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California Energy Commission

DRAFT STAFF REPORT

2018-2019 Investment Plan Update for the Alternative and Renewable Fuel and Vehicle Technology Program

California Energy Commission

Edmund G. Brown Jr., Governor

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California Energy Commission

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ABSTRACT

The *2018-2019 Investment Plan Update for the Alternative and Renewable Fuel and Vehicle Technology Program* guides the allocation of program funding for fiscal year 2018-2019. This *2018-2019 Investment Plan Update* covers the tenth year of the program and reflects laws, executive orders, and policies to reduce greenhouse gas emissions, petroleum dependence, and criteria pollution emissions. It details how the California Energy Commission determines the goal-driven priorities of the program by incorporating input from stakeholders and the Alternative and Renewable Fuel and Vehicle Technology Program (ARFVTP) Advisory Committee and by analyzing project opportunities for funding. These priorities are consistent with the overall goal of the program "to develop and deploy innovative technologies that transform California's fuel and vehicle types to help attain the state's climate change policies."

This *2018-2019 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 *2018-2019 Investment Plan Update* relies on the narrative and analyses developed in previous investment plans, most recently the *2017-2018 Investment Plan Update.*

This draft staff report represents the first step in developing the *2018-2019 Investment Plan Update*. Before the adoption of the report at an Energy Commission business meeting in spring 2018, the Energy Commission expects to release a revised staff report in January 2018 and a Lead Commissioner report in March 2018, as well as convene two public advisory committee workshops in the fourth quarter of 2017 and the first quarter of 2018.

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

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EXECUTIVE SUMMARY

Over the past decade, California has led the nation in combating climate change through aggressive greenhouse gas (GHG) emission reduction goals and innovative funding programs. The California Energy Commission's Alternative and Renewable Fuel and Vehicle Technology Program (ARFVTP) was one of the first programs created by the California Legislature to help achieve the state's climate change policies. The program has successfully done so with steady investments designed to transform California's fuel and vehicle types. Now in its tenth year, the ARFVTP has provided more than $745 million to 592 projects covering a broad spectrum of alternative fuels and technologies. In this time, California has experienced a rapid deployment of plug-in electric vehicles, the first sales of hydrogen fuel cell vehicles, and a notable increase in the in-state production and use of biofuels. The ARFVTP has supported this emerging revolution in the transportation sector with significant investments in alternative fuel vehicles and supporting infrastructure and will continue to do so with this *2018-2019 Investment Plan Update*.

Purpose of the ARFVTP

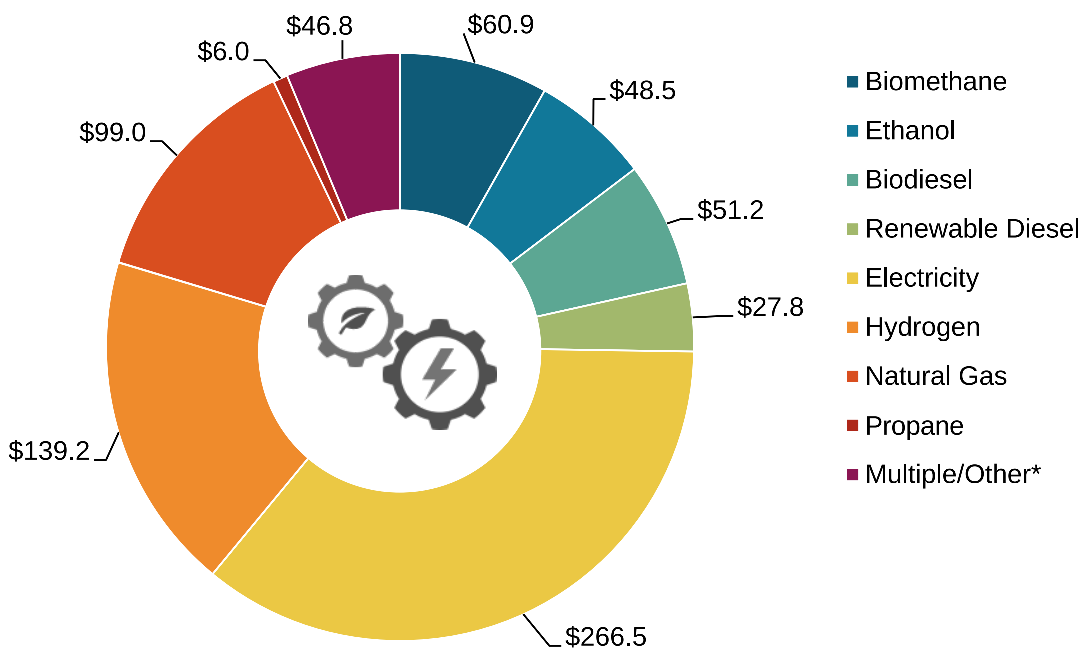
Since 2005, California has set several pivotal goals to reduce GHG emissions and address the threat posed by global climate change. These goals require incremental progress that will ultimately lead to major emission reductions, including:

- Reducing GHG emissions to 1990 levels by 2020.
- Reducing GHG emissions to 40 percent below 1990 levels by 2030.
- Reducing GHG emissions to 80 percent below 1990 levels by 2050.
- Reducing short-lived climate pollutant emissions, such as methane, to 40 to 50 percent below 2013 levels by 2030.

Achieving these goals will require significant technological and market changes within the transportation sector, which accounts for 39 percent of state greenhouse gas emissions. Both California and the 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 ARFVTP, which is administered by the Energy Commission. With funds collected from vehicle and vessel registration, vehicle identification plates, and smog-abatement fees, the ARFVTP 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." Assembly Bill 8 (Perea, Chapter 401, Statutes of 2013) subsequently extended the collection of fees that support the ARFVTP through January 1, 2024. The statute also emphasizes "develop[ing] and deploy[ing] technology and alternative and renewable fuels in the marketplace, without adopting any one preferred fuel or technology." Figure ES-1 illustrates the types of projects funded by the ARFVTP, sorted by the fuel or technology type.

Figure ES-1: ARFVTP Funding by Fuel Type (in Millions)



Source: California Energy Commission. As of September 1, 2017. *Some agreements, such as those for multifuel regional readiness plans or workforce training, cannot be readily categorized by fuel type.

