alternative fuel vehicles, advanced technology and zero-emission heavy-duty vehicles, and zero-emission freight and off-road equipment projects. Funding recommendations in this draft investment plan update consider the availability of other funding programs for similar purposes to appropriately target ARFVTP funding to maximize benefits for California.

Emerging technologies are also expected to transform the needs and opportunities for ARFVTP funding in coming years. Natural gas engines and emission control technologies that achieve the CARB optional low oxides of nitrogen (NO_x) emission standard are now commercially available, and, when combined with biomethane fuel, can reduce the life-cycle emissions of medium- and heavy-duty vehicles to levels near or equal to those of zero-emission electric vehicles. Nonpropulsion technologies, such as intelligent transportation systems for freight movement, may also provide an opportunity to reduce petroleum use as well as GHG and criteria pollutant emissions. Energy Commission staff will continue to monitor new opportunities and incorporate them into the ARFVTP investment plan update and solicitations when appropriate.

2017-2018 Investment Plan Update

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. These are discussed in Chapters 3 through 6 of this report, which describe the barriers and opportunities associated with alternative fuel production, alternative fuel distribution infrastructure, alternative fuel and advanced technology vehicles, and related activities that can accelerate progress in these areas. Table ES-2 outlines the funding allocations of the two most recent investment plan updates, in comparison to the funding allocations for FY 2017-2018.

If approved in the proposed state budget, beginning with FY 2017-2018, the ARFVTP will be required to fund program support costs from motor vehicle registration fees instead of funds that traditionally have been paid from commercial and residential utility surcharges. As a result of these additional expenses, $2.8 million less will be available for ARFVTP project funding for FY 2017-2018. This final *2017-2018 Investment Plan Update* reflects a total of $97.2 million for program funding, whereas the draft staff report and revised staff report versions assumed $100 million would be available. All funding allocations in this version of the report have been reduced by 2.8 percent and rounded to $0.1 million, compared to previous versions, to adjust for the lower amount of available funding.

Table ES-2: Most Recent and Current Investment Plan Allocations (in Millions)

Category	Funded Activity	2015-2016	2016-2017	2017-2018
Alternative Fuel Production	Biofuel Production and Supply	$20	$20	$19.4
Alternative Fuel Infrastructure	Electric Charging Infrastructure	$17	$17	$16.6
	Hydrogen Refueling Infrastructure	$20	$20	$19.4
	Natural Gas Fueling Infrastructure	$5	$2.5	$2.4
Alternative Fuel and Advanced Technology Vehicles	Natural Gas Vehicle Incentives	$10	$10	$9.7
	Advanced Freight and Fleet Technologies	$20*	$23*	$17.5
Related Needs and Opportunities	Manufacturing			$4.9
	Emerging Opportunities	$3	$3	$3.9
	Workforce Training and Development Agreements	$3	$2.5	$3.4
	Regional Alternative Fuel Readiness and Planning	$2	$2	-
Total		**$100**	**$100**	**$97.2**

Source: California Energy Commission. *For FY 2015-2016 and 2016-2017, funding for manufacturing and medium- and heavy-duty vehicle demonstrations was combined into the Medium- and Heavy-Duty Vehicle Technology Demonstration and Scale-Up category.

CHAPTER 1: Introduction

A decade ago, California assumed a leadership role in greenhouse gas (GHG) reduction efforts with the passage of Assembly Bill 32 – the Global Warming Solutions Act of 2006.[1] The law established a goal of reducing statewide GHG emissions to 1990 levels by 2020. In the years since, California's governors took additional action with Executive Order B-30-15, which set an interim goal to reduce statewide GHG emissions to 40 percent below 1990 levels by 2030, and with Executive Order S-3-05, which set a long-term goal to reduce statewide GHG emissions to 80 percent below 1990 levels by 2050. With California on track to meet or exceed the goals of AB 32, Governor Edmund G. Brown Jr. signed Senate Bill 32 into law in September 2016, codifying the goals of Executive Order B-30-15 and requiring the state to cut emissions to 40 percent below 1990 levels by 2030.[2]

The transportation sector is the largest source of GHG emissions in California, accounting for 37 percent of in-state emissions, according to the *California Greenhouse Gas Emission Inventory*.[3] California has made progress in reducing the carbon intensity of the transportation sector, with sales of low-carbon biofuels and electric vehicles steadily increasing and hydrogen fuel cell vehicles recently becoming commercially available.[4] Despite these advances, petroleum-based gasoline and diesel fuel still account for 90 percent of California ground transportation fuel use. The state will need to continue to reduce petroleum fuel use to meet GHG reduction targets.

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.[5] The American Lung Association's 2016 *State of the Air* report lists eight California metropolitan areas in the top-10 most polluted cities.[6] Protecting and improving public health in these areas will require

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

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

3 California Air Resources Board. *California Greenhouse Gas Emission Inventory*. June 17, 2016. Available at https://www.arb.ca.gov/cc/inventory/data/data.htm.

4 *Carbon intensity* is defined here as the amount of carbon dioxide equivalent greenhouse gasses by weight emitted per unit of energy consumed.

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

6 American Lung Association. *State of the Air 2016*. 2016. Available at http://www.lung.org/assets/documents/healthy-air/state-of-the-air/sota-2016-full.pdf.

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.[7] Table 1 summarizes the major policy goals and milestones developed to address these issues, reduce emissions, and reduce petroleum use in California.

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 and Executive Order B-30-15	GHG Reduction	Reduce GHG emissions to 40 percent below 1990 levels by 2030
Executive Order S-3-05	GHG Reduction	Reduce GHG emissions to 80 percent below 1990 levels by 2050
Low-Carbon Fuel Standard	GHG Reduction	Reduce carbon intensity of transportation fuels in California by 10 percent by 2020
State Alternative Fuels Plan	Petroleum Reduction	Reduce petroleum fuel use to 15 percent below 2003 levels by 2020
Energy Policy Act of 2005; Energy Independence and Security Act of 2007	Renewable Fuel Standard	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
California Air Resources Board's Zero-Emission Vehicle Regulations; California Executive Order B-16-2012	Increased Zero-Emission Vehicles	Infrastructure to accommodate 1 million electric vehicles by 2020 and 1.5 million electric vehicles by 2025 in California*
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 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 provides up to $100 million per year for projects that will "transform California's fuel

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

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."[8] Assembly Bill 8 (Perea, Chapter 401, Statutes of 2013) subsequently extended the collection of fees that support the ARFVTP through January 1, 2024.

As part of the ARFVTP, the Energy Commission prepares and adopts an annual investment plan update that identifies the funding priorities for the coming fiscal year. 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 entities' investments, policies, programs, and statutes; and a portfolio-based approach that avoids adopting any preferred fuel or technology. The investment plan update also describes how the allocations will complement existing public and private efforts, including related state programs.

The *2017-2018 Investment Plan Update* is the ninth investment plan document in the history of the ARFVTP and builds on the analyses and recommendations contained in the prior documents. This report is the final version of the *2017-2018 Investment Plan Update*. The Energy Commission held public workshops with the ARFVTP Advisory Committee on October 27, 2016 and February 16, 2017, during which representatives

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

from fuel and technology industry groups, nongovernmental entities, other state agencies, and the public were able to discuss and comment on this document. Comments on the *2017-2018 Investment Plan Update* were also provided using the Energy Commission's docket system.[9] In accordance with state law, the Energy Commission submitted a draft of the investment plan update to the Legislature concurrent with the Governor's budget in January 2017 and submitted this adopted investment plan update to the Legislature concurrent with the Governor's revised budget in May 2017.

Chapter 2 of this document provides an update on Energy Commission 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 according to the traditional supply chain of alternative fuels. Chapter 3 addresses the barriers and opportunities associated with alternative fuel production and supply within California. Chapter 4 focuses on the distribution of alternative fuels and associated refueling infrastructure, and Chapter 5 focuses on the vehicles that will use alternative fuels and advanced technologies. Chapter 6 identifies related activities and investments that can expedite the development and deployment of alternative fuels and advanced technology vehicles. Finally, Chapter 7 summarizes the funding allocations.

9 The Energy Commission encourages written comments on the *2017-2018 Investment Plan Update for the Alternative and Renewable Fuel and Vehicle Technology Program* (Docket #16-ALT-02). Comments can be provided through the Energy Commission's e-Commenting system at https://efiling.energy.ca.gov/Ecomment/Ecomment.aspx?docketnumber=16-ALT-02.

CHAPTER 2:
Context of the *2017-2018 Investment Plan Update*

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.[10] Energy Commission staff initially proposes funding allocations based on the GHG emission reduction potential of alternative fuels and technologies (both near-term and long-term), identification of the primary market and/or technological opportunities and barriers, evaluation of complementary funding or regulations, consideration of policy priorities such as air quality standards and environmental justice, and a statutory directive to maintain a "portfolio-based approach." 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 Advisory Committee workshops.

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"; formerly *program opportunity notices*, or PONs). Each solicitation has a set of scoring criteria that reflect project selection preferences established by statute.[11] 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 that particular solicitation. Outside agencies

10 The previous investment plan update, covering fiscal year 2016-2017, was adopted at the April 13, 2016 Energy Commission business meeting. It is available at http://energy.ca.gov/2015publications/CEC-600-2015-014/CEC-600-2015-014-CMF.pdf.

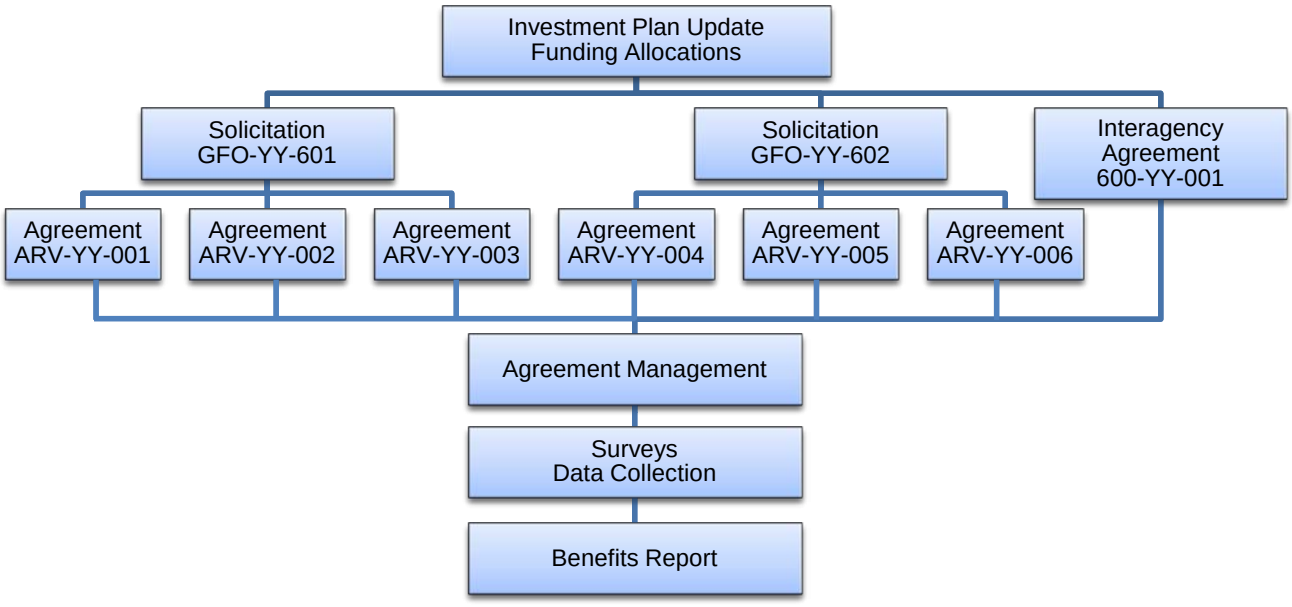
11 These preference criteria are listed in Health and Safety Code Section 44272 (c) and (d).

and contractors may also provide technical assessments of the proposals. Based on the total scores of each application, the Energy Commission releases a notice 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, including, but not limited, to the California Employment Training Panel, the University of California campuses, and the Division of Measurement Standards, 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 executed by the Energy Commission and the applicant. Energy Commission staff oversees the completion of these agreements according to the respective schedules, budgets, scopes of work, and terms and conditions of these agreements.

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 a broad array of 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 and Leveraged Funding

Competitive solicitations for grants have been the predominant funding mechanism for ARFVTP to date. However, as the Energy Commission gains experience implementing the ARFVTP, and alternative fuels and technologies advance in the marketplace, the Energy Commission has implemented alternative funding and financing mechanisms. Each of these mechanisms has respective strengths and weaknesses; the Energy Commission weighs these options ahead of developing the funding implementation strategy for each allocation. The most prominent funding mechanisms used for the ARFVTP by the Energy Commission to date 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 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 provide greater uncertainty for project investors and applicants.
- **Competitive Solicitation for Federal Cost-Sharing** – This mechanism is similar to above but with a specific emphasis on applications that can demonstrate federal cost-sharing opportunities. This solicitation can provide an additional economic benefit to the ARFVTP portfolio by encouraging federal investment within the state; it is also more difficult to coordinate and plan, however, as federal solicitations come and go throughout the year.
- **First-Come, First-Served** – This type of funding mechanism has been used primarily for vehicle incentives by both the Energy Commission ARFVTP and the CARB Air Quality Improvement Program. Once eligibility requirements are established, the funding can be administered relatively quickly and can provide greater market certainty for a project type. Without a method for evaluating the funding need for each project, however, these incentives may fund activities that would have already occurred without public investment. The first applicants in line for funding are likely to be those who are already the most interested in the activity.
- **Production or Operation Incentives** – To date, the Energy Commission has used these types of incentives for both 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 outside investment. This funding typically requires commercial operation and would be poorly suited for projects focused more 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 expansion.

- **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 considered for the biofuel production and electric vehicle charging categories.

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. The Energy Commission 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, 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 her 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).
- Encompassing initiatives addressing transportation energy-related challenges and opportunities in disadvantaged communities.
- Reaching out to women, minority, 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.

- Developing and posting online "Grant Funding Opportunities 101," a presentation on how to apply for ARFVTP funding.[12]
- Hosting a breakout session during the February 2016 Empower California workshop to increase participation of diverse business enterprises in the ARFVTP.
- Translating the most recent investment plan update covering fiscal year 2016-2017 into a Spanish-language version.[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 40 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 meet with small businesses, veteran, women, minority, and other interested groups to provide information on partnering for success through the ARFVTP. The information will also be available on the Energy Commission website.
- 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

State statutes established the ARFVTP to fund fuel and technology projects that, among other policy goals, help attain the state's climate change policies. The statutes also

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12 California Energy Commission. *Grant Funding Opportunities 101: Alternative and Renewable Fuels and Vehicle Technology Program.* October 2014. Available at http://www.energy.ca.gov/altfuels/notices/2014-10_workshops/ARFVTP_Solicitation_Grant_Tutorial.pdf.

13 *Actualización del Plan de Inversiones 2016-2017 para los Combustibles Alternativos y Renovables y el Programa de Tecnología de Vehículos - Comisión Informe Final.* Published May 13, 2016. Publication #CEC-600-2015-014-Spanish-CMF. Available at http://www.energy.ca.gov/2015publications/CEC-600-2015-014/CEC-600-2015-014-Spanish-CMF.pdf.

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.

provide several directives and preferences that the Energy Commission uses to evaluate and select prospective projects for funding under the ARFVTP. 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. Given the ARFVTP legislative requirement not to adopt any one preferred fuel or technology for the program, these criteria cannot be applied equally to all project types. To do so could lead to a preference for certain fuels or technologies while neglecting other project types that provide different but important benefits.

The Energy Commission has investigated how best to apply metrics to the selection of projects under the ARFVTP, including during public workshops in June 2014 and August 2016.[15] The findings from the June 2014 workshop are discussed in Chapter 4 of the *2014 Integrated Energy Policy Report Update* and have been integrated into subsequent ARFVTP solicitations.[16] Similarly, the discussion from the August 2016 workshop will guide the development and refinement of criteria for future ARFVTP solicitations.

During public workshops for the ARFVTP investment plan update, stakeholders have requested information regarding how the Energy Commission applies metrics for project selection and program evaluation. Many of the methods for implementing metrics, such as the benefit-cost score and program evaluation techniques, are detailed in the ARFVTP Benefits and Evaluation section of this chapter.