Investments to Date

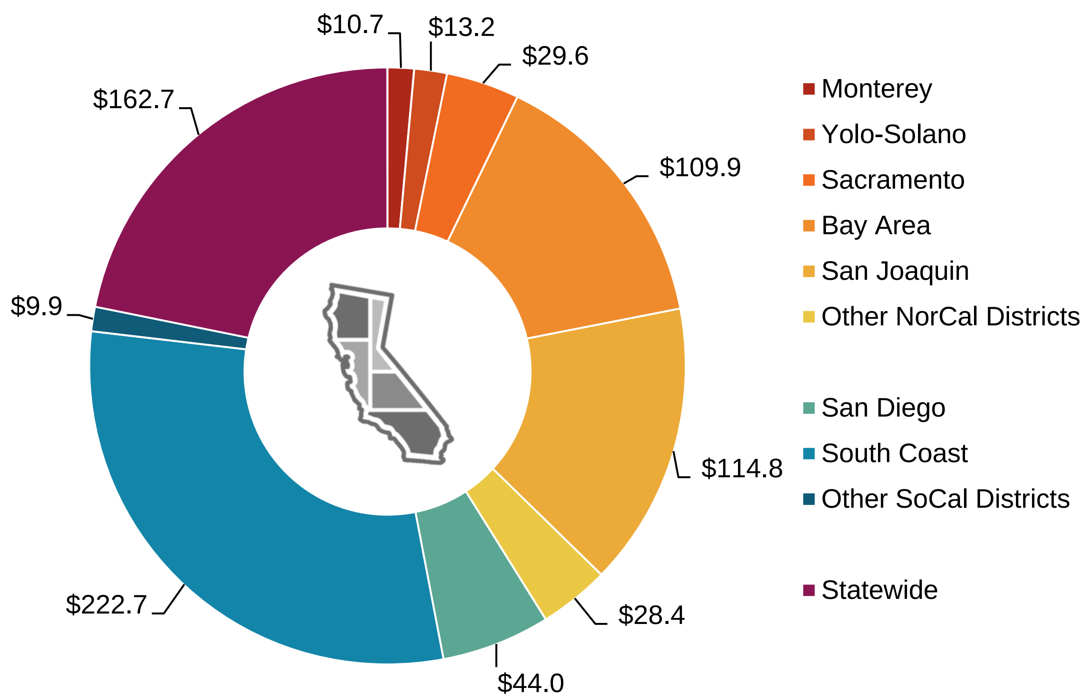
Since the first ARFVTP investment plan was released in 2009, the Energy Commission has continuously invested in projects that support the advancement and use of alternative fuels and advanced vehicle technologies. The Energy Commission, through the ARFVTP, has provided funding to cities, counties, school districts, universities, private companies, and other organizations throughout the state to pursue a wide variety of alternative fuel and vehicle technology projects. A detailed summary of all projects funded to-date by the ARFVTP can be found in Table ES-1, which is sorted by each specific funding area. In addition, Figure ES-2 illustrates the distribution of ARFVTP funding throughout the state divided by air district.

Table ES-1: ARFVTP Awards as of September 1, 2017

Funded Activity	Cumulative Awards to Date (in millions)*	# of Projects or Units
Alternative Fuel Production		
Biomethane Production	$60.9	20 Projects
Gasoline Substitutes Production	$32.1	15 Projects
Diesel Substitutes Production	$75.1	25 Projects
Alternative Fuel Infrastructure		
Electric Vehicle Charging Infrastructure**	$79.9	7,698 Charging Stations
Hydrogen Refueling Infrastructure	$122.3	60 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
Clean Vehicle Rebate Project Supplemental Funding	$25.1	10,700 Cars
Hybrid and Zero-Emission Truck and Bus Voucher Inventive Project Supplemental Funding	$4.0	150 Trucks
Advanced Freight and Fleet Technology Vehicles****	$130.1	49 Demonstrations
Related Needs and Opportunities		
Manufacturing	$46.5	21 Manufacturing Projects
Emerging Opportunities	†	†
Workforce Training and Development	$31.7	17,440 Trainees
Fuel Standards and Equipment Certification	$3.9	1 Project
Sustainability Studies	$2.1	2 Projects
Regional Alternative Fuel Readiness and Planning	$9.6	43 Regional Plans
Centers for Alternative Fuels	$5.8	5 Centers
Technical Assistance and Program Evaluation	$5.5	n/a
Total	**$745.9**	

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 funds reserved for future incentives. ****Includes projects from the former Medium- and Heavy-Duty Vehicle Technology Demonstration category. †Awards have been reclassified by project type into other rows.

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



Source: California Energy Commission. As of September 1, 2017.

Context of the ARFVTP Investment Plan Update

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

The funding recommendations in this draft are guided by, and complementary to, energy policies and regulations such as the Low-Carbon Fuel Standard, 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, with carbon intensity defined as a measure of greenhouse gas emissions per unit of energy. Similarly, the federal Renewable Fuel Standard provides a direct incentive for the introduction of biofuels. Both complement ARFVTP investments by creating market incentives for near-term GHG reductions and alternative fuel use, allowing the ARFVTP to focus more resources on longer-term market transformation goals. The *Zero-Emission Vehicle Action Plan* articulates market transformation goals for zero-emission vehicles and calls for developing infrastructure networks and community readiness plans for 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 FY 2017-2018, the state Legislature allocated $560 million from the Greenhouse Gas Reduction Fund (GGRF) to the California Air Resources Board (CARB) for low-carbon transportation projects. In its draft funding plan for Clean Transportation Incentives, CARB discusses project allocations totaling $663 million 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 these and 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 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 such as oxides of nitrogen and particulate matter. Energy Commission staff will continue to monitor new opportunities and incorporate them into the ARFVTP investment plan update and solicitations when appropriate.

2018-2019 Investment Plan Update

The *2018-2019 Investment Plan Update* builds on the analyses and recommendations contained in previously adopted investment plan updates. Past projects also provide direct feedback on how the ARFVTP can maximize value in 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.

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 proposed funding allocations for FY 2018-2019.

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

<table>
<tr><th>Category</th><th>Funded Activity</th><th>2016-2017</th><th>2017-2018</th><th>2018-2019 (Proposed)</th></tr>
<tr><td>Alternative Fuel Production</td><td>Low-Carbon Fuel Production and Supply†</td><td>$20</td><td>$19.4</td><td>$25</td></tr>
<tr><td rowspan="3">Alternative Fuel Infrastructure</td><td>Electric Charging Infrastructure</td><td>$17</td><td>$16.6</td><td>$20</td></tr>
<tr><td>Hydrogen Refueling Infrastructure</td><td>$20</td><td>$19.4</td><td>$20</td></tr>
<tr><td>Natural Gas Fueling Infrastructure</td><td>$2.5</td><td>$2.4</td><td>-</td></tr>
<tr><td rowspan="2">Alternative Fuel and Advanced Technology Vehicles</td><td>Natural Gas Vehicles</td><td>$10</td><td>$9.7</td><td>-</td></tr>
<tr><td>Advanced Freight and Fleet Technologies</td><td rowspan="2">$23*</td><td>$17.5</td><td>$17.5</td></tr>
<tr><td rowspan="4">Related Needs and Opportunities</td><td>Manufacturing</td><td>$4.9</td><td>$5</td></tr>
<tr><td>Emerging Opportunities</td><td>$3</td><td>$3.9</td><td>$4.2</td></tr>
<tr><td>Workforce Training and Development</td><td>$2.5</td><td>$3.4</td><td>$3.5</td></tr>
<tr><td>Regional Alternative Fuel Readiness</td><td>$2</td><td>-</td><td>-</td></tr>
<tr><td colspan="2">**Total**</td><td>**$100**</td><td>**$97.2****</td><td>**$95.2****</td></tr>
</table>

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. ** Beginning with FY 2017-2018, the ARFVTP is now required to fund program support costs from the annual appropriation, which reduces the amount of funding available for project allocations. †Previously the Biofuel Production and Supply category.

CHAPTER 1: Introduction

California has been at the forefront of national efforts to combat climate change since the passage of the Global Warming Solutions Act of 2006, which established a goal of reducing statewide greenhouse gas (GHG) emissions to 1990 levels by 2020.[1] California's governors have also taken notable steps to fight global climate change, beginning 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. Executive Order B-15-30 subsequently set an interim goal to reduce statewide GHG emissions to 40 percent below 1990 levels by 2030, and this goal was later codified with the passage of Senate Bill 32.[2]

Despite plans by the United States government to cease participation in the Paris Agreement to limit global warming, the state government has maintained its aggressive fight against climate change. The Under2 Coalition, which was formed in 2015 by California and the German state of Baden-Württemberg, has grown to include 177 subnational governments representing 16 percent of the global population in a commitment to dramatically reduce GHG emissions by 2050. In addition, in June 2017, the governors of California, New York, and Washington created the United States Climate Alliance, a bipartisan coalition of 14 states and U.S. territories committed to reducing greenhouse gas emissions in a manner consistent with the goals of the Paris Agreement.

In California, the transportation sector is the largest source of GHG emissions, accounting for 39 percent of in-state emissions.[3] To meet the goals set in these international agreements, state laws, and executive orders, the state transportation sector will need to transition to low-carbon fuels and technologies. California has made progress in reducing transportation carbon intensity, with sales of low-carbon biofuels and zero-emission vehicles steadily increasing and new transportation technologies becoming commercially available. Despite these advances, however, petroleum-based gasoline and diesel fuel still account for 91 percent of California ground transportation fuel use and result in significant GHG emissions.

In addition to greenhouse gases, the transportation sector is also a major emitter of criteria pollutants, with mobile sources responsible for nearly 80 percent of nitrogen

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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 6, 2017. Available at https://www.arb.ca.gov/cc/inventory/data/data.htm.

oxide emissions and 90 percent of diesel particulate matter emissions statewide.[4] The American Lung Association's 2017 *State of the Air* report lists 10 California metropolitan areas in the top-10 most polluted cities for ozone or particulate matter.[5] Protecting and improving public health in these areas will require substantial reductions in criteria pollutant emissions. The California Air Resources Board (CARB) estimates that attaining federal air quality standards in 2023 and 2031 may require up to an 80 percent reduction of smog-forming emissions in parts of the state.[6] 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
Senate Bill 1385	GHG Reduction	Reduce emissions of short-lived climate pollutants to 40 to 50 percent below 2013 levels by 2030
Low-Carbon Fuel Standard	GHG Reduction	Reduce carbon intensity of transportation fuels in California by 10 percent by 2020
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
CARB 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.

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

5 American Lung Association. *State of the Air 2017*. 2017. Available at http://www.lung.org/assets/documents/healthy-air/state-of-the-air/state-of-the-air-2017.pdf.

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

To help address state climate change and air quality objectives, the California Legislature passed Assembly Bill 118 (Núñez, Chapter 750, Statutes of 2007). This legislation created the Alternative and Renewable Fuel and Vehicle Technology Program (ARFVTP), which is administered by the California Energy Commission. With funds collected from vehicle and vessel registration, vehicle identification plates, and smog abatement fees, the ARFVTP 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." 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."[7] Assembly Bill 8 (Perea, Chapter 401, Statutes of 2013) extended the collection of fees that support the ARFVTP through January 1, 2024.

As part of the ARFVTP, the Energy Commission prepares and adopts an annual investment plan update that identifies the funding priorities for the coming fiscal year. The funding allocations reflect the potential for each alternative fuel and vehicle technology to contribute to the goals of the program; the anticipated barriers and opportunities associated with each fuel or technology; the effect of other investments, policies, programs, and statutes; and a portfolio-based approach that avoids adopting any preferred fuel or technology. The investment plan update also describes how the

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

allocations will complement existing public and private efforts, including related state programs.

This *2018-2019 Investment Plan Update* is the tenth investment plan document in the history of the ARFVTP and builds on the analyses and recommendations contained in the prior documents. This draft staff report is the first version of the *2018-2019 Investment Plan Update*. The Energy Commission will hold two public workshops with the ARFVTP Advisory Committee: one in the third quarter of 2017 and the other in the first quarter of 2018, during which representatives from fuel and technology industry groups, nongovernmental entities, other state agencies, and the public will be able to discuss and comment on this document. Comments on the *2018-2019 Investment Plan Update* can be provided using the Energy Commission's docket system.[8] In accordance with state law, the Energy Commission will submit a draft of this investment plan update to the Legislature concurrent with the Governor's budget in January 2018 and will submit the adopted investment plan update to the Legislature concurrent with the Governor's revised budget in May 2018.

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 development and deployment of alternative fuels and advanced technology vehicles. Finally, Chapter 7 summarizes the funding allocations.

8 The Energy Commission encourages written comments on the *2018-2019 Investment Plan Update for the Alternative and Renewable Fuel and Vehicle Technology Program* (Docket #17-ALT-01). Comments can be provided through the Energy Commission's e-Commenting system at https://efiling.energy.ca.gov/Ecomment/Ecomment.aspx?docketnumber=17-ALT-01.

CHAPTER 2: Context of the 2018-2019 Investment Plan

Implementation of the Alternative and Renewable Fuel and Vehicle Technology Program

The Energy Commission has followed a consistent approach toward implementing the ARFVTP since the beginning of the program. This approach, as summarized in Figure 1, begins with an annual investment plan update that determines the coming fiscal-year funding allocation for categories of projects.[9] 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 ARFVTP 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 unique scoring criteria that reflect the selection preferences set by law.[10] When developing solicitations, cost-related scoring criteria are generally weighted more heavily for commercially mature technologies than precommercial technologies. Priority is also given to projects that will benefit economically disadvantaged areas or areas with poor air quality. Some solicitations are first-come, first-served and establish minimum requirements that must be achieved to be eligible for funding.

Energy Commission staff reviews, scores, and ranks the proposals for each solicitation using the evaluation criteria developed for the particular solicitation. Outside agencies and contractors may also provide technical assessments of the proposals. Based on the

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9 The previous investment plan update, covering fiscal year 2017-2018, was adopted at the April 12, 2017 Energy Commission business meeting. It is available at https://efiling.energy.ca.gov/getdocument.aspx?tn=217569.

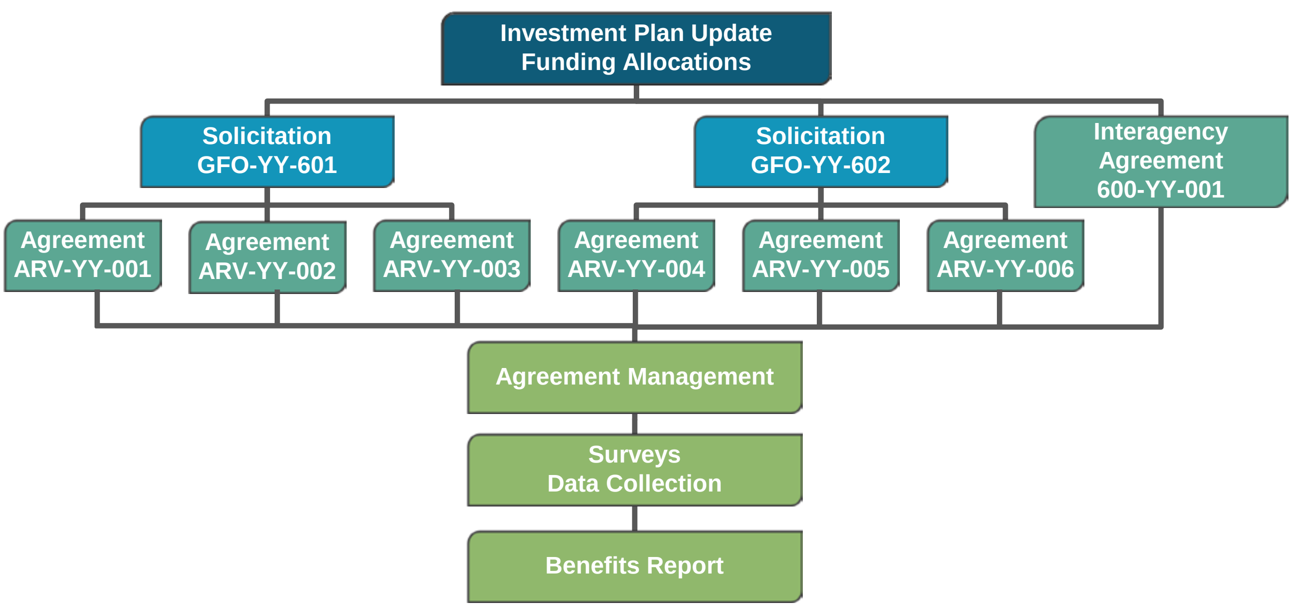
10 These preference criteria are listed in Health and Safety Code Section 44272 (c) and (d).