Benefit-Cost Assessments

AB 8 introduced the GHG benefit-cost score as a new element into 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."[17] AB 8 also directs the Energy Commission to "give additional preference to funding those projects with higher benefit-cost scores."[18] Energy Commission staff

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15 Materials from the August 2016 Lead Commissioner Workshop on Measuring the Success of the Alternative and Renewable Fuel and Vehicle Technology Program are available online at http://www.energy.ca.gov/altfuels/notices/index.html#08222016.

16 California Energy Commission. 2015. *2014 Integrated Energy Policy Report Update.* Publication Number: CEC-100-2014-001-CMF. Available at http://energy.ca.gov/2014publications/CEC-100-2014-001/CEC-100-2014-001-CMF.pdf.

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

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

apply 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. This calculation results in an estimate of direct GHG reduction benefits from a proposed project. 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 one of several project selection criteria established in statute and is used to evaluate project applications. The benefit-cost ratio is given greater scoring weight in solicitations that focus on technologically mature and commercially established project types. Conversely, the benefit-cost ratio is given smaller weighting in solicitations that focus on precommercial or evolving technologies. In recent solicitations, this preference has also been incorporated both 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 March 2017, the Energy Commission has issued or proposed more than $748 million in ARFVTP funding across 588 agreements. A summary of these agreements by fuel type is provided in Table 2, and these agreements are further summarized by project type in Table 3. The agreements support a broad portfolio of fuel types, supply chain phases, and commercialization phases. In most cases, projects are still in progress, with ongoing siting, installation, construction, and demonstrations. Major highlights of the ARFVTP funding portfolio to date include:

- 59 projects to promote the production of sustainable, low-carbon biofuels within California. Most will use waste-based feedstocks, which have some of the lowest carbon-intensity pathways recognized under the Low-Carbon Fuel Standard.
- 7,796 installed and planned charging stations for plug-in electric vehicles, including 4,231 residential charging stations, 3,141 commercial and workplace charging stations, and 320 direct current (DC) fast chargers.
- 64 new or upgraded hydrogen refueling stations that will help serve a nascent 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 nearly two-thirds of the initial network of 100 hydrogen refueling stations called for by AB 8.
- 49 projects to demonstrate zero- and near-zero-emission advanced technologies and alternative fuels in a variety of medium- and heavy-duty vehicle applications.

- 3,148 natural gas vehicles operating or soon to be operating in a variety of applications.
- 64 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.
- $49.1 million to fund incentives for all-electric and plug-in hybrid electric vehicles via the Air Resources Board Clean Vehicle Rebate Project (CVRP).
- 21 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 16,943 trainees and more than 255 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.
- 40 alternative fuels readiness planning and implementation grants to help regions plan for alternative fuel vehicle deployment, new fueling infrastructure, and permit streamlining.

The ARFVTP has funded projects throughout California. About 21 percent of funds have been awarded to projects in the Central Valley, 19 percent in Northern California, 38 percent in Southern California, and 22 percent with a statewide focus. The geographic distribution of ARFVTP funding is shown in Figure 2, sorted by air district. The details associated with each project type are discussed further in respective sections of this investment plan update. In addition, Table 4 outlines the funding allocations of the two most recent investment plan updates, in comparison to the funding allocations for FY 2017-2018.

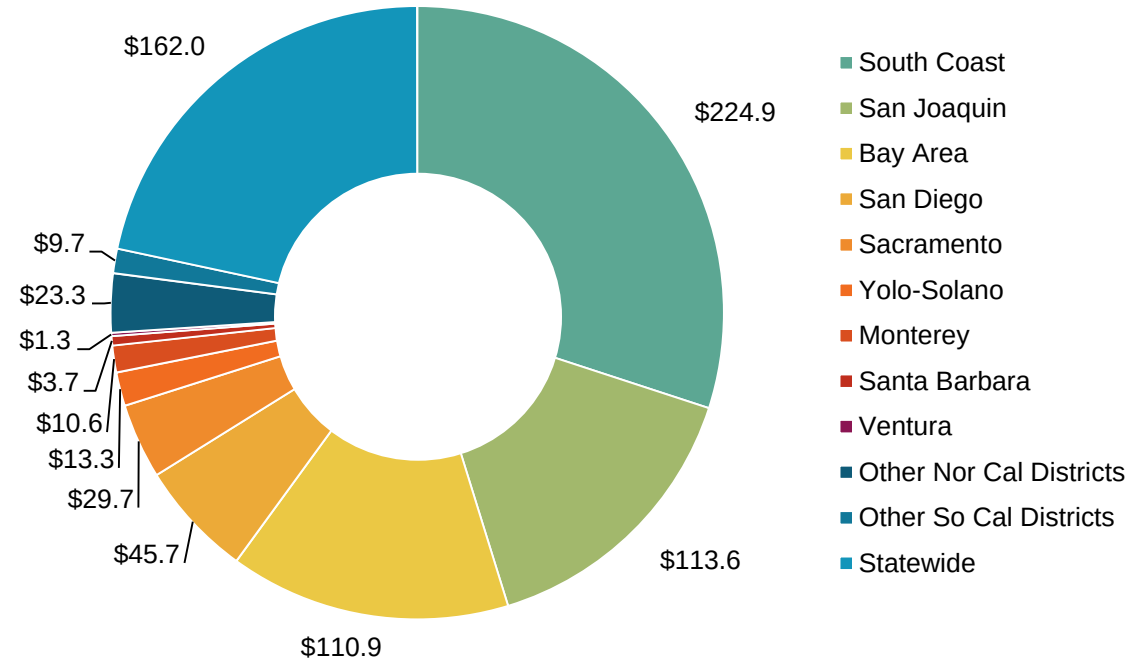
If approved in the proposed state budget, beginning with FY 2017-2018, the ARFVTP will be required to fund program support costs from motor vehicle registration fees instead of funds that traditionally have been paid from commercial and residential utility surcharges. As a result of these additional expenses, $2.8 million less will be available for ARFVTP project funding for FY 2017-2018. This final *2017-2018 Investment Plan Update* reflects a total of $97.2 million for program funding, whereas the draft staff report and revised staff report versions assumed $100 million would be available. All funding allocations in this version of the report have been reduced by 2.8 percent and rounded to $0.1 million, compared to previous versions, to adjust for the lower amount of available funding. In the event that less funding is available, the allocations in this document may be revised in subsequent versions or amended after final adoption. Future developments, including the potential availability of funding from the GGRF for these or related categories, may also prompt a need for modifying these allocations.

Table 2: ARFVTP Awards by Fuel Type as of March 1, 2017

Fuel Type	Cumulative Awards to Date (in Millions)	Cumulative Number of Projects to Date
Biomethane	$59.5	20
Ethanol	$48.8	19
Biodiesel	$56.3	22
Renewable Diesel	$22.8	7
Electricity	$260.8	176
Hydrogen	$145.2	87
Natural Gas	$103.5	150
Propane	$6.0	30
Multiple/Other*	$45.8	77
Total	**$748.7**	**588**

Source: California Energy Commission. Sum of cumulative awards may not equal total because of rounding.
*Some agreements, such as those for multifuel regional readiness plans or workforce training, cannot be readily categorized by fuel type.

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



Source: California Energy Commission

Table 3: Previous ARFVTP Awards as of March 1, 2017

Category	Funded Activity	Cumulative Awards to Date (in millions)*	# of Projects or Units
Alternative Fuel Production	Biomethane Production	$59.5	20 Projects
	Gasoline Substitutes Production	$32.4	14 Projects
	Diesel Substitutes Production	$75.1	25 Projects
Alternative Fuel Infrastructure	Electric Vehicle Charging Infrastructure**	$80.1	7,796 Charging Stations
	Hydrogen Refueling Infrastructure	$128.2	64 Fueling Stations
	E85 Fueling Infrastructure	$13.7	158 Fueling Stations
	Upstream Biodiesel Infrastructure	$4.0	4 Infrastructure Sites
	Natural Gas Fueling Infrastructure	$21.9	64 Fueling Stations
Alternative Fuel and Advanced Technology Vehicles	Natural Gas Vehicle Deployment***	$65.8	3,148 Vehicles
	Propane Vehicle Deployment	$6.0	514 Trucks
	Light-Duty Electric Vehicle Deployment	$25.1	10,700 Cars
	Medium- and Heavy-Duty Electric Vehicle Deployment	$4.0	150 Trucks
	Medium- and Heavy-Duty Vehicle Technology Demonstration and Scale-Up	$129.4	49 Demonstrations
Related Needs and Opportunities	Manufacturing	$46.5	21 Manufacturing Projects
	Emerging Opportunities	†	†
	Workforce Training and Development	$30.7	96 Recipients
	Fuel Standards and Equipment Certification	$3.9	1 Project
	Sustainability Studies	$2.1	2 Projects
	Regional Alternative Fuel Readiness and Planning	$9.0	40 Regional Plans
	Centers for Alternative Fuels	$5.8	5 Centers
	Technical Assistance and Program Evaluation	$5.5	n/a
Total		**$748.7**	

Source: California Energy Commission. Sum of cumulative awards may not equal total because of rounding. *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. **Includes $15.3 million for an agreement with the Center for Sustainable Energy 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 encumbered funds for future incentives. †Previous awards have been reclassified by project type into other rows.

Table 4: Most Recent and Current Investment Plan Allocations (in Millions)

Category	Funded Activity	2015-2016	2016-2017	2017-2018
Alternative Fuel Production	Biofuel Production and Supply	$20	$20	$19.4
Alternative Fuel Infrastructure	Electric Charging Infrastructure	$17	$17	$16.6
	Hydrogen Refueling Infrastructure	$20	$20	$19.4
	Natural Gas Fueling Infrastructure	$5	$2.5	$2.4
Alternative Fuel and Advanced Technology Vehicles	Natural Gas Vehicle Incentives	$10	$10	$9.7
	Advanced Freight and Fleet Technologies	$20*	$23*	$17.5
Related Needs and Opportunities	Manufacturing			$4.9
	Emerging Opportunities	$3	$3	$3.9
	Workforce Training and Development Agreements	$3	$2.5	$3.4
	Regional Alternative Fuel Readiness and Planning	$2	$2	-
Total		**$100**	**$100**	**$97.2**

Source: California Energy Commission. *For FY 2015-2016 and 2016-2017, funding for manufacturing and medium- and heavy-duty vehicle demonstrations was combined into the Medium- and Heavy-Duty Vehicle Technology Demonstration and Scale-Up category.

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 also 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 June 2014, NREL issued a *Program Benefits Guidance* draft report that describes its method for categorizing and assessing a series of benefit categories.[19] The methods and results of this report are discussed in the *2014 Integrated Energy Policy Report Update*.[20] For 2015, NREL analyzed updated ARFVTP project data for 262 projects totaling $552 million, representing the ARFVTP project portfolio technical projects as of June 30, 2015. In reviewing ARFVTP benefits, NREL identified four relevant categories, as summarized in Table 5. These categories range from benefits with relatively high levels of certainty about past trends and near-term projects to benefits with high levels of uncertainty regarding technological innovation and market transformation.

Table 5: Benefit Categories in NREL Program Benefits Guidance

Benefits Category	Description
Baseline Benefits	Expected to accrue without support from ARFVTP.
Expected Benefits	Directly associated with vehicles and fuels deployed by projects receiving ARFVTP funds.
Market Transformation Benefits	Accrued due to influence of ARFVTP projects on future market conditions to accelerate the adoption of new technologies.
Required Carbon Market Growth Benefits	Projections of future market growth trends comparable to those needed for deep GHG reductions by 2050.

Source: California Energy Commission, based on categories developed by NREL.

19 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.

20 California Energy Commission. 2015. *2014 Integrated Energy Policy Report Update.* Publication Number: CEC-100-2014-001-CMF. Available at http://energy.ca.gov/2014publications/CEC-100-2014-001/CEC-100-2014-001-CMF.pdf.

The first category, Baseline Benefits, is a conceptual category that represents GHG reductions without ARFVTP projects. The second category, Expected Benefits, is 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. The third category of benefits considered by NREL, Market Transformation Benefits, corresponds 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 tangible but 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 a low and high range. The fourth category, Required Carbon Market Growth Benefits, is also conceptual and represents growth trends needed to achieve deep GHG reductions by 2050.

Table 6: Summary of GHG Emission and Petroleum Fuel Reduction Benefits Based on 262 Projects

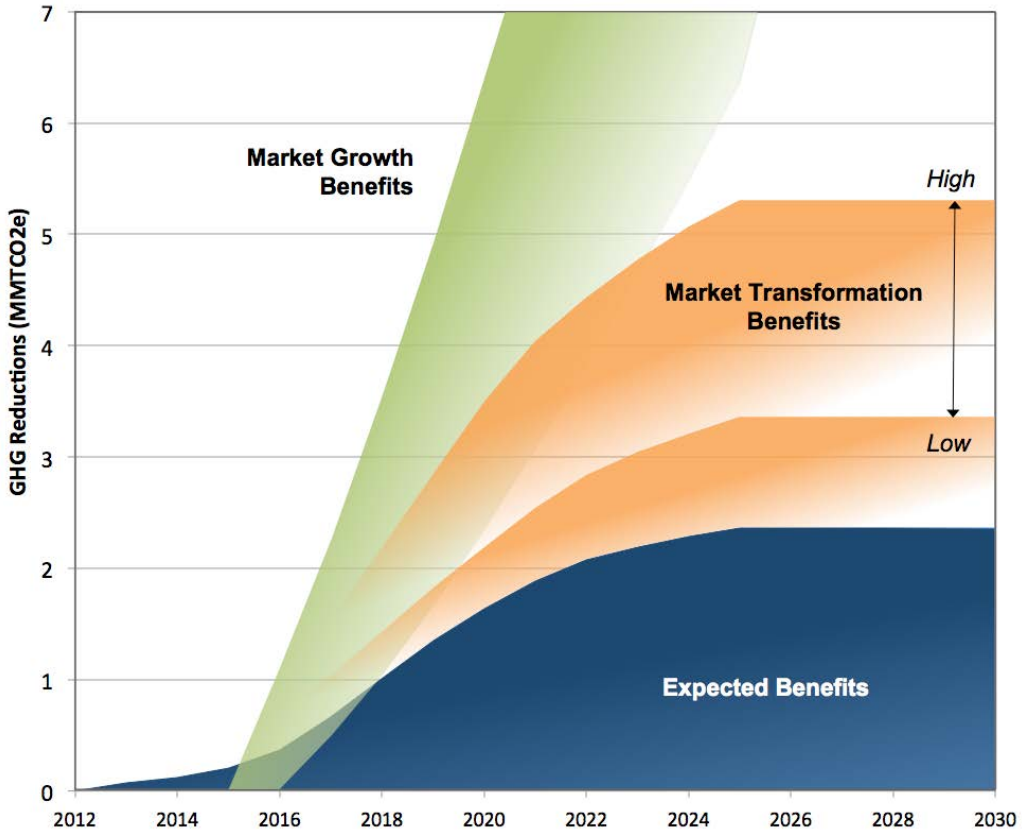
Category	Project Class/Range	GHG Reductions (Thousand Tonnes CO_2e)			Petroleum Reductions (Million Gallons)		
		2015	2020	2025	2015	2020	2025
Expected Benefits	Fueling Infrastructure	79.9	518.8	529.2	18.7	96.6	98.4
	Vehicles	106.9	605.0	1,119.3	25.1	81.3	141.9
	Fuel Production	39.2	589.8	782.5	3.5	55.0	73.2
	TOTAL	226.0	1,713.7	2,431.0	47.4	232.8	313.5
Market Transformation Benefits	Low Case	214.8	378.1	802.6	24.8	48.7	93.6
	High Case	483.9	2,038.3	3,184.0	65.3	245.2	364.6
Required Carbon Market Growth	Low Case	-	2,333	6,375	-	237.2	957.3
	High Case	-	6,397	15,189	-	665.4	1,959

Source: NREL.

The estimates for Expected Benefits and Market Transformation Benefits are summarized in Table 6. Expected Benefits for all project classes by 2025 total about 2.43 million metric tons of carbon dioxide equivalent ($MMTCO_2e$). The Market Transformation Benefits by 2025 range from 802,600 metric tons CO_2e in the Low Case to 3.18 $MMTCO_2e$ in the High Case. Combining this range of benefits with the Expected Benefits category yields a GHG reduction range of 3.2 $MMTCO_2e$ to 5.6 $MMTCO_2e$ by 2025. Cumulative petroleum reductions for Expected and Market Transformation Benefits range from 407.1 million to 678.1 million gallons by 2025.

These categories can be compared against the fourth category, Required Market Growth Benefits. This category represents an approximate trajectory for how California will need to reduce GHG emissions to meet its 2050 goal. Total Expected Benefits and Market Transformation Benefits represent a significant contribution to overall efforts to reduce transportation-related GHG emissions: more than half of the roughly 7 $MMTCO_2e$ needed in the 2020 to 2025 time frame, as indicated by Figure 3. Another comparative reference is that the high case GHG reduction estimate of 5.6 $MMTCO_2e$ would represent one-third of the 15 $MMTCO_2e$ in transportation GHG emissions reductions projected for the Low Carbon Fuel Standard program in 2020.[21] Figure 3 depicts steady progress along this trajectory but highlights the clear need for future investments as well.

Figure 3: GHG Reductions From Expected and Market Transformation Benefits in Comparison to Required Market Growth Benefits



Source: NREL.

ARFVTP Benchmarks of Progress

The ARFVTP takes a portfolio approach toward funding projects of different fuel and technology types to achieve the state's clean transportation goals. This approach

21 California Air Resources Board. *2014 LCFS Advisory Panel.* May 19, 2014. Available at http://www.arb.ca.gov/fuels/lcfs/workgroups/advisorypanel/051914advisorypanelpresentation.pdf.

reflects the fact that no single alternative fuel or technology is guaranteed to succeed in the marketplace or be perfect for all applications. Each fuel and technology type has its own unique market barriers. For this reason, in addition to the collective program benefits described in NREL's work, staff is also identifying and developing unique benchmarks of progress for each project type.

Staff initially raised the prospect of developing fuel- and technology-specific benchmarks at an August 2016 public workshop. Subsequently, during the October 2016 Advisory Committee meeting, staff presented ideas for what such benchmarks might look like. Staff expects to present initial benchmarks for discussion as part of the development of the FY 2018-2019 investment plan update.

Investments from the ARFVTP alone are not sufficient to achieve the state's policy goals. Because of this, ARFVTP benchmarks will focus primarily on what might be reasonably achieved by program funding. Other sources of government funding, as identified in the Related Policies and Programs section of this report, as well as increasing amounts of private sector funding, will also be critical to meeting state climate change and air quality goals.

Because these benchmarks will reflect an initial consensus on what is achievable by the ARFVTP, staff expects to periodically revisit and revise benchmarks in response to (1) refined assessments of what is truly possible within each project type, (2) refined assessments of the priorities within each project type, and (3) refined allocations in future investment plan updates.

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 the 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.

Subsequently, Executive Order B-30-15 set an interim goal to reduce statewide GHG emissions to 40 percent below 1990 levels by 2030, to ensure California meets the targets of Executive Order S-3-05. 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, codifying the goals of Executive Order B-30-15.

As part of its regulation, the 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 GGRF. The Governor and Legislature enact GGRF appropriations for state agencies to implement a variety of programs that reduce greenhouse gases.

Air Quality Improvement Program and Low Carbon Transportation Investments

In addition to the ARFVTP, AB 118 also created the Air Quality Improvement Program (AQIP), to be administered by the 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, AQIP has provided deployment incentives for light-duty electric vehicles through the CVRP, deployment incentives for alternative medium- and heavy-duty vehicles through the Hybrid and Zero-Emission Truck and Bus Voucher Inventive Project (HVIP), as well as funding for other advanced emission reduction technologies for vehicles. Prior to 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.

The 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. Many projects previously funded by AQIP are now funded by the LCTI program because demand has exceeded available funding from AQIP. The LCTI also provides incentives for light-duty pilot projects to benefit disadvantaged communities; zero-emission truck, bus, and freight equipment pilot commercial deployments; rural school buses; and advanced technology on- and off-road truck and freight demonstrations.

Beginning with FY 2014-2015, CARB combined the AQIP and LCTI into one funding plan. In the fiscal year 2016-17 funding plan, CARB allocated $500 million for LCTI projects and $28.6 million for AQIP.[22] The funding plan, however, was contingent on a full appropriation of $500 million from the GGRF, and the Legislature approved only $363 million.[23] A summary of the funding for the LCTI and the AQIP can be found in Tables 7 and 8.

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22 California Air Resources Board. *Proposed Fiscal Year 2016-17 Funding Plan for Low Carbon Transportation and Fuels Investments and the Air Quality Improvement Program.* May 20, 2016. Available at https://www.arb.ca.gov/msprog/aqip/fundplan/proposed_fy16-17_fundingplan_full.pdf.

23 California Air Resources Board. *Notice of Public Meeting to Consider Modifications to the Fiscal Year 2016-17 Funding Plan for Low Carbon Transportation and Fuels Investments and the Air Quality Improvement Program.* September 22, 2016. Available at https://www.arb.ca.gov/msprog/aqip/fundplan/fy1617_fundingplan_modifications.pdf.

Table 7: FY 2016-2017 Low Carbon Transportation Investments GGRF Allocations

Project Category	Allocation (in Millions)
Clean Vehicle Rebate Project	$133
Enhanced Fleet Modernization Program and Plus-Up Pilot Project and Other Light-Duty Pilot Projects	$80
Advanced Technology Demonstration	$34
Zero-Emission Freight Equipment Pilot Commercial Deployment	$5
Zero-Emission Truck Pilot Commercial Deployment	$18
Zero-Emission Bus Pilot Commercial Deployment	$42
Rural School Bus Pilot	$10
Low NO_X Engine Incentives With Renewable Fuel	$23
Hybrid and Zero-Emission Truck and Bus Voucher Incentive	$18
Total	**$363**

Source: California Air Resources Board.

Table 8: FY 2016-2017 Air Quality Improvement Program Allocations

Project Category	Allocation (in Millions)
Truck Loan Assistance Program	$22
Agricultural Equipment Trade-Up Pilot in the San Joaquin Valley	$3
Reserve for Revenue Uncertainty	$3.6
Total	**$28.6**

Source: California Air Resources Board.

Many project categories listed in the above tables have particular importance to the goals and strategies of the ARFVTP and are further discussed in the Natural Gas Vehicles and the Advanced Freight and Fleet Technologies subsections of 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 May 2016, CARB released a proposed SIP strategy to achieve the emission reductions from mobile sources and consumer products necessary to meet the NAAQS for ozone throughout California.

Also in May 2016, CARB released a *Mobile Source Strategy* that outlines a coordinated effort 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 zero-emission vehicles (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.[24] The actions described in the proposed SIP Strategy intend to resolve these problems and are expected to result in an 80 percent reduction in smog forming emissions and a 45 percent reduction in diesel particulate emissions in the South Coast air basin by 2031.[25] Since exposure to elevated levels of air pollutants causes significant health and economic impacts in the state, reducing emissions of criteria and air toxic 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 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 4, 5, and 6 of this report.

Low-Carbon Fuel Standard

The 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. Since then, regulated parties have had to slowly reduce the carbon intensity of their fuel.

A "credit" under the LCFS is equivalent to the reduction of 1 metric ton of CO_2e, roughly equivalent to the amount of CO_2e released from the combustion of 90 gallons of gasoline. The cost of credits has been volatile, as shown in Figure 4, ranging from a previous high of nearly $80 in December 2013 to a low of nearly $20 in early May 2015. The price per credit began rising in the third quarter of 2015 and maintained an average price of about $115 in the first half of 2016.[26] The recent rise in prices was most likely caused by anticipation and approval of CARB readoption of the LCFS with amendments

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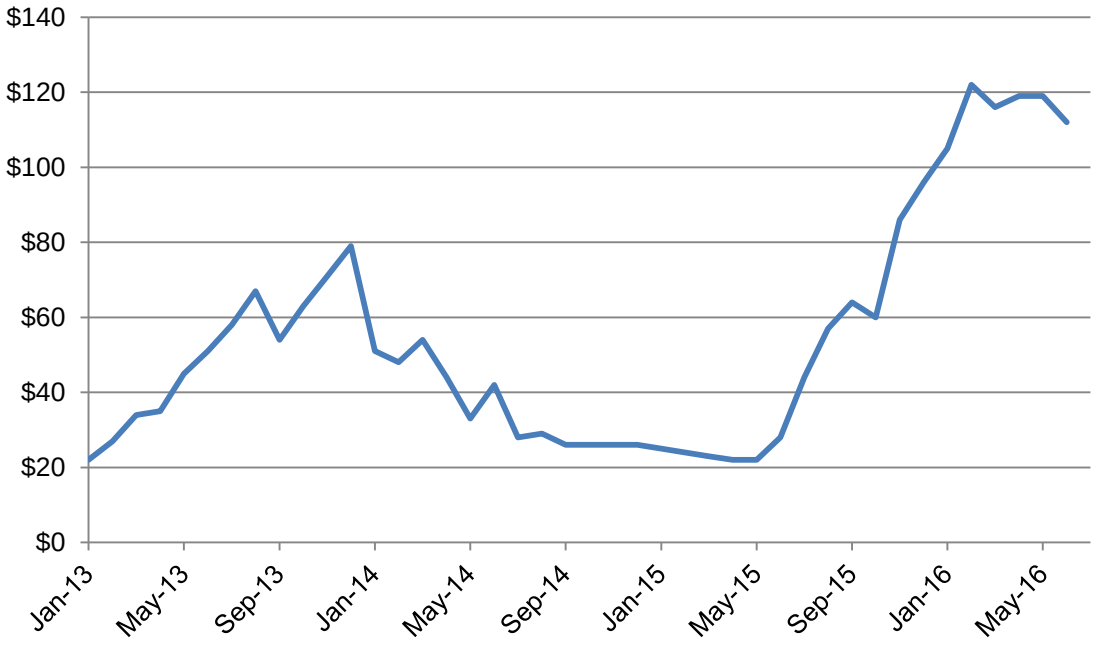
24 California Air Resources Board. *Proposed 2016 State Strategy for the State Implementation Plan.* May 17, 2016. Available at https://www.arb.ca.gov/planning/sip/2016sip/2016statesip.pdf.

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

26 California Air Resources Board. *LCFS Monthly Credit Price and Transaction Volumes June 2016 Spreadsheet*. July 28, 2016. Available at https://www.arb.ca.gov/fuels/lcfs/dashboard/archive/creditpriceserieswithoutargus_06-2016.xlsx.

in September 2015, with an effective date of January 1, 2016. As of December 2015, there were 402 certified transportation fuel pathways available for use under the LCFS, and as of May 2016, 203 parties have registered transactions under the LCFS, including oil refiners, biofuel producers, and electric and natural gas utilities.[27,28]

Figure 4: Average Monthly Low-Carbon Fuel Standard Credit Prices



Source: California Energy Commission. Data from the LCFS Monthly Credit Price and Transaction Volumes June 2016 Spreadsheet, available at http://www.arb.ca.gov/fuels/lcfs/dashboard/archive/creditpriceserieswithoutargus_06-2016.xlsx.

The LCFS has significance for the ARFVTP in several ways. Most importantly, the Energy Commission frequently relies on LCFS-derived carbon intensity numbers in numerous phases of ARFVTP implementation. This 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

27 Yeh, Sonia and Julie Witcover. *Status Review of California's Low Carbon Fuel Standard, 2011-2015: May 2016 Issue.* Institute of Transportation Studies, University of California, Davis, Research Report UCD-ITS-RR-16-02. Available at https://itspubs.ucdavis.edu/wp-content/themes/ucdavis/pubs/download_pdf.php?id=2634.

28 California Air Resources Board. *LRT Registered Parties.* May 20, 2016. Available at https://www.arb.ca.gov/fuels/lcfs/regulatedpartiesreporting20160520.xlsx.

average price of about $115 per credit, the LCFS value of an alternative fuel offering a 50 percent GHG emission reduction compared to gasoline would be roughly $0.64 per gasoline gallon equivalent (GGE).[29] 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.

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 9.[30]

Table 9: Projected Fuel Volumes and Proposed RFS Percentages for 2016 – 2018

Category	Projected Volume			Proposed Percentage of Fuels	
	2016	2017	2018	2016	2017
Cellulosic Biofuel	230 million	311 million	n/a	0.128%	0.173%
Biomass-Based Diesel	1.90 billion	2.00 billion	2.1 billion	1.59%	1.67%
Advanced Biofuel	3.61 billion	4.28 billion	n/a	2.01%	2.38%
Total Renewable Fuels	18.11 billion	19.28 billion	n/a	10.10%	10.70%

Source: U.S. EPA. *All volume is reported in ethanol-equivalent gallons, except for biomass-based diesel, which is in U.S. gallons.

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 regulated parties (and credit-generating 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 has recently been in the range of about $1.00 to

29 Based on assumptions of $115 per MT of CO2e and 0.0112 MT of CO2e per GGE.

30 United States Environmental Protection Agency. *Final Renewable Fuel Standards for 2017, and the Biomass-Based Diesel Volume for 2018.* May 18, 2016. Accessed January 3, 2017. Available at https://www.epa.gov/renewable-fuel-standard-program/final-renewable-fuel-standards-2017-and-biomass-based-diesel-volume.

$2.00, with one RIN representing the energy content of a gallon of ethanol.[31] This volatility affects the income of biofuel producers and can negatively affect investments in projects.

In summer 2014, the U.S. EPA also classified biomethane under the "Cellulosic Biofuel" category, which thereby expanded the eligibility of biomethane from landfills, wastewater treatment plants, agricultural digesters, and municipal solid waste digesters and nearly doubled the projected volume of cellulosic biofuel for 2014. This expansion should encourage the growth of biomethane production both within and outside California.

Executive Order on Sustainable Freight

Executive Order B-32-15, issued by Governor Brown on July 17, 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.[32] The resulting *California Sustainable Freight Action Plan* was released in July 2016 and identifies state policies, programs, and investments to achieve these targets.[33]

The plan was developed as a combined effort by the California State Transportation, California Environmental Protection, and California Natural Resources Agencies, including CARB, California Department of Transportation, Energy Commission, and 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.

Executive Order on Zero-Emission Vehicles

On March 23, 2012, Governor Brown issued Executive Order B-16-12[34], 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. The *ZEV Action Plan*, first issued in 2013 and subsequently updated in October 2016, includes actions that apply directly to the funding categories of the ARFVTP.[35] Some actions in the *ZEV Action Plan*

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31 PFL Fuel Services. *PFL Markets Daily*. September 15, 2016. Available at http://www.progressivefuelslimited.com/Web_Data/pfldaily.pdf.

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

33 Available at http://www.casustainablefreight.org/app_pages/view/154.

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

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

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 Charging Infrastructure, Hydrogen Refueling Infrastructure, and Advanced Freight and Fleet Technologies sections of this investment plan update discuss proposed ARFVTP activities to 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. 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 the CARB in consultation with the Energy Commission and related agencies. The new 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 by disadvantaged, low-income, and moderate-income communities and consumers. In implementing the initiative, the CARB must include a three-year funding forecast for near zero- and zero-emission vehicles. The first of these forecasts was made available in the *Fiscal Year 2016-17 Funding Plan for Low Carbon Transportation and Fuels Investments and the Air Quality Improvement Program*, which was released by CARB in May 2016. The 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 Alternative-Fueled Vehicle Proceedings

In 2014, the California Public Utilities Commission (CPUC) adopted Decision 14-12-079 in Rulemaking 13-11-007, which allows for the consideration of utility ownership of electric vehicle charging stations (EVCS) 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.[36] These pilot programs are described further in the Electric Charging Infrastructure section. The Energy Commission has worked and will continue to work

36 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/General.aspx?id=5597.

closely with other agencies to ensure the strategic deployment of EVCS and avoid redundant investments in infrastructure.

The CPUC is working to implement the transportation electrification provisions of Senate Bill 350 by directing the six investor-owned electric utilities under CPUC jurisdiction to propose portfolios of transportation electrification programs and investments that can be implemented over the next two to five years. These utilities are expected to submit applications for CPUC review in 2017. Also in 2017, PG&E, SCE, and SDG&E are expected to provide customer incentives to plug-in electric and natural gas vehicle drivers as part of the utility implementation of the LCFS program.[37]

Volkswagen Diesel Emissions Settlement

Between 2009 and 2015, Volkswagen sold 2.0- and 3.0-liter diesel vehicles in California that used illegal devices to defeat emission tests. To remedy the environmental harm caused by the use of defeat devices, California will receive about $1.2 billion for air pollution reduction and ZEV advancement projects in the state.[38,39] This amount includes about $381 million from a national Environmental Mitigation Trust for projects to reduce NO_x emissions from medium- and heavy-duty vehicles, including in disadvantaged communities, and $800 million that Volkswagen will invest in ZEV-related programs.