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 approved and signed by both the Energy Commission and the applicant. Energy Commission staff oversees completion of these agreements according to the respective schedules, budgets, scopes of work, and terms and conditions.

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

Figure 1: Schematic of ARFVTP Implementation



Source: California Energy Commission.

Alternative Financing Mechanisms and Leveraged Funding

To date, the Energy Commission has predominantly used grants to distribute funding, with awardees selected through competitive solicitations. As alternative fuels and technologies have advanced in the marketplace, the Energy Commission has also implemented alternative funding and financing mechanisms, when appropriate. Each of these mechanisms has respective strengths and weaknesses; 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 are described below.

- **Competitive Solicitation for Grants** – This type of solicitation represents the most common funding mechanism for the ARFVTP to date. It is flexible, as project requirements and scoring criteria can be adapted for a broad variety of commercial and technological maturity levels. Competitive scoring allows for increased scrutiny on key issues for each project type. Because of the amount of time and attention required to review each application and oversee each subsequent award, this approach is more manageable when funding larger projects, typically of at least several hundreds of thousands of dollars. The specific time window for applying under these solicitations, as well as the uncertainty of receiving an award, may also result in greater uncertainty for project investors and applicants.
- **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 more difficult to coordinate and plan, however, as federal funding opportunities do not necessarily occur simultaneously with ARFVTP funding opportunities.
- **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 to apply 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 investment from nongovernment sources. This funding typically requires commercial operation and is poorly suited for projects focused on technological

research, development, or demonstration. It is also important that the ARFVTP seek options that limit such support to finite amounts of time or funding and avoid providing a perpetual subsidy without encouraging market maturation.

- **Loan Loss Reserve/Loan Guarantees** – These financing types are being tested by the ARFVTP as a way to potentially increase opportunities to leverage private financing and transition alternative fuel and vehicle investments from public to private sources. These funding mechanisms become more appropriate as technologies and markets mature and are being tested with a pilot program for electric vehicle charging equipment.

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, the LGBT community, and disabled veterans, and is similarly committed to increasing their ARFVTP participation rates. During legislative testimony and at other public forums, Commissioner Janea Scott has reiterated 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).
- Reaching out to small business, women, minority, LGBT, and disabled veteran groups, sharing information from the ARFVTP Web page, and encouraging their presence and participation in ARFVTP workshops.
- Distributing ARFVTP information at key expositions and conferences throughout the state.

- Developing and posting online "Grant Funding Opportunities 101," a presentation on how to apply for ARFVTP funding.[11]
- Hosting a breakout session during the February 2016 Empower California workshop to increase participation of diverse business enterprises in the ARFVTP.
- Publishing Spanish-language translations of the 2016-2017 and 2017-2018 Investment Plan Updates, as well as providing Spanish-language translations of the public notices for the ARFVTP Advisory Committee workshops.[12]

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.[13] 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 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 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,

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11 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.

12 *2017-2018 Actualización del Plan de Inversiones para el Programa de Tecnología de Combustibles y Vehículos Alternativos y Renovables - Comisión Informe Final.* Published June 28, 2017. Publication # CEC-600-2016-007-CMF-Spanish. Available at https://efiling.energy.ca.gov/getdocument.aspx?tn=219947.

13 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.

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.

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.[14] The findings from the June 2014 workshop are discussed in Chapter 4 of the *2014 Integrated Energy Policy Report Update* (IEPR Update) and have been integrated into subsequent ARFVTP solicitations.[15] Similarly, the discussion from the August 2016 workshop will guide 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."[16] AB 8 also directs the Energy Commission to "give additional preference to funding those projects with higher benefit-cost scores."[17] Energy Commission staff applies the benefit-cost preference when evaluating proposals for similar types of projects during funding solicitations.

Benefit-cost measurements and scoring are incorporated into the development of solicitations and the review of proposals for the ARFVTP. The "benefit" is calculated as the amount of conventional fuel displaced per year by the resulting alternative fuel or technology, multiplied by the carbon intensity of that fuel or technology relative to

14 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.

15 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.

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

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

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 September 2017, the Energy Commission has approved more than $745 million in ARFVTP funding across 592 agreements. A summary of these agreements by fuel type is provided in Table 2. The agreements support a broad portfolio of fuel types, supply chain phases, and commercialization phases. In most cases, projects are in progress, with ongoing siting, installation, construction, and demonstrations. Major highlights of the ARFVTP funding portfolio to date include:

- 60 projects to promote the production of sustainable, low-carbon biofuels within California, with a cumulative annual production capacity equivalent to more than 130 million gallons of diesel fuel. Most will use waste-based feedstocks, which have some of the lowest carbon-intensity pathways recognized under the Low-Carbon Fuel Standard.
- 7,698 installed or planned charging stations for plug-in electric vehicles, including 4,369 private charging stations at homes, fleet yards, and workplaces; 3,049 public Level 2 charging stations; and 306 public direct current (DC) fast chargers.
- 60 new or upgraded hydrogen refueling stations that will help serve an emerging population of fuel cell electric vehicles, plus the development of retail fueling standards to enable hydrogen sales on a per-kilogram basis. Once built, these stations will represent 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. This includes five projects at major California Seaports to support Governor Edmund G. Brown Jr.’s Executive Order on Sustainable Freight, which will deploy a variety of zero- and near-zero-emission freight vehicles.
- 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).
- $35 million to fund incentives for clean agricultural equipment and trucks that will reduce emissions.
- 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 17,440 trainees and more than 277 businesses that translate clean technology investments into sustained employment opportunities.
- Five Centers for Alternative Fuels and Advanced Vehicle Technologies, located throughout the state, which are dedicated to expanding the role of alternative fuels and advanced vehicle technologies in California.
- 43 alternative fuels readiness planning and implementation grants to help regions plan for alternative fuel vehicle deployment, new fueling infrastructure, and permit streamlining.

The Energy Commission has provided ARFVTP funding for 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 Table 3, sorted by air district. Table 4 provides a more detailed listing of ARFVTP awards to date, and each project type is discussed further in the respective sections of this investment plan update. In addition, Table 5 outlines the funding allocations of the two most recent investment plan updates, in comparison to the funding allocations for FY 2018-2019.

Beginning with FY 2017-2018, the ARFVTP is now required to fund program support costs from the motor vehicles registration fees that provide funding for the program. Historically, these program support costs were paid from a different funding source that was supported by commercial and residential utility surcharges. Because of these additional expenses that are now borne by the ARFVTP appropriation, Energy Commission staff expects that $95.2 million will be available for ARFVTP projects for FY 2018-2019. This draft staff report of the *2018-2019 Investment Plan Update* reflects a total of $95.2 million for program funding. In the event that a different amount of funding is available, the allocations in this document may be revised in subsequent versions or amended after final adoption.