The ZEV program investment will occur over a 10-year period and eligible projects include fueling infrastructure for both plug-in electric vehicles and hydrogen fuel cell 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 ZEV infrastructure funding, valued at up to $80 million per year, is expected to complement ARFVTP investments in electric charging infrastructure and hydrogen refueling infrastructure. The Energy Commission will monitor the development of the Volkswagen settlement investment plans to ensure that investments are coordinated.

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37 California Public Utilities Commission Decisions (D.)14-05-021 and D.14-12-083. Available at http://www.cpuc.ca.gov/General.aspx?id=5597.

38 California Air Resources Board. "Volkswagen to Spend Over One Billion Dollars in California to Address Illegal Emissions Caused by Cheating Devices on its 2.0-Liter Diesel Vehicles." June 28, 2016. Release # 16-33. Available at https://www.arb.ca.gov/newsrel/newsrelease.php?id=834.

39 California Air Resources Board. "CARB Announces Partial Consent Decree for Audi, Volkswagen and Porsche 3-Liter Diesel Vehicles." December 20, 2016. Release # 16-61. Available at https://www.arb.ca.gov/newsrel/newsrelease.php?id=885.

CHAPTER 3:
Alternative Fuel Production and Supply

Biofuel Production and Supply

The California transportation sector depends largely on petroleum, with 91 percent of the roughly 29.8 million vehicles in the state relying exclusively on either gasoline or diesel for fuel.[40] Any low-carbon substitute fuel that can displace the roughly 13.6 billion gallons of gasoline and 3.4 billion gallons of diesel used per year in California can provide both an immediate and long-term opportunity to reduce GHG emissions and petroleum use.[41] 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.[42] One goal of the ARFVTP is to expand the production of low-carbon, economically competitive biofuels from waste-based and renewable feedstocks in California.

The carbon intensity of biofuels can vary significantly, depending on the feedstocks and conversion processes used in production. CARB provides carbon intensity values for most petroleum fuels and biofuels 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 per megajoule (gCO_2e/MJ). California reformulated gasoline and ultra-low-sulfur diesel have carbon intensities of 99.78 and 102.01 gCO_2e/MJ, respectively.[43] A biofuel with a lower carbon intensity than these values can provide net GHG emission benefits if it is used to displace gasoline or diesel fuel. The carbon intensity of a biofuel depends on the pathway, which accounts for the specific feedstock and production process used. Maximizing biofuel production from the lowest-carbon pathways represents a key opportunity to reduce near-term GHG emissions in combustion engines. Biofuels derived from waste-based feedstocks typically have the lowest carbon intensity of all biofuels.

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

41 Ibid.

42 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.

43 CARB. *LCFS Fuel Pathway Table.* August 11, 2016. Available at https://www.arb.ca.gov/fuels/lcfs/fuelpathways/pathwaytable.htm.

In 2015, renewable diesel was the most common diesel substitute used in California, the majority of which was supplied through overseas imports. The ARFVTP has provided funding to two in-state commercial-scale renewable diesel producers to expand their production capacity. When operational, the projects will have a combined production capacity of 47.5 million gallons per year, which is expected to increase renewable diesel use in California. 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. California has nine biodiesel production facilities in operation with a combined production capacity of 74 million gallons per year, four of which were funded by the ARFVTP.[44] An additional four biodiesel production projects have received ARFVTP funding but are not operational. The eight ARFVTP-funded biodiesel production projects are expected to expand production capacity by a cumulative 55 million gallons of fuel per year. Renewable diesel and biodiesel have carbon intensities ranging from 18 to 96 percent lower than diesel fuel, depending on the pathway used.[45] Together, renewable diesel and biodiesel accounted for about 40 percent of LCFS credits from a combined total of about 292 million gallons of fuel in 2015.[46]

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. 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 1.5 million FFVs are registered in California, which, during 2015, used a total of 14.8 million gallons of E85.

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44 Comments submitted by California Biodiesel Alliance to Energy Commission docket 15-ALT-01, TN 210127. February 2, 2016.

45 Compared to California diesel (102.01 gCO2e/MJ), with biodiesel carbon intensity of 4 to 83.25 gCO2e/MJ and renewable diesel carbon intensity of 19.65 to 82.16 gCO2e/MJ. Based on data from the LCFS Fuel Pathway Table (August 11, 2016), available at https://www.arb.ca.gov/fuels/lcfs/fuelpathways/all-composite-pathways-081116.xlsx.

46 California Air Resources Board. *LCFS Quarterly Data.* July 28, 2016. Available at http://www.arb.ca.gov/fuels/lcfs/lrtqsummaries.htm.

While sales of E85 continue to increase as more fueling stations come on-line, E85 accounts for only about 1 percent of the total fuel used by FFVs.[47] Though ethanol continues to be the largest volume alternative fuel used in California, in-state ethanol use has not substantially changed since 2011. The state has the capacity to produce about 220 million gallons of ethanol per year, using primarily corn or sorghum as a feedstock.[48,49]

The Energy Commission has provided support for E85 distribution infrastructure to reduce petroleum dependence and decrease greenhouse gas emissions. Through FY 2012-2013, the ARFVTP provided more than $16.4 million in grants to fund the construction of 205 E85 fueling stations throughout the state. Many of these projects, however, have proceeded with fewer stations than originally proposed or have not yet proceeded at all. In addition, compared to other biofuels, E85 provides only a modest reduction in carbon intensity of about 15 percent below that of gasoline.[50] Furthermore, recent E85 prices have been, on average, 12 percent higher than gasoline on an energy-equivalent basis.[51] This price premium makes it difficult for E85 to complete with gasoline. For these reasons, the Energy Commission discontinued funding for E85 infrastructure beginning with the *2013-2014 Investment Plan Update*.

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, development,

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

48 Nebraska Energy Office. *Ethanol Facilities Capacity by State and Plant*. July 2016. Accessed August 26, 2016. Available at http://www.neo.ne.gov/statshtml/122.htm.

49 California Air Resources Board. *LCFS Quarterly Data*. July 28, 2016. Available at http://www.arb.ca.gov/fuels/lcfs/lrtqsummaries.htm.

50 Assumes California gasoline carbon intensity of 99.78 gCO2e/MJ, average ethanol carbon intensity in 2015 of 81.6 gCO2e/MJ, and an E85 blend consisting of 83 percent ethanol and 17 percent gasoline. Based on data from the LCFS Fuel Pathway Table (August 11, 2016) available at https://www.arb.ca.gov/fuels/lcfs/fuelpathways/all-composite-pathways-081116.xlsx and LCFS Quarterly Data (July 28, 2016) available at https://www.arb.ca.gov/fuels/lcfs/dashboard/quarterlysummary/media_request_072816.xlsx.

51 Energy equivalent pricing derived from California average fuel price data for E10 and E85 for the 24-month period covering September 2014 through August 2016 from http://e85prices.com/california.html. Accessed August 26, 2016. E85 prices were adjusted to account for differences in energy density of 114,300 BTU/gallon for E10 and 81,655 BTU/gallon for E85.

and demonstration phases and, if developed into a commercially viable product, may contribute significantly to California's environmental and energy goals.

Biomethane is a prominent biofuel that, in addition to serving as a low-carbon substitute for conventional natural gas, can be used as a source for renewable hydrogen. 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 possesses a negative carbon intensity roughly 125 percent below diesel.[52] Assembly Bill 341 (Chesbro, Chapter 476, Statutes of 2011) set a state goal of reducing, recycling, or composting 75 percent of solid waste by 2020. In addition, Senate Bill 1383 (Lara, Chapter 395, Statutes of 2016) set additional goals to reduce statewide disposal of organic waste from 2014 levels by 50 percent by 2020 and 75 percent by 2025. These goals should support prelandfill biomethane production by increasing the availability of organic waste feedstocks. Given these state goals to divert substantial amounts of organic waste from landfills and the corresponding need for infrastructure to process this organic waste, the ARFVTP will exclude landfill gas projects from consideration in FY 2017-2018.

Feedstock availability must also be considered when determining the potential of biofuels. In July 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.[53] 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.

To date, the Energy Commission has awarded $167 million to 59 biofuel production projects. These awards are summarized by fuel type in Table 10.

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

53 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.

Table 10: Summary of Biofuel 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	$32.4
Diesel Substitutes	56	$162.2	25	$75.1
Biomethane	45	$139.5	20	$59.5
Total	**126**	**$360.5**	**59**	**$167.0**

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

Low life-cycle GHG emissions, as well as other sustainability considerations, have been a primary factor in determining ARFVTP funding for biofuel production projects. Table 11 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 11: GHG Emission Reduction Potential of Commercial-Scale ARFVTP Projects

Fuel Type	Pathway Descriptions	Average GHG Emission Reduction[54]	# of Projects	Range of Annual Capacity for Individual Projects	Total Annual Capacity Increase
Biomethane	Food, green, yard, and mixed municipal waste	110%	5	394,000 – 2,870,000 DGE	6.0 Million DGE per Year
Diesel Substitutes	Waste oils (various)	81%*	10	4,600,000 – 20,000,000 DGE	74.9 Million DGE per Year
Gasoline Substitutes	Grain sorghum	25%	3	2,600,000 – 3,000,000 GGE	8.6 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).

54 Compared to California diesel (102.01g CO2e/MJ) for biomethane and diesel substitutes, and California gasoline (99.78g CO2e/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.

Recent ARFVTP biofuel 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 biofuel production. The ARFVTP 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 precommercial ARFVTP projects is shown in Table 12, including pathways and greenhouse gas emission reduction potential.

Table 12: Sample of Precommercial ARFVTP Projects

Fuel Type	Pathway Description	Estimated GHG Emission Reduction[55]	# of Projects	Annual Capacity for Individual Projects (Diesel or Gasoline Gallon Equivalent)
Biomethane	Wastewater	88%	1	160,000
Diesel Substitutes	Algae	66%-122%	2	1,200 – 5,000
Diesel Substitutes	Green Waste	66%	1	365,000
Gasoline Substitutes	Agricultural Residues* and Energy Crops	73%-76%	2	Nominal

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

The most recently completed biofuel production and supply solicitation, GFO-15-606, was released in July 2016 and was open to both 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 preapplication proposals requesting $148.1 million, illustrating a continuing need for and interest in ARFVTP funding in this sector. Twenty-one of these preapplications received a passing score, 12 applicants applied for funding in Phase Two of the solicitation, and 11 of these proposals were selected to receive a total of $37.1 million in awards.

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

55 Ibid.

of ARFVTP funding. As such, this investment plan will retain the single allocation for all biofuels as used in previous years to allow greatest flexibility for funding solicitations.

Other state and federal programs may also provide support and incentives to biofuel producers. For example, the California Department of Resources Recycling and Recovery (CalRecycle) Organics Grant Program awarded $8.9 million to three biomethane-producing projects in 2014. For fiscal year 2016-2017, CalRecycle made $12 million from the GGRF available for anaerobic digester projects under the Organics Grant Program. In addition, the California budget for fiscal year 2016-2017 appropriated a $50 million GGRF allocation to the California Department of Food and Agriculture, with up to $36 million expected to fund anaerobic digesters at dairies.[56] 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 biofuel producers by creating markets for carbon credits and renewable fuels.

In September 2015, the Energy Commission hosted a Lead Commissioner Technology Merit Review workshop for biofuel 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. Biofuels are linked in price to that of gasoline, diesel fuel, and conventional natural gas because they are substitutes for those fuels. During times of low petroleum prices or high feedstock prices, biofuel producers may have no choice but to sell at a loss. Energy Commission staff has considered biofuel production incentives 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, biofuel production incentives are not viable under the ARFVTP.

Given the enormous petroleum and GHG emission reduction potential of any low-carbon, drop-in gasoline or petroleum replacement, future ARFVTP 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. Recent drought and other effects of climate change have accelerated a

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[56] California Air Resources Board. *Greenhouse Gas Reduction Fund: California Department of Food and Agriculture Expenditure Record for Fiscal Year 2016-17 – Dairy Digester Research and Development Program.* February 7, 2017. Available at https://www.arb.ca.gov/cc/capandtrade/auctionproceeds/ddrdpexpenditurerecordandconcurrencememo.pdf.

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. Through the ARFVTP, the Energy Commission hopes 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 developed. The Energy Commission may evaluate biofuel 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 biofuels 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 2017-2018, the Energy Commission allocates $19.4 million for biofuel production and supply to continue support for new and expanded biofuel production plants in California.

Summary of Alternative Fuel Production and Supply Allocations

Table 13: FY 2017-2018 Funding for Alternative Fuel Production and Supply

Biofuel Production and Supply Relevant Policy Goals: – GHG Reduction – Petroleum Reduction – In-State Biofuels Production – Low Carbon Fuel Standard	$19.4 Million	$0.6 million decrease relative to FY 2016-2017*
Total	**$19.4 Million**	

Source: California Energy Commission. *This allocation has been decreased compared to previous versions of this report because of a 2.8 percent reduction applied to all allocations. The reasons for the reduction are discussed in the Summary of Program Funding section of Chapter 2.

CHAPTER 4:
Alternative Fuel Infrastructure

Electric Charging Infrastructure

Electric vehicles are expected to be a key component of achieving zero-emission vehicle deployment, greenhouse gas reduction, and air quality goals in California. ARFVTP investments in electric charging infrastructure are guided in part by the *ZEV Action Plan*, which sets a goal of deploying infrastructure capable of supporting up to 1 million zero-emission vehicles by 2020. The majority of these ZEVs are expected to be plug-in electric vehicles (PEVs) since CARB manufacturer surveys forecast that fewer than 20,000 fuel cell electric vehicles will be on California roads by 2020.[57] Cumulative sales of PEVs, which include both battery-electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs), are steadily growing in California, with more than 275,000 sold through February 2017.[58] Most current-generation PEVs, however, are restricted in electric-drive range by the limitations of existing battery technology. A convenient, reliable network of public EVCS is therefore critical to address these limitations, support the expansion of PEV ownership in California, and achieve the goals of the *ZEV Action Plan*.

The Energy Commission has supported the rollout of PEVs by awarding more than $78 million in ARFVTP funding for EVCS. Due in part to these investments, California has the largest network of nonresidential chargers in the nation, accounting for nearly one out of every four public charging stations.[59] ARFVTP investments have funded multiple categories of EVCS, as detailed in Table 14.

57 California Air Resources Board. *2016 Annual Evaluation of Fuel Cell Electric Vehicle Deployment and Hydrogen Fuel Station Network Development*. July 2016. Available at http://www.arb.ca.gov/msprog/zevprog/ab8/ab8_report_2016.pdf.

58 California Plug-In Electric Vehicle Collaborative. *Detailed Monthly Sales Chart*, March 3, 2017. http://www.pevcollaborative.org/sites/all/themes/pev/files/2_feb_2017_Dashboard_PEV_Sales.pdf.

59 U.S. Department of Energy. *Alternative Fueling Station Counts by State*. August 24, 2016. http://www.afdc.energy.gov/fuels/stations_counts.html.

Table 14: Charging Stations Funded by ARFVTP as of March 1, 2017

	Residential	Multiunit Dwelling	Commercial	Workplace*	Fleet	DC Fast Chargers	Total
Installed	3,936	280	2,172	233	104	68	6,793
Planned	-	15	603	133	-	252	1,003
Total	3,936	295	2,775	366	104	320	7,796

Source: California Energy Commission. Does not include projects that have yet to be approved at a Commission business meeting. *An unspecified number of additional workplace charging stations are included in the commercial column, which were funded before workplace chargers were tracked separately.

More than 95 percent of charging stations funded to date by the ARFVTP are Level 2 chargers, which use alternating current electricity to charge a PEV at 240 volts to provide about 10 to 20 miles of range per hour of charging. The ARFVTP has also funded a small number of Level 1 chargers, which use alternating current electricity at 120 volts to provide about 5 miles of range per hour of charging.[60] The residential, multiunit dwelling, commercial, workplace, and fleet charging stations reported in Table 14 consist entirely of Level 1 and Level 2 charging stations.

Residential projects account for half of all charging stations funded by the ARFVTP, 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 charging stations at single-family homes. Chargers for multiunit dwellings, however, still face market barriers that impede PEV adoption. Although multiunit dwellings account for nearly 40 percent of the state housing stock, only 9 percent of PEV owners live in an apartment or condominium.[61] This area has also been historically underrepresented by project applicants despite efforts to target incentives toward EVCS installations in multiunit dwellings.

Workplace and commercial charging stations are another major component of the ARFVTP portfolio of charging stations. Commercial charging, as identified in Table 14, includes stores, parking garages, universities, municipal governments, curbside locations, and other common, publicly accessible destinations. When residents of multi-unit dwellings 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 commercial charging can also help BEV owners extend their range and PHEV owners increase their electric miles driven.

60 Center for Sustainable Energy. *Electric Vehicles 101*. Accessed August 24, 2016. Available at https://cleanvehiclerebate.org/eng/electric-vehicles-101.

61 Center for Sustainable Energy. *California Air Resources Board Clean Vehicle Rebate Project, EV Consumer Survey Dashboard*. Accessed August 24, 2016. Available at http://cleanvehiclerebate.org/survey-dashboard/ev.

Open access to commercial 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.[62] Nearly all workplace and commercial chargers funded by the ARFVTP are publicly accessible. In addition, the majority of charging at these 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 intermittent renewable energy is available to the electricity grid, the electricity supply available during the day will increase and possibly result in overgeneration. Daytime PEV charging, notably at workplace and commercial charging stations, has the opportunity to reduce the negative effects of overgeneration.

A complete PEV charging network will also require fast chargers, which use direct current electricity at 480 volts to recharge a BEV in about 30 minutes.[63] When located along major interregional corridors, these 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 multiunit housing. Next-generation BEVs with higher-capacity batteries will require higher-powered fast chargers than what is adequate for current-generation BEVs. The Energy Commission is considering how to best apply ARFVTP funding to meet the anticipated infrastructure needs of future vehicles.

Senate Bill 350 (De León, Chapter 547, Statutes of 2015) 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. The recommendations in the study, specifically on how to increase access to ZEVs in disadvantaged communities, are expected to inform and guide ARFVTP deployment efforts for EVCS.

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, require new 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

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

63 Center for Sustainable Energy. *Electric Vehicles 101.* Accessed August 24, 2016. Available at https://cleanvehiclerebate.org/eng/electric-vehicles-101.

of financing EVCS, the ARFVTP funded the Electric Vehicle Charging Station Financing Program, which is administered by the California Pollution Control Financing Authority. Potential borrowers have shown limited interest in this demonstration-scale financing program, so the Energy Commission may reconfigure the program to better meet the needs of charging station site hosts. Other advanced financing mechanisms may also be considered as EVCS markets continue to mature.

The ARFVTP has undertaken additional efforts to ensure adequate charging infrastructure for future PEVs in California, such as allowing grant 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. Further activities beyond those described in this section may be needed to ensure adequate charging infrastructure. Coordination of and support for the effective deployment of EVCS signage throughout the state may be necessary to enable long-distance PEV travel. Moreover, there may be future opportunities for the state to demonstrate the value of vehicle-to-grid technologies in expanding the business case for PEVs.

In December 2014, the CPUC adopted Decision (D.) 14-12-079, which permits utility ownership of EVCS, contingent upon an examination of the utility program through a balancing test.[64] A prior CPUC decision, D.11-07-029, had prohibited utility ownership of charging infrastructure; however, utilities may now apply for ownership approval on a case-specific basis. To date, three investor-owned utilities have applied to install electric vehicle chargers or supporting infrastructure in their respective service territories. Southern California Edison launched its "Charge Ready" pilot program in May 2016, and San Diego Gas & Electric expects to begin installations under its "Power Your Drive" program in early 2017. Energy Commission-funded projects and the investor-owned utility projects are expected to complement one another within the utility service territories. Table 15 summarizes the objective and status of the three investor-owned utility programs.

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

Table 15: Proposed and Approved Utility EVCS Investments

Investor-Owned Utility	Proposed # of EVCS	Proposed Type of Infrastructure and Location	Estimated Cost	Status
Pacific Gas and Electric Company	7,500	Supporting infrastructure and EVCS at commercial and public locations, including multiunit dwellings	$130 million	Approved
San Diego Gas & Electric	3,500	EVCS at workplaces and multiunit dwellings	$45 million	Approved
Southern California Edison Company	1,500	Supporting infrastructure and rebates for customer-owned EVCS	$22 million	Approved

Source: Pacific Gas and Electric Company (PG&E), San Diego Gas & Electric, and Southern California Edison.

Other organizations have also committed to provide substantial funding for EVCS deployment in California as well. EVgo is expected to install at least 200 fast chargers and 10,000 Level 2 chargers as part of the energy crisis settlement reached between the CPUC and NRG Energy, Inc. Volkswagen has also agreed to invest $800 million over a 10-year period to install EVCS in California as part of a settlement with CARB.[65] 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 for EVCS, the Energy Commission may need to focus deployment on specific project types and geographic areas to avoid duplication. The smaller scale and limited scope of these specialized projects may require a funding mechanism with more flexibility than the grant solicitations that have been predominantly used to date. Vouchers or rebates, provided to recipients through third-party administrators, can provide this level of flexibility, as well as simplify the funding process and accelerate deployment. The Energy Commission may consider disbursing EVCS infrastructure funding using such a mechanism to provide incentives through one or multiple regional organizations.

The Energy Commission may also make funding available for the repair and upgrade of existing chargers. Several hundred legacy charging stations remain in service that use largely obsolete charging connectors. While these charging stations are incapable of charging a modern PEV, they can be upgraded to a modern charger at a reduced cost since the site is already set up for electric vehicle infrastructure. 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

65 California Air Resources Board. "Volkswagen to Spend Over One Billion Dollars in California to Address Illegal Emissions Caused by Cheating Devices on Its 2.0-Liter Diesel Vehicles." June 28, 2016. Release # 16-33. Available at https://www.arb.ca.gov/newsrel/newsrelease.php?id=834.

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.

To date, the majority of California PEV sales and EVCS deployment has occurred in larger urbanized areas such as the San Francisco Bay Area and the Los Angeles metropolitan area. Infrastructure deployment in smaller metro areas, however, has been insufficient to support existing and future PEVs. Given the uneven deployment, the Energy Commission may dedicate funding from this category to cities or counties that have insufficient publicly available chargers. These targeted projects would deploy sufficient EVCS to meet the current and projected needs in the locality. In addition, these projects would showcase the ability of a city or county to become PEV-ready and provide guidance and lessons learned to other municipalities with similar objectives. These projects would also more evenly distribute EVCS throughout the state, promote interregional travel, and encourage PEV sales outside early adopter communities.

New mobility services, including car and ride sharing, present another opportunity 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 most recently completed electric vehicle charging infrastructure solicitation, GFO-15-603, was released in January 2016. The solicitation built upon the previous fast charger deployment efforts of GFO-15-601 and sought to deploy fast chargers along specific corridors on state and interstate highways in California. Forty-seven proposals were received under GFO-15-603, requesting more than $52 million in funding. Of these, 21 projects were funded with a combined $13.9 million in grants.

For FY 2017-2018, the Energy Commission allocates $16.6 million for electric charging infrastructure. Despite the significant amount of funding for electric vehicle infrastructure expected from other sources, the Energy Commission believes continued funding for this allocation is necessary for projects not covered by the geographic area or scope of other programs. Electric vehicle charging infrastructure investments from multiple sources will be necessary to keep pace with expected deployment of PEVs in the state and meet the goals of the *ZEV Action Plan*.

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 broad variety of pathways, including the use of renewable sources of energy. When

produced with one-third renewable energy, the hydrogen for a passenger FCEV can reduce GHG emissions by 50 to 70 percent compared to gasoline for a conventional vehicle, which is comparable to the GHG emissions benefits of BEVs.[66] FCEVs can also travel farther and be refueled more quickly than BEVs. Fuel cells enable electrification of a broad range of vehicles, from midsize sedans to SUVs, vans, trucks, and transit buses. For this reason, FCEVs can complement BEVs in the marketplace by offering a portfolio of zero-emission vehicles to drivers who want or need a larger vehicle, more range, and/or faster refueling.

Several automakers have already announced near- and long-term plans for launching FCEVs in early markets. In 2014, Hyundai became the first automaker to offer a production model FCEV, the Tucson Fuel Cell, for lease to private customers in California. Toyota subsequently released the Mirai FCEV in 2015, and Honda released its production Clarity FCEV in December 2016. Toyota and Honda have also offered loans to hydrogen refueling station provider FirstElement Fuel to support the construction of new hydrogen refueling stations within California.[67]

The Energy Commission is working with hydrogen station developers to create a network of stations needed to support the initial deployment of hydrogen fuel cell vehicles from Hyundai, Toyota, Honda, and other manufacturers. As of March 2017, 26 ARFVTP-funded hydrogen refueling stations were operational in California. An additional 22 stations are expected to be operational in 2017. Through the ARFVTP, the Energy Commission has thus far provided funding to install or upgrade 64 publicly available hydrogen stations capable of light-duty vehicle refueling. This network of stations will have sufficient capacity to support the initial 13,500 FCEVs projected to be on the road in California by the end of 2019. The number of hydrogen refueling stations open to light-duty FCEV drivers is expected to increase significantly with investments from the ARFVTP and support from related public agencies.

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 108 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.

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66 Based on a range of potential fuel pathways hydrogen established by the LCFS. This includes an energy economy ratio of for 2.5 FCEVs and a range of 76.1-120.2 grams CO2e/MJ for hydrogen with one-third renewable content. Source: CARB. *LCFS Fuel Pathway Table.* August 11, 2016. Available at https://www.arb.ca.gov/fuels/lcfs/fuelpathways/pathwaytable.htm.

67 "Honda to Loan First Element $14 Million for Hydrogen Fueling Stations." *Green Car Reports.* November 19, 2014. Available at http://www.greencarreports.com/news/1095563_honda-to-loan-first-element-14-million-for-hydrogen-fueling-stations.

As under previous awards, the 16 stations funded under GFO-15-605 will provide at least 33 percent of the hydrogen from renewable resources. Six 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 35 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 facilities. Of the 64 stations that have received ARFVTP funding, 8 are planned to use on-site electrolysis to generate hydrogen. Renewable hydrogen production is further discussed in the Emerging Opportunities section in Chapter 6 of this report.

In addition to funding new or upgraded stations, the Energy Commission and related agencies have supported projects to accelerate the growth of FCEVs and hydrogen refueling infrastructure throughout the state. Table 16 summarizes support projects that have been funded through the ARFVTP. Other organizations have also supported the growth of hydrogen transportation fuel. For example, the Governor's Office of Business and Economic Development hosted workshops in 2014 and 2015 to bring together state and local officials with fuel-cell vehicle manufacturers, hydrogen safety experts, and refueling station developers to familiarize participants with hydrogen fuel and vehicles.

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

The California Fuel Cell Partnership (CaFCP) has also supported the growth of hydrogen as a transportation fuel. 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 vehicles and hydrogen stations. In addition, to address consumer issues associated with station downtime, the CaFCP developed the Station Operational Status System mobile Web application.[68] This application provides status information for hydrogen refueling stations to consumers, allowing them to avoid stations with insufficient fuel or offline equipment.

68 The Station Operational Status System is available at http://cafcp.org/stationmap.

Table 16: Related Projects for Hydrogen Refueling

ARFVTP Project(s)	ARFVTP Amount (in Millions)	Description
Agreement for Mobile Refueler	$1	Developed and deployed a mobile hydrogen refueler with storage, compression, and dispensing capabilities
Agreement With AC Transit	$3	Deployed a hydrogen refueling station for transit buses only
Agreement With California Department of Food and Agriculture	$3.9*	Interagency agreement that developed regulations and test procedures for selling hydrogen on a per-kilogram basis
Agreement With California Department of Food and Agriculture	$0.1*	Interagency agreement to provide staff to test station dispensing equipment and verify that hydrogen fueling protocols are being followed
Agreement With UC Irvine	$1.9*	Enhancements to STREET model for identifying and assessing station locations
O&M Support	$12.8	Operations and maintenance funding up to $300,000 for new and existing stations
Agreements for Hydrogen Regional Readiness Plans	$0.8	Statewide FCEV readiness activities, such as streamlining station permits, promoting FCEV interest, installation of signage

Source: California Energy Commission. *Funded by a mixture of ARFVTP funds and technical support funds.

Assembly Bill 8 requires the CARB to evaluate the need annually for additional publicly available hydrogen-fueling stations for the subsequent three years. This evaluation includes 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.

The CARB released the *2016 Annual Evaluation of Hydrogen Fuel Cell Electric Vehicle Deployment and Hydrogen Fuel Station Network Development* report in July 2016.[69] This report, prepared to comply with the requirements of Assembly Bill 8, provides CARB's latest assessment of the California FCEV fleet and hydrogen fueling station network. The assessment shows station deployment has progressed at a slower pace than expected, likely due to extended development schedules. This has resulted in a slower FCEV release rate and delay of about one year in FCEV deployments, since automakers cannot sell these vehicles until the appropriate refueling infrastructure is in place.

69 California Air Resources Board. *2016 Annual Evaluation of Fuel Cell Electric Vehicle Deployment and Hydrogen Fuel Station Network Development*. July 2016. Available at http://www.arb.ca.gov/msprog/zevprog/ab8/ab8_report_2016.pdf.

Manufacturer surveys, however, project 13,500 vehicles by the end of 2019 and 43,600 vehicles by the end of 2022. Compared to analyses conducted in previous years, fewer vehicles are expected to be sold before 2018; however, vehicle sales are expected to accelerate in the following years.

Similar to previous years, the 2016 CARB evaluation anticipates a shortfall in hydrogen refueling capacity in future years. Using the vehicle projections to estimate the adequacy of hydrogen refueling capacity in the future, CARB estimates that ARFVTP-funded stations will be sufficient only until around 2020, after which California may experience refueling capacity shortfalls.

The annual evaluation is also complemented by a separate Energy Commission-CARB joint report, titled *Joint Agency Staff Report on Assembly Bill 8: 2016 Annual Assessment of Time and Cost Needed to Attain 100 Hydrogen Fueling Stations in California.*[70] The 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, and the ability of the hydrogen refueling network to serve the anticipated 34,000 FCEVs projected by the end of 2021.

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. The costs for early market hydrogen refueling stations remain high, ranging from $2 million to more than $3 million, depending on method of hydrogen production and delivery, and are not expected to decrease significantly in the near term. The joint report concludes that California will attain the goal of 100 hydrogen refueling stations in 2023 and that $140 million to $150 million in additional ARFVTP funding will be needed.

As noted in the CARB annual evaluation, as well as the California Fuel Cell Partnership report, *A California Road Map: The Commercialization of Hydrogen Fuel Cell Vehicles*, the initial network of hydrogen refueling stations must provide potential FCEV customers with convenient access to hydrogen refueling stations to optimize FCEV adoption.[71] To identify areas of the state with the greatest need for hydrogen refueling infrastructure, the 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

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70 Baronas, Jean, Gerhard Achtelik, et al. California Energy Commission. *Joint Agency Staff Report on Assembly Bill 8: 2016 Annual Assessment of Time and Cost Needed to Attain 100 Hydrogen Refueling Stations in California.* January 2017. Publication Number CEC-600-2016-009. Available at http://www.energy.ca.gov/2017publications/CEC-600-2017-002/CEC-600-2017-002.pdf.

71 California Fuel Cell Partnership. *A California Road Map: The Commercialization of Hydrogen Fuel Cell Vehicles. 2014 Update: Hydrogen Progress, Priorities and Opportunities (HyPPO) Report.* July 2014. Available at http://cafcp.org/sites/default/files/Roadmap-Progress-Report2014-FINAL.pdf.

recent hydrogen refueling infrastructure solicitation, GFO-15-605, used CHIT as part of the proposal evaluation to determine the project coverage, capacity, and market viability.

In addition to funding for infrastructure development, the Energy Commission recognizes the need for operation 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 prior to the mass introduction of FCEVs and is meant to sustain the stations until enough vehicles are on the roads to be profitable. Since 2014, the Energy Commission offered up to $300,000 for three years' worth of O&M funding for each existing or planned station, once operational. As of March 2017, 26 stations have been eligible for this funding.

O&M reimbursements were minimal during FY 2015-2016 but are expected to be notable during fiscal years 2016-2017 and 2017-2018. Assuming all stations are completed as expected, and $100,000 per station is available each year for O&M support for the new stations, the ARFVTP might provide up to $3 million per year in O&M support in each of these fiscal years.[72] The O&M support, however, is expected to reduce the amount of funding available for new hydrogen station development. Given the potential for future shortfalls in station capacity, 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 average station infrastructure development costs may be as low as $1.6 million per station in FY 2017-2018, based on analyses from the 2015 Joint Agency Staff Report on Assembly Bill 8. Given these costs, other station development costs, and projected O&M expenditures, Energy Commission staff estimates a $19.4 million allocation will be able to fund roughly eight or nine new stations. This scenario is expected to result in capacity shortfalls around 2020 and delay the completion of the initial network of 100 stations until about 2023. To avoid such situations, 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 further 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.