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

Fuel Type	Cumulative Awards (in Millions)	Cumulative Number of Agreements
Biomethane	$60.9	20
Ethanol	$48.5	20
Biodiesel	$51.2	21
Renewable Diesel	$27.8	8
Electricity	$266.5	179
Hydrogen	$139.2	74
Natural Gas	$99.0	151
Propane	$6.0	31
Multiple/Other*	$46.8	88
Total	**$745.9**	**592**

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

Table 3: ARFVTP Awards by Air District as of September 1, 2017

Air District	Cumulative Awards (in Millions)	Cumulative Number of Projects Sites*
Monterey	$10.7	15
Yolo-Solano	$13.2	26
Sacramento	$29.6	51
Bay Area	$109.9	173
San Joaquin	$114.8	100
Other Northern California Districts	$28.4	99
San Diego	$44.0	88
South Coast	$222.7	339
Other Southern California Districts	$9.9	73
Statewide	$162.7	59
Total	**$745.9**	**1,023**

Source: California Energy Commission. *Each agreement has one or more project site; each project site is a distinct geographic location where agreement work is conducted.

Table 4: ARFVTP Awards as of September 1, 2017

Funded Activity	Cumulative Awards to Date (in millions)*	# of Projects or Units
Alternative Fuel Production		
Biomethane Production	$60.9	20 Projects
Gasoline Substitutes Production	$32.1	15 Projects
Diesel Substitutes Production	$75.1	25 Projects
Alternative Fuel Infrastructure		
Electric Vehicle Charging Infrastructure**	$79.9	7,698 Charging Stations
Hydrogen Refueling Infrastructure	$122.3	60 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
Clean Vehicle Rebate Project Supplemental Funding	$25.1	10,700 Cars
Hybrid and Zero-Emission Truck and Bus Voucher Inventive Project Supplemental Funding	$4.0	150 Trucks
Advanced Freight and Fleet Technology Vehicles****	$130.1	49 Demonstrations
Related Needs and Opportunities		
Manufacturing	$46.5	21 Manufacturing Projects
Emerging Opportunities	†	†
Workforce Training and Development	$31.7	17,440 Trainees
Fuel Standards and Equipment Certification	$3.9	1 Project
Sustainability Studies	$2.1	2 Projects
Regional Alternative Fuel Readiness and Planning	$9.6	43 Regional Plans
Centers for Alternative Fuels	$5.8	5 Centers
Technical Assistance and Program Evaluation	$5.5	n/a
Total	**$745.9**	

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. ****Includes projects from the former Medium- and Heavy-Duty Vehicle Technology Demonstration category. †Awards have been reclassified by project type into other rows.

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

Funded Activity	2016-2017	2017-2018	2018-2019 (Proposed)	Unencumbered Funds*
Low-Carbon Fuel Production and Supply†	$20	$19.4	$25	$18
Electric Charging Infrastructure	$17	$16.6	$20	$22.6
Hydrogen Refueling Infrastructure	$20	$19.4	$20	$22.1
Natural Gas Fueling Infrastructure	$2.5	$2.4	-	$4.4
Natural Gas Vehicles	$10	$9.7	-	$19.7
Advanced Freight and Fleet Technologies	$23**	$17.5	$17.5	$22.3
Manufacturing		$4.9	$5	$4.9
Emerging Opportunities	$3	$3.9	$4.2	$3.9
Workforce Training and Development	$2.5	$3.4	$3.5	$4.9
Regional Alternative Fuel Readiness	$2	-	-	$1.8
Total	**$100**	**$97.2**	**$95.2**	**$124.6**

Source: California Energy Commission. *Unencumbered funds include funding from FY 2016-2017 and FY 2017-2018 that has not yet been reserved for a funding solicitation or dedicated to a specific agreement. This funding is accurate as of September 1, 2017 and is available for new agreements, including grants, contracts, and incentives. Energy Commission staff are continuously developing new funding solicitations and agreements that will use this funding. Unencumbered funds are highest at the start of each fiscal year when new funds are made available and gradually decline throughout the fiscal year as the funds are used. **For FY 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. †Previously the Biofuel Production and Supply 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 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.[18] The methods and results of this report are discussed in the *2014 IEPR Update*, and the assessment was subsequently updated in the 2015 and 2017 *IEPRs*.

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

Expected benefits are defined as the benefits most likely to occur from ARFVTP projects being executed successfully, assuming a one-to-one substitution of existing fuel or technology with a new fuel or technology. *Market transformation benefits* correspond to the core mission of ARFVTP to transform the California transportation system into a low-carbon, low-emission system of alternative fuel and vehicle technologies. Market transformation benefits are 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 "high case" and "low case" assumptions. The expected benefits from NREL's 2017 assessment can be found in Table 6, and the estimated market transformation benefits can be found in Table 7.

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

Project Type	Petroleum Displacement (million gallons)			Greenhouse Gas Emission Reductions (thousand tonnes CO_2e)		
	2020	2025	2030	2020	2025	2030
Fuel Production	92.2	137.9	137.9	1,734.7	1,582.9	1,582.9
Fueling Infrastructure	71.3	71.9	73.4	323.2	329.2	338.6
Vehicles	73.3	116.0	102.8	580	951.2	863.5
Total	**236.8**	**325.8**	**314.1**	**2,637.9**	**2,863.3**	**2,785.0**

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

18 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.

Table 7: Expected Annual Market Transformation Benefits in 2030

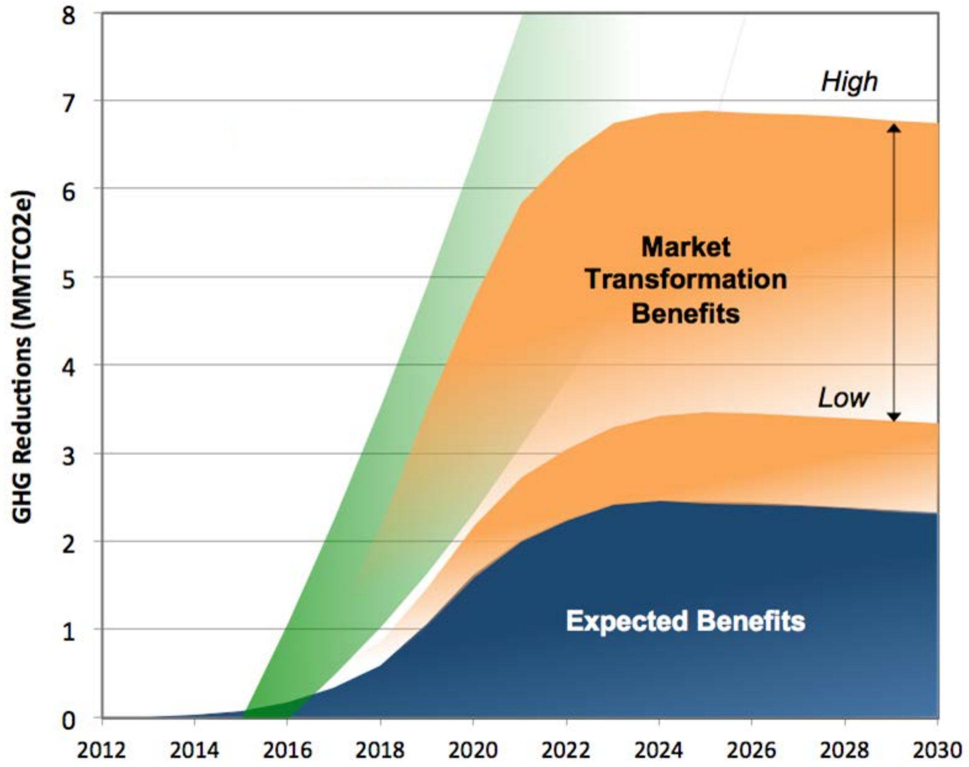
Market Transformation Influence	Case	Petroleum Displacement (million gallons)	Greenhouse Gas Emission Reductions (thousand tonnes CO_2e)
Vehicle Price Reductions	High	104.4	865.5
	Low	45.0	371.2
ZEV Industry Experience	High	10.9	83.4
	Low	9.6	71.1
Next-Generation Trucks	High	257.8	1,513.0
	Low	10.2	70.7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

Source: NREL.

By 2025, the expected benefits for all project classes total about 2.87 million metric tons of carbon dioxide equivalent greenhouse gases ($MMTCO_2e$) reduced per year. The market transformation benefits for 2025 range from 1.02 $MMTCO_2e$ in the low case to 4.49 $MMTCO_2e$ in the high case. Combining this range of market transformation benefits with the expected benefits category yields an annual GHG reduction range of 3.89 $MMTCO_2e$ to 7.36 $MMTCO_2e$ by 2025. Combined petroleum reductions for expected and market transformation benefits range from 462.3 million to 985.5 million gallons per year by 2025.

Figure 2 depicts the expected GHG reductions per year from both expected benefits and market transformation benefits. In this figure, the expected benefits are shown in blue, and the market transformation low and high cases are shown in orange. The green segment represents the needed trajectory for the California transportation sector to meet long-term GHG reduction goals.

Figure 2: GHG Reductions From Expected and Market Transformation Benefits in Comparison to Required Market Growth Benefits



Source: NREL.

Related Policies and Programs

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

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

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, 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. Assembly Bill 398 (Garcia, Chapter 135, Statutes of 2017) extended California's Cap-and-Trade Program through 2030.

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 CARB. While the ARFVTP emphasizes achieving state GHG reduction goals within the transportation sector, the AQIP is responsible primarily for reducing air pollutants from the transportation sector. Since 2009, the AQIP has provided deployment incentives for light-duty electric vehicles through the CVRP, deployment incentives for alternative medium- and heavy-duty vehicles through the Hybrid and Zero-Emission Truck and Bus Voucher Inventive Project (HVIP), as well as funding for other advanced emission reduction technologies for vehicles. Before the availability of appropriations from the GGRF, the ARFVTP provided $49.1 million in funding to backfill CVRP needs, as well as an additional $4 million for HVIP incentives.

CARB also distributes GGRF funding through its Low Carbon Transportation Investments (LCTI) program to reduce greenhouse gas emissions and advance the purposes of AB 32 and SB 32. Many projects previously funded by the AQIP are now funded by the LCTI program because demand has exceeded available funding from the 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.

In September 2017, CARB released a draft Clean Transportation Incentives funding plan for FY 2017-2018 that proposed $663 million in funding allocations from multiple sources, including $560 million from the GGRF and $28 million in AQIP funds. A summary of this funding can be found in Table 8.

Table 8: Draft FY 2017-2018 CARB Clean Transportation Incentives Allocations

Project Category	Allocation (in Millions)		
	LCTI	AQIP	Other*
Clean Vehicle Rebate Project	$140		
Transportation Equity Projects			
Enhanced Fleet Modernization Program Plus-Up	$10		
Financing Assistance for Lower-Income Consumers	$10		
Clean Mobility Options in Disadvantaged Communities	$17		
Agricultural Worker Vanpools	$3		
Rural School Bus Pilot	$10		
CVRP Rebates for Low-Income Applicants	$40		
To Be Allocated in Spring 2018 (Based on Demand)	$10		
Equity ZEV Replacement Incentives (One-Stop-Shop)			
Advanced Freight Equipment Demonstration and Deployment Project			
Zero- and Near-Zero-Emission Freight Facilities	$100		$50
Zero-Emission Off-Road Freight Voucher Incentive Project	$40		
Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project	$180	$8	
Truck Loan Assistance Program		$20	
Total	**$560**	**$28**	**$50**

Source: California Air Resources Board. *Includes funding from Senate Bill 132 (Committee on Budget and Fiscal Review, Chapter 7, Statutes of 2017) for the Zero/Near-Zero Emission Warehouse Program.

Many project categories listed above have particular importance to the goals and strategies of the ARFVTP and are further discussed in the Advanced Freight and Fleet Technologies section of Chapter 5 in this investment plan update.

State Implementation Plans and Mobile Source Strategy

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

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.[19] 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.[20] 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

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 88 gallons of gasoline. The price of credits has been volatile, as shown in Figure 3, ranging from a low of $22 in May 2015 to a high of $122 in February 2016.[21] As of August 2017, more than

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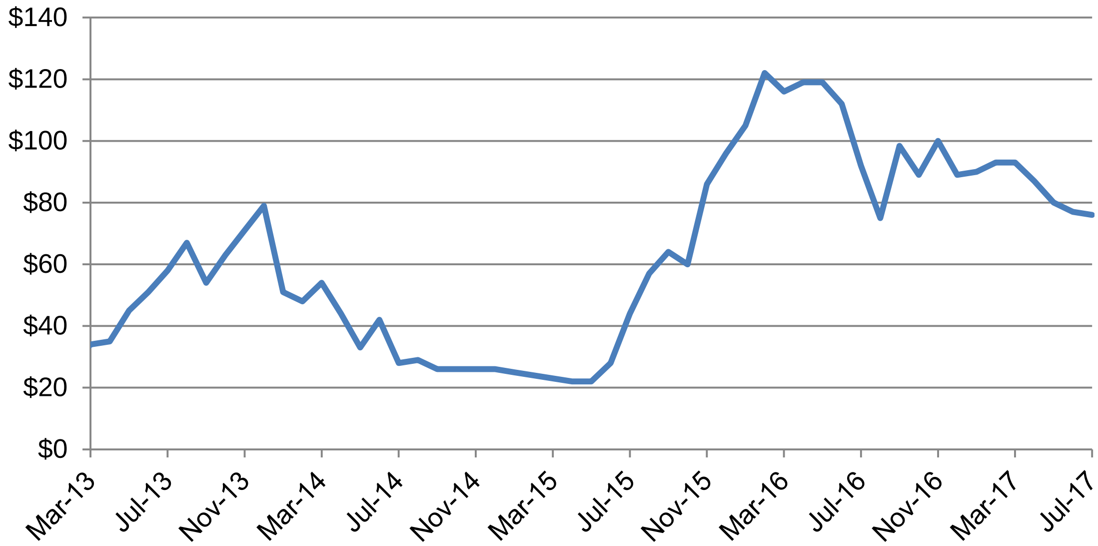
19 California Air Resources Board. *Revised Proposed 2016 State Strategy for the State Implementation Plan.* March 7, 2017. Available at https://www.arb.ca.gov/planning/sip/2016sip/rev2016statesip.pdf .

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

21 California Air Resources Board. *LCFS Monthly Credit Price and Transaction Volumes August 2017 Spreadsheet.* August 14, 2017. Available at https://www.arb.ca.gov/fuels/lcfs/dashboard/creditpriceserieswithoutargusopis.xlsx.

390 certified transportation fuel pathways are available for use under the LCFS, and 250 parties are registered for transactions under the LCFS, including oil refiners, biofuel producers, and electric and natural gas utilities.[22,23]

Figure 3: Average Monthly Low-Carbon Fuel Standard Credit Prices



Source: California Energy Commission. Data from the LCFS Monthly Credit Price and Transaction Volumes August 2017 Spreadsheet, available at https://www.arb.ca.gov/fuels/lcfs/dashboard/creditpriceserieswithoutargusopis.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 reliance is due to the LCFS program life-cycle analysis of GHG emissions, the specificity of the analysis to California, and the consistent method of calculation across multiple fuel pathways. The life-cycle GHG emission numbers are used in assessing the opportunities from different alternative fuels within the investment plan update, estimating the GHG reduction potential from applicants during solicitations, and analyzing ARFVTP benefits.