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72 The amount of funding to be provided for O&M support for future stations is still under evaluation. To the extent that O&M costs are less than estimated, or station operators are able to recoup O&M costs from increasing retail sales, the amount may be reduced in the future. Of the $14.1 million set aside for proposed O&M support grants awarded under PON-13-607, up to $6.6 million will not be awarded and may be available to fund new hydrogen station development. O&M funding amounts are based on the actual operational date of the station.

For FY 2017-2018, the Energy Commission allocates $19.4 million for hydrogen refueling infrastructure. This funding will provide O&M support for operational stations and continue the deployment of hydrogen refueling infrastructure in preparation for increased FCEV sales.

Natural Gas Fueling Infrastructure

Natural gas vehicles in California depend on a mix of public and private fueling stations capable of dispensing compressed natural gas (CNG) or liquefied natural gas (LNG). California leads the United States in the number of CNG and LNG fueling stations, with more than 300 public or private CNG stations and roughly 45 public or private LNG stations.[73] The technology necessary for natural gas fueling infrastructure is commercially mature, and fuel can be sourced through the existing natural gas pipeline infrastructure throughout the state.

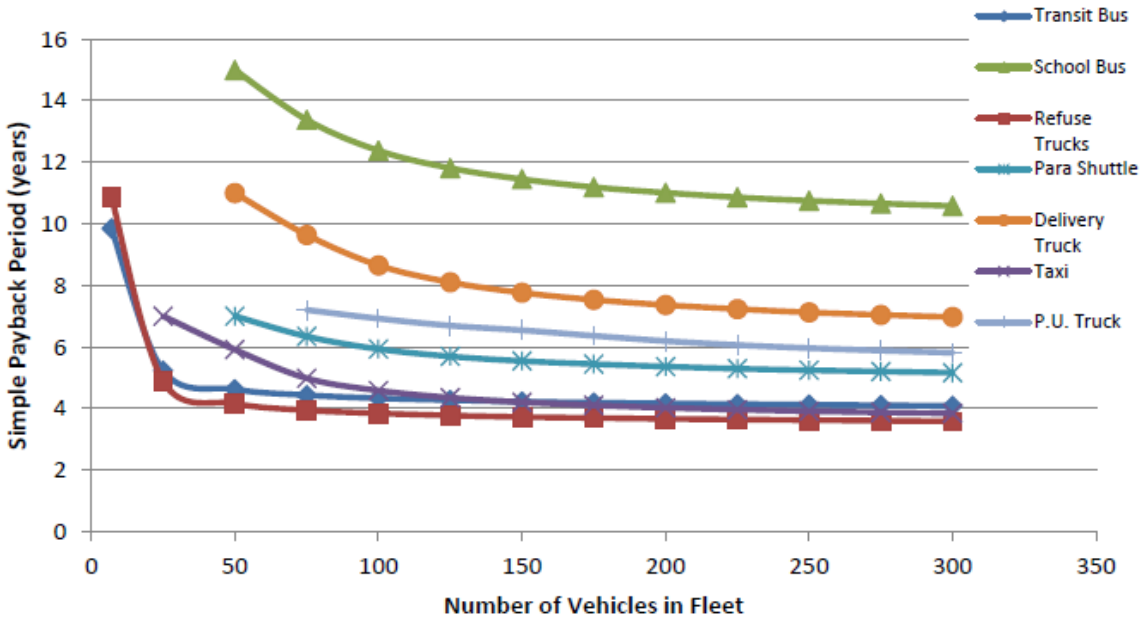
The cost of a natural gas fueling station depends on many factors, including compressor size, storage capacity, and LNG or CNG dispensing capabilities. Costs generally range from $500,000 for smaller CNG-only stations to several million dollars for large combined LNG-CNG fueling stations. Based on this range of costs and the needs of funding recipients, the Energy Commission has offered up to $500,000 in ARFVTP funding to support CNG stations and up to $600,000 for stations dispensing LNG.

The simple payback period for a natural gas vehicle fleet depends on numerous variables, including the cost of infrastructure, the size of the fleet, the price of natural gas relative to diesel fuel, and the vehicle-miles traveled. A 2015 NREL report analyzed of the simple payback period for CNG fleets based on different vehicle types and fleet sizes, which can be seen in Figure 5.[74] School buses, which typically travel fewer miles annually than other vehicle types, have the longest payback period under this analysis.

73 U.S. Department of Energy Alternative Fuels Data Center. *Alternative Fuel Station Locator*. Accessed September 8, 2016. Available at http://energy.gov/maps/alternative-fueling-station-locator.

74 Mitchell, George. *Building a Business Case for Compressed Natural Gas in Fleet Applications*. NREL. March 2015. Publication Number NREL/TP-5400-63707. Available at http://www.nrel.gov/docs/fy15osti/63707.pdf.

Figure 5: Relationship Between CNG Fleet Size and Simple Payback Period



Source: NREL.

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 (SoCal Gas), are also available. This tariff allows SoCal Gas to plan, design, procure, construct, own, operate, and maintain compression equipment on customer premises in exchange for a fee on natural gas dispensed. As 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. The ability of many station operators to obtain financing is reflected in recent investment plans, with funding allocations for natural gas vehicles significantly higher than funding allocations for fueling infrastructure.

Because options exist for many private fleets to obtain financing, the Energy Commission has prioritized its ARFVTP natural gas fueling infrastructure funding toward entities that may not have access to the necessary capital for such long-term investments. The most recent solicitation for natural gas fueling infrastructure projects, GFO-16-602, limited applicants exclusively to public K-12 school districts in California. The Energy Commission received four applications under this solicitation, three of which were eligible for funding and were provided with a total of $1.5 million in grants. Future natural gas fueling infrastructure solicitations will likely continue to prioritize funding for school districts and municipal governments to assist in the conversion or replacement of older diesel vehicles. This will provide public health benefits, most notably to school children, who are disproportionately affected by the emissions of these vehicles and are more susceptible to the adverse effects of pollutant exposure.

Conventional natural gas offers modest GHG reductions compared to gasoline and diesel and has been an early source of GHG reductions for ARFVTP investments. The potential for upstream methane leakage, however, risks undermining any GHG advantages of conventional natural gas. In addition, as diesel engines have become cleaner, natural gas may no longer provide any significant NO_X reduction benefits, except in the case of low-NO_X engines. These issues are discussed in greater depth in the Natural Gas Vehicles section, although the same concerns apply to natural gas fueling infrastructure.

Despite the above-mentioned concerns, the risk of methane leakage is significantly reduced with the use of biomethane, since biomethane is most frequently used at the point of production, whereas natural gas must be transmitted through a pipeline. In addition, unlike conventional natural gas, biomethane can have one of the lowest carbon intensities of any alternative fuel. Given these considerations, future natural gas fueling infrastructure solicitations may place a greater emphasis on or contain specific requirements for the incorporation of biomethane. Funding from this category may be made available for natural gas fueling infrastructure located at biomethane production facilities to both encourage the use of biomethane and displace conventional natural gas as a transportation fuel.

For FY 2017-2018, the Energy Commission allocates $2.4 million for natural gas fueling infrastructure. The Energy Commission believes future demand for natural gas infrastructure funding will be adequately served by the funding levels allocated in this investment plan update. While natural gas is expected to continue playing a role in reducing emissions and petroleum use, the market for natural gas as a transportation fuel is maturing, and ARFVTP incentives are expected to have less of an effect as other financing options become available.

Summary of Alternative Fuel Infrastructure Allocations

Table 17: FY 2017-2018 Funding for Alternative Fuel Infrastructure

Electric Charging Infrastructure Relevant Policy Goals: – GHG Reduction – Petroleum Reduction – Low-Carbon Fuel Standard – Air Quality – ZEV Regulations	$16.6 Million	$0.4 million decrease relative to FY 2016-2017*
Hydrogen Refueling Infrastructure Relevant Policy Goals: – GHG Reduction – Petroleum Reduction – Low-Carbon Fuel Standard – Air Quality – ZEV Regulations	$19.4 Million	$0.6 million decrease relative to FY 2016-2017*
Natural Gas Fueling Infrastructure Relevant Policy Goals: – Petroleum Reduction – Air Quality – Low-Carbon Fuel Standard – GHG Reduction (with incorporation of biomethane)	$2.4 Million	$0.1 million decrease relative to FY 2016-2017*
Total	**$38.4 Million**	

Source: California Energy Commission. *This allocation has been decreased compared to previous versions of this report because of a 2.8 percent reduction applied to all allocations. The reasons for the reductions are discussed in the Summary of Program Funding section of Chapter 2.

CHAPTER 5:
Alternative Fuel and Advanced Technology Vehicles

Natural Gas Vehicles

Natural gas vehicles are a readily available and economically competitive alternative transportation option, 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.[75] Furthermore, there are nearly 35,000 light-duty natural gas cars, trucks, and vans within the state.[76] Despite an increase in the calculated carbon intensity for fossil natural gas and improvements in diesel truck emission standards, existing renewable natural gas options and new natural gas vehicle emission control technologies provide substantial reductions in greenhouse gas and criteria pollutant emissions compared to a conventional diesel truck.

While gasoline and diesel fuel prices have fluctuated in recent years, the retail price of CNG has stabilized at lower levels. Between April 2014 and October 2016, the average price of CNG per diesel-gallon equivalent (DGE) in West Coast states ranged from $2.55 to $2.71, with a price of $2.70 in October 2016. The average price per gallon of diesel fuel during this same period decreased from $3.97 in April 2014 to $2.78 in October 2016. This sustained reduction in diesel fuel prices has resulted in a low, and at times unfavorable, price difference for natural gas, which impacts the cost-effectiveness of natural gas vehicles.[77] As a result, vehicle owners may be less likely to shift from conventional fuels 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.[78] Energy Commission staff will continue to monitor the price difference between CNG and gasoline, including how it affects the need for incentives and demand for CNG vehicles.

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

76 Ibid.

77 The U.S. Department of Energy *Clean Cities Alternative Fuel Reports* are available at http://www.afdc.energy.gov/publications/search/keyword/?q=alternative%20fuel%20price%20report.

78 U.S. Department of Energy, *Clean Cities Alternative Fuel Report,* April 2016. Available at http://www.afdc.energy.gov/uploads/publication/alternative_fuel_price_report_april_2016.pdf.

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."[79] This includes 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 transportation sector, as well as development of the 2015 AB 1257 report in general.[80] The first of these reports was completed November 2015, and the report will be updated every four years thereafter.

In September 2015, the CARB readopted the LCFS, which included a switch from 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 have increased because of higher pipeline energy intensity, higher methane leakage estimates, and higher tailpipe emissions.[81] Though the revised carbon intensity value for CNG is less beneficial than previously assumed, it still provides GHG reductions compared to gasoline and diesel fuel. These life-cycle GHG emissions can also be significantly reduced with the introduction of biomethane, which possesses some of the lowest carbon intensity values established by the LCFS. CNG 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.[82] Biomethane use for transportation has steadily increased, averaging 55 percent of the total reported natural gas volume under the LCFS during the period covering the second quarter of 2015 through the first quarter of

79 California Public Resources Code Section 25303.5(b).

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

81 CA-GREET 1.8b lists EER-adjusted (0.9 EER for spark-ignition natural gas) carbon intensity values of 98.03 g/MJ for ultra-low-sulfur diesel and 75.57 g/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 g/MJ for ultra-low-sulfur diesel and 87.08 g/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.

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

2016.[83] The potential for in-state renewable natural gas production is high, and companies offer this fuel on a commercial basis.

Ongoing research into methane leakage from production and transmission infrastructure will provide opportunities to refine the GHG emission reduction potential of natural gas and biomethane, as well as the potential to identify and eliminate fugitive methane emissions in the future. The Environmental Defense Fund, for instance, partnered with universities, natural gas producers, and utilities to identify the extent of methane leakage throughout the natural gas supply chain.[84]

Natural gas vehicles may also offer the opportunity for lower criteria pollution emissions. Though natural gas trucks historically held an edge in reduced NO_X and other emissions, the 2010 diesel emission standards have made emissions from the two fuel types roughly equal in new medium- and heavy-duty vehicles. In 2013, the 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. The initial statement of reasons for the voluntary standard suggests that heavy-duty natural gas engines may be the primary initial technology for meeting the more aggressive 75 percent and 90 percent NO_X reduction targets.[85]

In September 2015, a Cummins Westport Inc. natural gas engine became the first to receive emission certifications from both the U.S. EPA and CARB at the 90 percent NO_X reduction level of 0.02 grams per brake horsepower-hour and is available for purchase.[86] Technologies such as these have the potential to further support the market deployment of medium- and heavy-duty natural gas trucks. By using biomethane and low-NO_X engines, natural gas trucks have the potential to reduce criteria pollutant and GHG emissions to levels near those of zero-emission BEVs and FCEVs. CR&R Incorporated is expected to operate the first fleet in the country that combines biomethane fuel and low NO_X natural gas trucks, using fuel produced at its anaerobic digester facility in Riverside County that was partially funded by the ARFVTP.

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83 California Air Resources Board. *LCFS Quarterly Data July 28, 2016.* Accessed 23 August 2016. Available at http://www.arb.ca.gov/fuels/lcfs/dashboard/quarterlysummary/media_request_072816.xlsx.

84 Environmental Defense Fund. *What Will It Take to Get Sustained Benefits From Natural Gas?* http://www.edf.org/methaneleakage.

85 Air Resources Board. *Staff Report: Initial Statement of Reasons for Proposed Rulemaking.* October 23, 2013. Available at http://www.arb.ca.gov/regact/2013/hdghg2013/hdghg2013isor.pdf.

86 Cummins Westport Inc. *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~.* October 5, 2015. Available at http://www.cumminswestport.com/press-releases/2015/isl-g-near-zero-natural-gas-engine-certified-to-near-zero.

The ARFVTP has provided significant support to date for the deployment of natural gas vehicles, as summarized in Table 18. 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. After that, the Energy Commission released two solicitations (PON-10-604 and PON-11-603) 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) increases. As a result, these investments have favored heavier-duty vehicle classes (both in terms of numbers and funding), which offer the largest per-vehicle opportunities for petroleum displacement. In addition, the Energy Commission issued a third solicitation (PON-13-610) for buydown incentives. For this solicitation, staff reconfigured vehicle incentive levels based on the estimated fuel displacement for each GVW class per ARFVTP dollar, as well as comparisons to other vehicle incentives.

Table 18: ARFVTP Funding for Natural Gas Vehicle Deployment

Funding Agreement or Solicitation	Vehicle Type	# of Vehicles	ARFVTP Funding (in Millions)
San Bernardino Associated Governments (ARV-09-001)	Heavy-duty trucks	202	$9.3
South Coast Air Quality Management District (ARV-09-002)	Heavy-duty drayage trucks	132	$5.1
Buydown Incentives PON-10-604 and PON-11-603	Up to 8,500 GVW	245	$0.7
	8,501-14,000 GVW	137	$1.1
	14,001-26,000 GVW	211	$4.2
	26,001 GVW and up	446	$12.9
Buydown Incentives PON-13-610	Up to 8,500 GVW	117	$0.1
	8,501-16,000 GVW	154	$0.9
	16,001-26,000 GVW	71	$0.8
	26,001-33,000 GVW	0	$0
	33,001 GVW and up	353	$8.8
Natural Gas Vehicle Incentive Project	TBD	1,080*	$21.9
Total		**3,148**	**$65.8**

Source: California Energy Commission. *Estimated number of incentives to be provided under the Natural Gas Vehicle Incentive Project with current funding.

Current ARFVTP incentives for the purchase of natural gas vehicles are available through the Natural Gas Vehicle Incentive Project (NGVIP), which is administered by the Institute of Transportation Studies at the University of California, Irvine, on behalf of the Energy Commission. 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. Consumers have shown strong demand for these incentives, initially placing reservations for vehicle purchases in excess of available funding. The NGVIP allows potential purchasers six months to use a reservation, and if no vehicle is purchased, it is cancelled, and the funding is made available to those on a waitlist.