The LCFS also provides a direct financial incentive per gallon, kilowatt-hour, therm, or kilogram to the producers and distributors of low-carbon alternative fuels. At the recent average price of about $85 per credit, the LCFS value of an alternative fuel offering a 50 percent GHG emission reduction compared to gasoline would be $0.47 per gasoline gallon equivalent (GGE).[24] This complements the investments of the ARFVTP by creating

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22 California Air Resources Board. *LCFS Current Lookup Table.* August 18, 2017. Available at https://www.arb.ca.gov/fuels/lcfs/fuelpathways/current-pathways_all_post.xlsx.

23 California Air Resources Board. *LRT Registered Parties.* August 4, 2017. Available at https://www.arb.ca.gov/fuels/lcfs/regulatedpartiesreporting20170804.xlsx.

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

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.[25,26]

Table 9: RFS Fuel Volumes and Percentages for 2016-2019

Category	Volume Standards			Percentage of Fuels	
	2017	2018	2019	2016	2017
Cellulosic Biofuel	311 million	238 million*	n/a	0.128%	0.173%
Biomass-Based Diesel	2.00 billion	2.1 billion	2.1 billion*	1.59%	1.67%
Advanced Biofuel	4.28 billion	4.24 billion*	n/a	2.01%	2.38%
Total Renewable Fuels	19.28 billion	19.24 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. *Proposed volume requirements as of July 18, 2017.

As with the LCFS, the RFS provides a per-gallon subsidy for alternative fuels through saleable RINs. This subsidy complements the goals of the ARFVTP by encouraging credit-generating and regulated parties to invest in the lowest-cost means of increasing alternative fuel use. The market value of these RINs can be volatile. Pricing depends on the category of RIN and, for the first half of 2017, has ranged from about $0.35 to

25 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.

26 United States Environmental Protection Agency. *Proposed Volume Standards for 2018, and the Biomass-Based Diesel Volume for 2019.* July 24, 2017. Accessed August 25, 2017. Available at https://www.epa.gov/renewable-fuel-standard-program/proposed-volume-standards-2018-and-biomass-based-diesel-volume-2019.

$1.15, with one RIN representing the energy content of a gallon of ethanol.[27] This volatility affects the income of biofuel producers and can negatively affect investments in projects.

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.[28] The resulting *California Sustainable Freight Action Plan* was released in July 2016 and identifies state policies, programs, and investments to achieve these targets.[29]

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.

In response to this executive order, the Energy Commission released two solicitations for advanced freight vehicle demonstrations in 2015 and 2016. These solicitations awarded $34 million to five projects demonstrating advanced technologies in the Ports of Los Angeles, Long Beach, and San Diego. These projects will deploy 90 zero-emission, plug-in hybrid, and low-NOx natural gas engine vehicles across a wide array of vehicle types, including yard trucks, drayage trucks, gantry cranes, top handlers, and forklifts. Moreover, the Energy Commission regularly engages with seaports in California through the Ports Energy Collaborative, which provides a forum for the Energy Commission and the ports to come together to discuss important energy issues, mutual challenges, and opportunities for transitioning to alternative and renewable energy technologies.

Executive Order on Zero-Emission Vehicles

On March 23, 2012, Governor Brown issued Executive Order B-16-12, which set a target of 1.5 million zero-emission vehicles on the road by 2025 and tasked various state agencies with specific actions needed to support this goal.[30] The *ZEV Action Plan*, first

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27 Progressive Fuels Limited. *PFL Weekly Recap*. Accessed August 2, 2017. Available at http://www.progressivefuelslimited.com/web_data/PFL_RIN_Recap.pdf.

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

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

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

issued in 2013 and subsequently updated in October 2016, includes actions that apply directly to the funding categories of the ARFVTP.[31] Some actions in the *ZEV Action Plan* that are particularly relevant to the ARFVTP include ensuring ZEVs are accessible to a broad range of Californians and making ZEV technologies commercially viable in the medium- and heavy-duty and freight sectors. Many recommendations in the *ZEV Action Plan* have been captured in the ARFVTP since the inception of the program and continue to be priorities in the ARFVTP. The Electric Charging Infrastructure, Hydrogen Refueling Infrastructure, and Advanced Freight and Fleet Technologies sections of this investment plan update discuss proposed ARFVTP activities that will help achieve the goals of the *ZEV Action Plan*.

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

Charge Ahead California Initiative

Senate Bill 1275 (De León, Chapter 530, Statutes of 2014) established the Charge Ahead California Initiative, administered by CARB in consultation with the Energy Commission and related agencies. 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 for disadvantaged, low-income, and moderate-income communities and consumers. In implementing the initiative, CARB must include a three-year funding forecast for near-zero- and zero-emission vehicles. 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. CARB also adopted revisions to the Clean Vehicle Rebate Project to phase down rebate levels based on cumulative sales, limit eligibility based on income, and consider other methods of incentives.

CPUC Transportation Electrification Activities

In 2014, the California Public Utilities Commission (CPUC) adopted Decision 14-12-079 to allow the consideration of utility ownership of electric vehicle charging stations (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

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31 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.

Gas & Electric Company (SDG&E), and Southern California Edison (SCE) to install 7,500, 3,500, and 1,500 charging stations, respectively.[32] These pilot programs are described further in the Electric Charging Infrastructure section in Chapter 4 of this report. The Energy Commission has worked and will continue to work closely with other agencies to ensure the strategic deployment of EVCS and avoid redundant investments in infrastructure.

The CPUC is also working to implement the transportation electrification provisions of Senate Bill 350 (De León, Chapter 547, Statutes of 2015) by directing the six investor-owned electric utilities under CPUC jurisdiction to propose portfolios of transportation electrification programs and investments that can be implemented over the next two to five years. In addition to the applications previously submitted by PG&E, SDG&E, and SCE, the remaining three investor-owned electric utilities, including PacifiCorp, Liberty Utilities, and Bear Valley Electric Service, filed applications with the CPUC in June 2017. Also in 2017, PG&E, SCE, and SDG&E began providing customer incentives for plug-in electric vehicles as part of the utility implementation of the LCFS program.[33]

Volkswagen Diesel Emissions Settlement

Beginning with its 2009 model year, Volkswagen sold 2.0- and 3.0-liter diesel vehicles in the United States, including in California, which violated federal and State law by using illegal devices to defeat emission tests. To remedy the harm caused by the use of these defeat devices, California entered into a series of settlement agreements with Volkswagen. From these agreements, California will receive about $422 million from a national Environmental Mitigation Trust for projects to fully mitigate the lifetime excess NO_x emissions caused by the illegal devices, and a minimum of 35 percent of this will be used for the benefit of low-income or disadvantaged communities. California will also receive $25 million for vehicle replacement programs for low-income consumers and $153.8 million in civil penalties.[34] In addition, Volkswagen will invest $800 million in ZEV-related projects in the State, and must offer and sell additional battery electric vehicle models in California between 2019 and 2025.

Volkswagen's ZEV investments will occur over a 10-year period, and eligible projects include fueling infrastructure for plug-in electric vehicles and hydrogen fuel cell vehicles, consumer awareness campaigns, and car-sharing programs. Volkswagen will submit four ZEV investment plans, each of which will cover 30 months and total

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32 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.

33 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.

34 California Air Resources Board. "California to Receive $153M in Final Settlement with Volkswagen." July 20, 2017. Release #17-48. Available at https://www.arb.ca.gov/newsrel/newsrelease.php?id=944.