As part of the Energy Commission agreement with UC Irvine, the Institute of Transportation Studies will also analyze data from the NGVIP to determine what are the appropriate future incentive levels, when natural gas vehicles will be able to grow in the market without subsidies, and how natural gas fuel can be best used in the California medium- and heavy-duty vehicle market. Other incentives for natural gas vehicles are also available, which must be considered in the context of this allocation. Notably, the FY 2016-2017 funding plan for the CARB Low Carbon Transportation Investments and AQIP includes $23 million in funding to provide incentives for the purchase of low-NO_x trucks. These CARB incentives, however, are limited to vehicles with a gross vehicle weight rating (GVWR) of more than 14,000 pounds and require a 100 percent renewable, three-year fueling contract for the vehicle.

The differential upfront costs for natural gas engines vary significantly by engine size and supplier. Although these costs have decreased in recent years, they can still 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 engine can be two years or less. Lower petroleum fuel prices, however, can extend the payback period or make natural gas a more expensive option.

Although the carbon intensity of CNG is higher than previously believed, the fuel still provides a 15 percent reduction in GHG emissions compared to diesel fuel.[87] The GHG emissions of natural gas vehicles can be further lowered with the use of biomethane, which reduces carbon intensity by up to 125 percent compared to diesel.[88] In addition, natural gas vehicles with low NO_x engine technologies provide substantial criteria pollutant emission reductions compared to diesel vehicles. Combined, these two technologies can provide important contributions to California's climate change and air quality goals. For these reasons, the Energy Commission allocates $9.7 million to support natural gas vehicle deployment for FY 2017-2018.

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87 EER-Adjusted (0.9 EER for natural gas) carbon intensity values of 102.01 g/MJ for ultra-low-sulfur diesel, 87.08 g/MJ for North American CNG, and -25.48 for HSAD biomethane. California Air Resources Board. *Low Carbon Fuel Standard Final Regulation Order (Table 6).* 2015. Available at http://www.arb.ca.gov/regact/2015/lcfs2015/finalregorderlcfs.pdf.

88 Ibid.

The Energy Commission may consider limiting incentives to the purchases of and upgrades to low-NO_x vehicles, if an appropriate low-NO_x engine is available for the specific vehicle type and weight class. In using these funds, staff will continue to monitor revisions to life-cycle GHG emissions and seek opportunities for more efficient per-vehicle incentives. The long-term goal for ARFVTP vehicle incentives is to increase consumer familiarity and supplier production to a point where various natural gas vehicle types can grow in the market without subsidies. Zero-emission powertrains, including battery-electric and hydrogen fuel cell, are expected to continue to advance in capabilities and reduce in price. As these occur, natural gas vehicle incentives may be limited to vehicle types and duty cycles for which no suitable and economical zero-emission powertrain is available.

Advanced Freight and Fleet Technologies

The California freight and fleet sectors are critical to the California economy by promoting domestic goods movement and international trade and providing other critical services. Since the beginning of the ARFVTP, vehicle manufacturers have developed and refined new technologies that have increased the capabilities of alternative vehicles in this sector. New legislation and other incentive programs, such as the GGRF and CARB's Low Carbon Transportation Investments program, have created additional incentives for clean vehicle deployment that overlap with past ARFVTP activities in this sector. Combined, these changes necessitate a new approach to ARFVTP funding for medium- and heavy-duty vehicles.

The Advanced Freight and Fleet Technologies category replaces the Medium- and Heavy-Duty Vehicle Technology Demonstration and Scale-Up category from prior investment plans. As in previous years, this category has a significant focus on medium- and heavy-duty vehicles, which are defined here as vehicles with a GVWR above 10,000 lbs. These vehicles represent a small share of California registered vehicle stock, accounting for about 984,000 out of 29.8 million vehicles, or 3 percent.[89] Medium- and heavy-duty vehicles, however, are responsible for about 23 percent of on-road GHG emissions because of comparatively low fuel efficiency and high number of miles traveled per year.[90] For this reason, they represent a significant opportunity to reduce GHG emissions while focusing on a small number of vehicles. Other related freight vehicles, such as forklifts and other cargo handlers, fall outside the definition of medium- and heavy-duty vehicles for this category but have similar purpose and potential for emission reductions. This category also places a significant focus on alternative fuel

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

90 California Air Resources Board. *California Greenhouse Gas Inventory for 2000-2014*. March 30, 2016. Available at https://www.arb.ca.gov/cc/inventory/data/tables/ghg_inventory_scopingplan_2000-14.pdf.

infrastructure for the above-mentioned vehicles, as well as nonpropulsion projects that improve freight and fleet vehicle efficiency.

In addition to reducing GHG emissions, transitioning to zero- and near-zero-emission freight and fleet vehicles will provide significant air quality benefits, especially near ports and transportation hubs, and along freight corridors that have high traffic of these vehicles. Executive Order B-32-15, issued by Governor Brown in July 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 July 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 five ports throughout California, including the ports of Hueneme, Long Beach, Los Angeles, Oakland, and San Diego. The collaboration will identify and implement transportation project concepts that 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.

Providing zero- and near-zero-emission options for freight and fleet vehicles is challenging because the fuel and technology must be closely matched to the needs of the particular vehicle duty cycle and vocation. For example, a low-emission solution such as a hybrid electric system might be appropriate for urban delivery trucks with many stops and starts but will provide little benefit to long-haul trucks. Similarly, a battery-electric system might be appropriate for a vehicle that can regularly recharge but inappropriate for trucks that have unpredictable operating hours or travel routes. Providing the right solution for the right duty cycle is, therefore, a key element in reducing GHG emissions from this vehicle sector. Though certain non-ZEV fuels and technologies may result in per-vehicle emission reductions that are not as substantial as those of ZEV technologies, they nevertheless provide an early market, cost-effective option for emission reductions when other advanced technologies are not practical.

The Energy Commission has provided more than $129.4 million in ARFVTP funding for a wide variety of fuel and technology types that can be incorporated into California trucks and buses. Table 19 summarizes the portfolio of advanced vehicle technology demonstration projects that the ARFVTP has supported in the medium- and heavy-duty vehicle sectors. Financial support for demonstration and precommercial projects can lead to reduced costs for future generations of advanced technology vehicles. Furthermore, by demonstrating the feasibility and reliability of such technologies in the field, these projects can increase interest from potential fleet adopters.

Table 19: Demonstration Projects Supported by ARFVTP

Vehicle/Technology Type	# of Vehicles	ARFVTP Funding (in Millions)
Medium-Duty Hybrids, PHEVs and BEVs	166	$16.4
Heavy-Duty Hybrids, PHEVs and BEVs	78	$48.6
Electric Buses	35	$14.6
Natural Gas Trucks	51	$19.1
Fuel Cell Trucks and Buses	13	$14.5
Vehicle-to-Grid	6	$7.0
Off-Road Hybrids	2	$4.5
E85 Hybrids	1	$2.7
Intelligent Transportation Systems	110	$2.0
Total	**462**	**$129.4**

Source: California Energy Commission.

While the projects funded by this category are expected to significantly reduce GHG and criteria pollutant emissions on a unit basis, thereby providing public health benefits, the vehicles have much higher differential costs than conventional gasoline or diesel vehicles. The higher costs are justified not only by the per-unit emission reductions, but also 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 December 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.

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. Future solicitations may also focus on freight corridors and hubs in an effort to comprehensively reduce emissions and petroleum use and improve sustainability. These

projects may include both propulsion and nonpropulsion aspects, such as alternative-fueled vehicles, infrastructure, and other advanced freight technologies.

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.

Many alternative-fueled freight and fleet vehicles require specialized refueling infrastructure. While light-duty electric vehicles use standard Level 1, Level 2, or DC fast chargers, medium- and heavy-duty electric vehicles often require 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 many use specialized charging systems that can be significantly more expensive than light-duty EVCS. In addition, fleets may require dedicated refueling infrastructure in areas that cannot provide public access because of security or safety concerns. Since specialized and dedicated refueling infrastructure can add significant cost and affect the financial viability of alternatively fueled vehicle projects, the Energy Commission may fund infrastructure projects at ports, transportation hubs, fleet vehicle yards, and similar locations.

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 the CARB, provides deployment incentives for hybrid, battery-electric, and fuel cell trucks and buses. Since 2010, HVIP has provided more than $72 million in incentives to help California fleets purchase about 460 zero-emission trucks and buses and 2,000 hybrid trucks, with each incentive averaging $28,953.[91] The ARFVTP and HVIP are regularly coordinated to ensure that applicants are not receiving funding from both sources.

In addition to the HVIP, CARB also funds other demonstration and deployment projects through its LCTI program. These investments include $150 million in FY 2016-2017 from the GGRF for heavy-duty vehicles and off-road equipment investments, many of which have some overlap with the activities discussed in this category. Funding for the

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91 California Air Resources Board. *Fiscal Year 2016-17 Funding Plan for Low Carbon Transportation and Fuels Investments and The Air Quality Improvement Program.* May 21, 2016. Available at https://www.arb.ca.gov/msprog/aqip/fundplan/proposed_fy16-17_fundingplan_full.pdf.

LCTI program far exceeds that available to the ARFVTP; however, LCTI funding depends on revenues from California's cap-and-trade auction proceeds, which have been unpredictable in recent years. Conversely, ARFVTP funding has been stable since the inception of the program. The Energy Commission expects to continue providing funding for advanced freight and fleet vehicle demonstration projects in FY 2017-2018 despite the overlap with some activities of the LCTI program. This continued funding will provide a degree of stability in incentive funding to the nascent market for advanced freight and fleet vehicles. To avoid duplication of efforts and funding, the Energy Commission will continue to monitor and consider GGRF allocations when developing the ARFVTP investment plan update and related solicitations.

Unlike major vehicle manufacturers with broader access to private financing and larger federal programs, many startup and early-stage companies often seek Energy Commission support to bridge the span between initial capital funding for prototype development and revenue from early commercialization. To demonstrate vehicles successfully, these companies may also require support to expand their production capabilities. Funding from this category may be made available for modest capital expenditures, such as tools and equipment, to scale up an applicant's production capabilities to a level sufficient for the demonstration project. Such funding would be provided at a much smaller scale than in the Manufacturing category, as discussed in Chapter 6, and would need to be linked specifically to a demonstration project under this category.

The most recent solicitation for medium- and heavy-duty advanced vehicle technology demonstration projects, GFO-16-604, was released in November 2016. The solicitation provided more than $24 million to three projects that will demonstrate advanced freight vehicles at California seaports. Two additional qualifying proposals requesting $15.6 million were received but not funded.

For FY 2017-2018, the Energy Commission allocates $17.5 million for this category. This allocation balances the need to continue demonstration and deployment projects discussed in this section with the similar funding available from other sources. Funding from this category is also 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.

Summary of Alternative Fuel and Advanced Technology Vehicles Allocations

Table 20: FY 2017-2018 Funding for Alternative Fuel and Advanced Technology Vehicles

Natural Gas Vehicle Deployment Relevant Policy Goals: – Petroleum Reduction – Air Quality – Low-Carbon Fuel Standard – GHG Reduction (with incorporation of biomethane)	$9.7 Million	$0.3 million decrease relative to FY 2016-2017*
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	$5.5 million decrease relative to FY 2016-2017 (Medium- and Heavy-Duty Vehicle Technology Demonstration and Scale-Up)*
Total	**$27.2 Million**	

Source: California Energy Commission. *This allocation has been decreased compared to previous versions of this report because of a 2.8 percent reduction applied to all allocations. The reasons for the reductions are discussed in the Summary of Program Funding section of Chapter 2.

CHAPTER 6:
Related Needs and Opportunities

Manufacturing

Emerging technologies face a long path to commercialization, beginning with research and development, leading 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, and the production process must attain financial margins capable of sustaining business operations. Companies must also address their workforce hiring, needs, and growth to bring products forward.

Funding support is critical at all stages of development to bring emerging technologies to market successfully. The state and federal governments both continue to fund research and development activities with programs such as the Electric Program Investment Charge (EPIC) research and development program, administered by the Energy Commission and investor-owned utilities, and the Advanced Research Projects Agency – Energy (ARPA-E) program, administered by the U.S. Department of Energy. California leads the nation in venture capital funding for clean transportation technologies, with about 90 percent of these investments nationwide being made in California in 2015.[92] Grant funding from both 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 alternative vehicle developers at many stages, early stage companies often struggle to transition from producing pilot and demonstration products to achieving full commercialization. This difficult transition is often because of a lack of available funding from both the private and public sector, commonly referred to as the commercialization "Valley of Death."[93] At this stage, companies have demonstrated the technical validity and viability of their pilot products but now must prove that the manufacturing process is economical and viable. To do this requires significant funding, which traditional financiers may be unwilling to provide because of the high-risk nature of unproven manufacturing processes. Additional sources of funding, such as ARFVTP grants, can help reduce this risk and encourage lenders and investors to invest as well.

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92 Thornberg, Christopher, Hoyu Chong, Adam Fowler (Beacon Economics). 2016. *California Green Innovation Index 8th Edition*. NEXT 10.

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

Through FY 2014-2015, the Energy Commission invested more than $46 million in 21 in-state manufacturing projects that support the goals of the ARFVTP. These investments often encourage the siting or expansion of manufacturing facilities 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, focused on advanced vehicle technology manufacturing and proposed awards totaling $10 million for manufacturing facilities that produce complete vehicles and/or vehicle components. Previous ARFVTP awards for manufacturing projects are summarized in Table 21.

Table 21: Summary of Manufacturing Projects

Category	Number of Projects	ARFVTP Funding (in Millions)	Match Funding (in Millions)
Battery Systems*	4	$11.6	$16.6
Charging Equipment	1	$1.1	$1.1
Electric Cars*	1	$0.2	$2.9
Electric Motorcycles	3	$3.7	$3.2
Electric Powertrains and Platforms*	4	$7.5	$12.0
Electric Trucks and Buses	8	$22.4	$43.7
Total	**21**	**$46.5**	**$79.5**

Source: California Energy Commission. *Includes canceled projects; funding amount is limited to invoices that were paid before projects were canceled.

Some notable examples of ARFVTP manufacturing projects include:

- ChargePoint, Inc., which received a $1.1 million grant 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. ChargePoint placed the communications processor in commercial production after completing the ARFVTP project.
- Motiv Power Systems, Inc., which received a $2.4 million grant to create a production line to manufacture a powertrain control system. The system allows original equipment manufacturers and vehicle upfitters to integrate zero-emission battery-electric powertrains into existing truck production lines. The production line funded by the grant is initially capable of producing up to 20 powertrain control systems per month.

Beginning with the *2015-2016 Investment Plan Update,* the Manufacturing and the Medium- and Heavy-Duty Vehicle Technology Demonstration allocations were combined into one category with a broader scope. The goal of merging the two allocations was to provide greater flexibility in developing solicitations that combine elements of both vehicle technology demonstration and manufacturing facility tooling and production. This combination, however, excluded light-duty vehicle, vehicle component,

infrastructure, and stand-alone manufacturing projects. Such projects have the potential to contribute to the goals of the ARFVTP.

During the development of the *2016-2017 Investment Plan Update*, stakeholders provided comments requesting dedicated funding for manufacturing projects. For FY 2017-2018, the Energy Commission is reintroducing the Manufacturing category with a $4.9 million allocation to provide support for projects to expand in-state manufacturing capabilities for light-, medium-, and heavy-duty alternative vehicles; vehicle components; and refueling infrastructure. This funding can provide incentives for companies to locate manufacturing projects in California, which otherwise may have been undertaken elsewhere. Projects funded under this allocation are expected to produce vehicles, components, and infrastructure that directly achieve the air quality, greenhouse gas emission, and petroleum use reduction goals of the ARFVTP. In addition, these projects will expand and strengthen the in-state workforce and expertise for alternative vehicles and may be able to coordinate with ARFVTP workforce training and development projects for employee placement and training.

Emerging Opportunities

The Emerging Opportunities allocation was created to provide funding for project types that were not anticipated during the development of the investment plan. This category also has been used to provide matching funds for projects seeking federal funding. The scope of this category has expanded in recent years as well, as new potential project types are identified that do not neatly fit in other existing allocations.

To date, the Energy Commission has developed six agreements through this funding category. The first three rows in Table 22 are partnerships with other government agencies to conduct projects that contribute to the goals of the ARFVTP. The last three rows in Table 22 represent successful projects from solicitation PON-13-604, which focused specifically on federal cost-sharing projects. In addition, funding from this allocation has been used to augment related solicitations, such as Intelligent Transportation Systems activities funded under a recent solicitation for freight transportation projects at California seaports (GFO-15-604).

Table 22: Summary of ARFVTP Agreements Funded by the Emerging Opportunities Category

Primary Partners	Description	ARFVTP Funding (in Millions)	Outside Funding (in Millions)
California Institute of Technology; U.S. DOE	Develop methods to generate fuels directly from sunlight as part of U.S. DOE Energy Innovation Hub program.	$4.1	Up to $122
Lawrence Berkeley National Laboratory; Concurrent Technologies Corporation; U.S. Department of Defense	Three projects to demonstrate the viability of an all-electric, nontactical vehicle fleet, integrate vehicle charging with local building loads, and explore the possibility of the vehicles participating in the California Independent System Operator's ancillary services markets.	$7	$5.1
South Coast Air Quality Management District	Two projects to demonstrate the use of hybrid-electric trucks with the ability to use an overhead electric line for charging and as a range extender and to demonstrate a zero-emission fuel cell electric hybrid Class 8 transport vehicle.	$5.4	$10.5
Center for Transportation and the Environment	Develop and demonstrate fuel cell hybrid walk-in delivery vans. Expand to a limited deployment of 4 (out of 16) additional vehicles in Phase II.	$1.1	$3.4
CALSTART, Inc.	Develop and demonstrate a battery-dominant fuel cell hybrid transit bus and compare operation against previous fuel cell bus generations.	$0.9	$7.6
The Regents of the University of California, Davis Campus	Establish a center for research on strategies for promoting alternative fuels and advanced vehicle technologies, increase system efficiency, and reduce single-occupant driving.	$1.1	$5.6

Source: California Energy Commission.

Various federal agencies, notably the U.S. Department of Transportation and the U.S. Department of Energy, periodically release solicitations related to the goals of the ARFVTP. In many of these solicitations, the state government or other project partners must contribute match funding to be approved. One such source of funding, the Fixing America's Surface Transportation (FAST) Act, authorizes $305 billion to be spent nationwide over fiscal years 2016 through 2020 on numerous surface transportation project types.[94] Energy Commission staff expects some federal FAST Act funding opportunities to complement ARFVTP activities, and Emerging Opportunities funding

94 Fixing America's Surface Transportation Act. Pub. L. No. 114-94. December 4, 2015. Available at https://www.gpo.gov/fdsys/pkg/PLAW-114publ94/pdf/PLAW-114publ94.pdf.

may be used to pursue such opportunities. The Energy Commission may also provide match funding from this category to encourage applicants to federal solicitations to conduct projects in California, thereby bringing more project benefits to the state.

The ARFVTP may also use the Emerging Opportunities category for projects that have the potential to achieve the goals of the program but do not readily fit within other funding categories. One such potential project type is hydrogen production from renewable power sources in California. Through electrolysis, 100 percent renewable hydrogen can be produced from water and renewable electricity. Several ARFVTP projects use electrolysis to generate modest volumes of hydrogen at fueling stations. Using surplus renewable energy, however, can potentially produce large volumes of renewable hydrogen for use as a transportation fuel or pipeline injection.

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.[95] Renewable hydrogen production is being investigated as a viable technology for storage of this surplus renewable energy and may become eligible for the utility procurement part of the CPUC proceeding on storage. This proceeding stems from Assembly Bill 2514 (Skinner, Chapter 469, Statutes of 2010) and sets an initial procurement target of 1,325 megawatts of storage for California investor-owned utilities by 2020.[96] The U.S. Department of Energy is also investigating technology options and business cases for hydrogen-based storage. In addition, the Energy Commission's Energy Research and Development Division, NREL, and CARB are studying early market business cases for the use of hydrogen as a storage medium that can be used for transportation fuels or grid storage.

For FY 2017-2018, the Energy Commission allocates $3.9 million for the Emerging Opportunities category. This increased allocation is based on historical demand for funding from this category, as well as new potential project types and opportunities to leverage federal funding.

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

96 California Public Utilities Commission, Order Instituting Rulemaking R.15-03-011 and Decisions (D.)13-10-040 and D.14-10-045. Available at http://www.cpuc.ca.gov/General.aspx?id=3462.

Workforce Training and Development

The ARFVTP continues to support alternative transportation workforce training and development throughout California. The efforts undertaken with this category continue to evolve to match the demand growth and changes in the field. ARFVTP workforce activities have grown both through longstanding interagency agreements, as well as new partnership agreements, both of which will deliver a robust and focused effort for alternative workforce needs in the state. The interagency agreement partners include the Employment Development Department (EDD), the Employment Training Panel (ETP), and the California Community Colleges Chancellor's Office (CCCCO).

The Energy Commission's agreement with EDD focused on delivering training through seven regional centers, as well as job surveys for current and future alternative transportation workforce training needs in the state. In addition, EDD's California Workforce Development Board (CWDB), through the Regional Industry Clusters of Opportunity efforts, developed regional market support for alternative transportation companies to better understand their training needs. The CWDB is working with three regional workforce investment boards to increase interest in alternative transportation careers for high school students and those seeking career technical jobs outside traditional college pathways. This agreement is set to expire in December 2017.

The interagency agreement with ETP focuses primarily on incumbent training across various alternative transportation organizations that includes public transit, first responders, alternative clean fuels developers, and manufacturers of advanced clean vehicle technologies. To qualify for ARFVTP training funds, ETP training contracts require employers to commit matching funds and prove the retention of employees on the 91st day of employment after completion of their training. This agreement is scheduled to be completed in March 2017; however, a new agreement with ETP was approved and will continue to deliver workforce training funds for alternative transportation industry organizations.

The newest ARFVTP workforce training and development efforts include two agreements that focus on apprenticeship and preapprenticeship training in alternative fuels and advanced vehicle technologies. These agreements with the CWDB and CCCCO will leverage a $1 million grant from the Governor's Office to the West Valley-Mission Community College District. This combined effort is designed to build a replicable model for an apprenticeship path for transit agencies and builds upon support provided to transit agencies through ETP contracts during the past five years.

The Energy Commission also recently entered into an agreement with the Advanced Transportation Technology and Energy (ATTE) Center to assist the alternative fuel workforce training and development efforts of the California community colleges. ATTE is an initiative of the CCCCO and is tasked with supporting alternative fuels and advanced energy training and development throughout the state's community college system. A grant funding opportunity for $1.6 million was recently released, and award notices of up to $200,000 were sent to nine awardees in October 2016.

The Energy Commission is exploring opportunities to expand ARFVTP workforce training and development efforts with pilot programs that focus on alternative fuel and vehicle career paths for high school students. These high school pilot programs are expected to provide opportunities for students in disadvantaged communities who might otherwise not have the ability to pursue a career in this developing sector. High school career path programs are also expected to complement existing ARFVTP efforts at California community colleges.

A summary of ARFVTP workforce training and development efforts can be found in Table 23.

Table 23: Workforce Training and Development Funding From FY 2008-2009 Through FY 2015-2016

Partner Agency	Funded Training (in Millions)	Match Contributions (in Millions)	Trainees	Businesses Assisted	Municipalities Assisted
ETP	$13.5	$10.8	15,944	151+	16+
EDD	$8.2	$7.5	999	36+	-
CCCCO	$5.5	N/A	N/A	68+	-
CWDB	$0.25	$0.5	N/A*	N/A*	-
CCCCO	$0.25	$0.5	N/A*	N/A*	-
ATTE	$2.0	N/A	N/A*	N/A*	-
Total	**$29.70**	**$19.3**	**16,943**	**255+**	**16+**

Source: California Energy Commission. The number of trainees includes completed, partially completed, and anticipated participants from approved contracts. *Participant data are incomplete because these are new agreements.

Examples of current workforce training funding recipients:

- **ETP/Buster Biofuels, LLC** was approved for $58,500 to train 15 participants with a focus on job skills to produce and distribute new alternative fuels, including the design, construction, installation, operation, service, and maintenance of fueling infrastructure and vehicles.
- **ETP/Tesla Motors, Inc.** was approved for $444,600 for 975 California participants to receive training in electric vehicle production, including powertrain component assembly, plastic molding, aluminum stamping, specialty painting, assembly, and quality testing.
- **ETP/Maas Energy Works, Inc.** was approved for $15,600 to train 10 workers in biogas production and installation, operation, and servicing of alternative fuel vehicles.
- **ETP/Applied Materials, Inc.** was approved for $749,952 to provide advanced battery manufacturing and production training to up to 434 trainees. The training will include courses in lithium-ion battery design, fabrication, manufacturing, modeling, and integration. The focus of this training is to

provide skills to foster innovation and product development in the lithium-ion battery manufacturing market.

- **ETP/California Labor Federation Labor-Management Transit Training** was approved for $1,341,300 to provide training in the maintenance and repair of alternative energy-efficient equipment, technical documentation and specifications, test equipment and procedures, and sustainable management systems. This contract supports 1,700 trainees in bus operations for the Los Angeles County Metropolitan Transit Authority and the Santa Clara Valley Transit Authority.

In August 2016, Energy Commission staff hosted a public workshop for workforce training and development funding opportunities. Public and private organizations brought forward ideas to increase opportunities for disadvantaged and low-income communities, veteran participation, and career awareness for high school students and young adults. The Energy Commission will consider these recommendations when developing future workforce training and development projects.

Based on expectations of needed funds from partner agencies in FY 2017-2018, the Energy Commission allocates $3.4 million for workforce training and development projects. The Energy Commission will continue to work with partner agencies to determine how ARFVTP funding can best be invested to maximize the benefits of this funding.

Regional Alternative Fuel Readiness and Planning

In addition to alternative fuel infrastructure and vehicles, the Energy Commission has provided funding to regions to prepare for and expedite deployment. Using comparatively small amounts of funding, the Energy Commission has helped regions identify and implement policies and practices that reduce the barriers to expanding alternative fuel vehicles, particularly PEVs and FCEVs, into the market. These include, but are not limited to:

- Streamlining of permitting and inspection processes to promote installations.
- Updating building codes, zoning, and parking.
- Training, education, and outreach.
- Setting regional priorities for charging and refueling locations.

To further these goals, the Energy Commission conducted four grant solicitations for regional readiness planning. The first of these, released in 2011, provided funding exclusively for PEV regional readiness planning. Funding recipients from this solicitation included combinations of local planning entities, air districts, government associations, and nongovernmental organizations. The awardees covered 40 counties and all major metropolitan areas.

A second solicitation in this area was released in 2013. Unlike the previous solicitation, this one was open to multiple alternative fuel types. Proposals were accepted on a first-come, first-served basis with eight successful applications submitted. These successful

applications included the first planning award for hydrogen refueling, which covers early FCEV adopter markets identified by automakers throughout the state.

In 2014, the Energy Commission released PON-14-603, its third solicitation in this area. Funding in this solicitation was divided into three categories pertaining to PEVs and FCEVs. The first category focused on implementation activities identified in previous regional PEV planning awards, the second category provided for the development of regional PEV readiness plans in areas where no such plans had yet been developed, and the third category provided funding for FCEV readiness activities. All eight applications with passing scores under PON-14-603 were funded.

Many applicants that applied to PON-14-603 did not pass; however, the projects were believed to be viable once any flaws were fixed. To provide these applicants another opportunity, the Energy Commission subsequently revised and reissued the previous solicitation in 2015 as PON-14-607. This fourth regional readiness solicitation funded an additional eight projects covering the same categories as PON-14-603.

The results of the regional readiness solicitations are summarized in Table 24.

Table 24: Regional Alternative Fuel Readiness and Planning Awards

Readiness Plan Fuel Type	Agreements in Progress	Agreements Completed	ARFVTP Funding (in Millions)
Electricity	17	11	$5.0
Hydrogen	4	-	$0.8
Electricity & Hydrogen	2	-	$1.4
Multiple Fuels/Other	1	5	$1.8
Total	**24**	**16**	**$9.0**

Source: California Energy Commission.

In both FY 2015-2016 and 2016-2017, the Energy Commission allocated $2 million for regional alternative fuel readiness and planning. Funding from these previous fiscal years remains available and should be sufficient to cover readiness and planning needs through FY 2017-2018. For this reason, the Energy Commission is not providing additional funding for this category for FY 2017-2018, but staff will continue to review the need for assistance in this area in coming fiscal years.

Summary of Related Needs and Opportunities Allocations

Table 25: FY 2017-2018 Funding for Related Needs and Opportunities

Manufacturing Relevant Policy Goals: – GHG Reduction – Petroleum Reduction – Air Quality	$4.9 Million	$4.9 million increase relative to FY 2016-2017*
Emerging Opportunities Relevant Policy Goals: – GHG Reduction – Petroleum Reduction – Air Quality	$3.9 Million	$0.9 million increase relative to FY 2016-2017*
Workforce Training and Development Relevant Policy Goals: – GHG Reduction – Petroleum Reduction – Air Quality	$3.4 Million	$0.9 million increase relative to FY 2016-2017*
Regional Alternative Fuel Readiness and Planning Relevant Policy Goals: – GHG Reduction – Petroleum Reduction – Air Quality	-	$2 million decrease relative to FY 2016-2017
Total	**$12.2 Million**	

Source: California Energy Commission. *This allocation has been decreased compared to previous versions of this report because of a 2.8 percent reduction applied to all allocations. The reasons for the reductions are discussed in the Summary of Program Funding section of Chapter 2.

CHAPTER 7:
Summary of Funding Allocations

Funding allocations for FY 2017-2018 are summarized in Table 26. Future developments, including the potential availability of GGRF allocations for these or related categories, may prompt a need for modifications to these allocations. For specific details on each allocation, please see the relevant section of the preceding chapters.

If approved in the state budget, beginning with FY 2017-2018, the ARFVTP will be required to fund program support costs from motor vehicle registration fees instead of funds that traditionally have been paid from commercial and residential utility surcharges. As a result of these additional expenses, $2.8 million less will be available for ARFVTP project funding for FY 2017-2018. This final *2017-2018 Investment Plan Update* reflects a total of $97.2 million for program funding, whereas the draft staff report and revised staff report versions assumed $100 million would be available. All funding allocations in this version of the report have been reduced by 2.8 percent and rounded to $0.1 million, compared to previous versions, to adjust for the lower amount of available funding. In the event that less funding is available, the allocations in this document may be revised in subsequent versions or amended after final adoption. Future developments, including the potential availability of funding from the GGRF for these or related categories, may also prompt a need for modifying these allocations.

Table 26: Summary of Funding Allocations for FY 2017-2018

Category	Funded Activity	Funding Allocation
Alternative Fuel Production	Biofuel Production and Supply	$19.4 million
Alternative Fuel Infrastructure	Electric Charging Infrastructure	$16.6 million
	Hydrogen Refueling Infrastructure	$19.4 million
	Natural Gas Fueling Infrastructure	$2.4 million
Alternative Fuel and Advanced Technology Vehicles	Natural Gas Vehicle Incentives	$9.7 million
	Advanced Freight and Fleet Technologies	$17.5 million
Related Needs and Opportunities	Manufacturing	$4.9 million
	Emerging Opportunities	$3.9 million
	Workforce Training and Development	$3.4 million
	Total	**$97.2 million**

Source: California Energy Commission.

GLOSSARY

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

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 other trace amounts of gases. The biogas can be further processed into a transportation fuel or burned 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 to form 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. It takes one Btu 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.

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, carbon monoxide, nitrogen dioxide, sulfur dioxide, and particulate matter.

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 the 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 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.

GREENHOUSE GAS – Any gas that absorbs infrared radiation in the atmosphere. 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 distinct 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 burned to generate heat or electricity.

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.

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 are 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.

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
ATTE Center	Advanced Transportation Technology and Energy Center
BEV	battery-electric vehicle
CaFCP	California Fuel Cell Partnership
CA-GREET	California Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation Model
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
CPUC	California Public Utilities Commission
CVRP	Clean Vehicle Rebate Project
CWDB	California Workforce Development Board
DC	direct current
DGE	diesel gallon-equivalent
EDD	Employment Development Department
EPIC	Electric Program Investment Charge
ETP	Employment Training Panel
EVCS	electric vehicle charging station
FAST Act	Fixing America's Surface Transportation Act
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 per megajoule
GVW	gross vehicle weight
GVWR	gross vehicle weight rating
GHG	greenhouse gas
HVIP	Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project
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
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
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
SCE	Southern California Edison
SDG&E	San Diego Gas & Electric Company
SIP	State Implementation Plan
SoCal Gas	Southern California Gas Company
U.S. DOE	United States Department of Energy
U.S. EPA	United States Environmental Protection Agency
ZEV	zero-emission vehicle