$200 million, to CARB for approval. The ZEV infrastructure funding is expected to complement ARFVTP investments in electric charging infrastructure and hydrogen refueling infrastructure. A portion of the funds from the Environmental Mitigation Trust may also be used for infrastructure projects, though the use of these funds will be determined through a public process coordinated by CARB. The Energy Commission will monitor the development of the Volkswagen settlement investment plans to ensure that investments are coordinated. Details from the first Volkswagen settlement investment plan are discussed in the Electric Charging Infrastructure section in Chapter 4 of this report.[35]

SB 110 School Bus Retrofit and Replacement

In the November 2012 California general election, voters approved Proposition 39 to improve energy efficiency and expand clean energy generation in schools and community colleges. This proposition provides up to $550 million annually for five fiscal years for these purposes, beginning with FY 2013-2014. Senate Bill 110 (Committee on Budget and Fiscal Review, Chapter 55, Statutes of 2017) appropriates the available remaining funds from the implementation of Proposition 39 to improve energy efficiency at California schools. The energy efficiency measures in SB 110 include one-time funding of up to $75 million for the retrofit or replacement of school buses, to be administered by the Energy Commission. Energy Commission staff expects these buses will use advanced technology or zero-emission powertrains and will require new fueling infrastructure. SB 110, and the related impact on the ARFVTP, is discussed further in the Advanced Freight and Fleet Technologies section in Chapter 5 of this report.

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

CHAPTER 3: Alternative Fuel Production and Supply

Low-Carbon Fuel 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.[36] Any low-carbon substitute fuel that can displace the roughly 13.9 billion gallons of gasoline and 3.3 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.[37] 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.[38] In addition, production of and demand for renewable hydrogen are expected to increase in the coming years as more hydrogen fuel cell vehicles are sold. One goal of the ARFVTP is to expand the production of low-carbon, economically competitive fuels from waste-based and renewable feedstocks in California.

The carbon intensity of renewable fuels can vary significantly depending on the pathway, which accounts for the specific feedstock and production process of the fuel. CARB provides carbon intensity values for most transportation fuels as part of the LCFS. The carbon intensity value accounts for the life-cycle GHG emissions of the fuel, including production, transportation, and consumption, and is reported in grams of carbon dioxide equivalent greenhouse gases per megajoule (gCO2e/MJ).[39] California reformulated gasoline and ultra-low-sulfur diesel have carbon intensities of 99.78 and 102.01 gCO_2e/MJ, respectively.[40] Maximizing renewable fuel production from the lowest-carbon pathways represents a key opportunity to reduce near-term GHG emissions in

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

37 Ibid.

38 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.

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

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

combustion engines and fuel cell vehicles. Biofuels derived from waste-based feedstocks typically have the lowest carbon intensity of all transportation fuels.

In 2016, renewable diesel was the most common diesel substitute in California with 248 million gallons used, the majority of which was supplied through overseas imports.[41] One renewable diesel production facility is operating in California and produced 23 million gallons of renewable diesel fuel in 2016.[42] The ARFVTP has provided funding to four in-state commercial-scale renewable diesel producers to expand their production capacity. When operational, these projects will have a combined production capacity of 54.5 million gallons per year and are 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. In 2016, California biodiesel production facilities produced 40 million gallons of biodiesel, and 163 million gallons of biodiesel were registered with the LCFS.[43,44] The Energy Commission has provided 11 grants through the ARFVTP to expand the in-state annual production capacity of biodiesel by a cumulative 82 million gallons, and two of these projects have been completed and are producing fuel. Renewable diesel and biodiesel have carbon intensities ranging from 18 to 96 percent lower than diesel fuel, depending on the pathway used.[45] Together,

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41 California Air Resources Board. *LCFS Quarterly Data Spreadsheet*. August 2, 2017. Available at http://www.arb.ca.gov/fuels/lcfs/lrtqsummaries.htm.

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

43 Ibid.

44 California Air Resources Board. *LCFS Quarterly Data Spreadsheet*. August 2, 2017. Available at http://www.arb.ca.gov/fuels/lcfs/lrtqsummaries.htm.

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.

renewable diesel and biodiesel accounted for about 42 percent of LCFS credits in 2016, increasing from 9 percent of LCFS credits in 2011.[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 1.6 million FFVs are registered in California, which, during 2016, used a total of 18.7 million gallons of E85.[47] 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.[48] 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 as a feedstock.[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, 7 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*.

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46 California Air Resources Board. *LCFS Quarterly Data Spreadsheet*. August 2, 2017. Available at http://www.arb.ca.gov/fuels/lcfs/lrtqsummaries.htm.

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

48 Ibid.

49 Nebraska Energy Office. *Ethanol Facilities Capacity by State and Plant*. June 2017. Accessed August 22, 2017. Available at http://www.neo.ne.gov/statshtml/122.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 2015 through August 2017 from http://e85prices.com/california.html. Accessed August 22, 2017. 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.

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

Biomethane is a commercially mature biofuel that serves as a low- or negative-carbon substitute for conventional natural gas. According to the most recently listed LCFS carbon intensity values, biomethane from anaerobic digestion of wastewater sludge can reduce GHG emissions by as much as 92 percent below diesel, and biomethane derived from high-solids anaerobic digestion of prelandfill food and green wastes possesses a negative carbon intensity roughly 125 percent below diesel.[52] Energy Commission staff expects the availability of organic waste feedstocks suitable for prelandfill biomethane production to increase as a result of Assembly Bill 341 (Chesbro, Chapter 476, Statutes of 2011) and Senate Bill 1383 (Lara, Chapter 395, Statutes of 2016). AB 341 set a state goal of reducing, recycling, or composting 75 percent of solid waste by 2020, and SB 1383 set additional goals to reduce statewide disposal of organic waste from 2014 levels by 50 percent by 2020 and 75 percent by 2025. 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.

Renewable hydrogen is a relatively new transportation fuel, as hydrogen fuel cell electric vehicles (FCEVs) have only recently become commercially available. The production methods, however, are commercially mature, and the fuel can be produced most commonly through steam reformation of biomethane or through electrolysis using water and renewable electricity. According to the California Independent System Operator, increasing amounts of renewable power generation may result in electricity oversupply as California renewable power requirements grow from 33 percent to 50 percent.[53] Renewable hydrogen production is being investigated as a viable technology for beneficial use of this surplus renewable energy. Several ARFVTP projects already use electrolysis to generate modest volumes of hydrogen at fueling stations. Potential

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

renewable hydrogen projects may include using renewable energy to produce large volumes of renewable hydrogen through electrolysis, or commercial-scale steam reformation facilities that exclusively use biomethane as a feedstock.

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.[54] 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 more than $168 million to 60 biofuel production projects. These awards are summarized by fuel type in Table 10.

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	15	$32.1
Diesel Substitutes	56	$162.2	25	$75.1
Biomethane	45	$139.5	20	$60.9
Total	**126**	**$360.5**	**60**	**$168.1**

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 renewable fuel 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.

54 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 11: GHG Emission Reduction Potential of Commercial-Scale ARFVTP Projects

Fuel Type	Feedstock Descriptions	Average GHG Emission Reduction [55]	# of Projects	Range of Annual Capacity for Individual Projects	Total Annual Capacity Increase
Biomethane	Dairy manure; fats, oils, & grease; food, green, yard, & municipal waste	166%	10	140,000 – 2,870,000 DGE	8.5 Million DGE per Year
Diesel Substitutes	Waste oils* (various)	83%	15	1,928,311 – 20,000,000 DGE	106.4 Million DGE per Year
Gasoline Substitutes	Sugar beets; grain sorghum	47%	4	2,600,000 – 26,000,000 GGE	34.6 Million GGE per Year

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

ARFVTP 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.

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

Table 12: Sample of Precommercial ARFVTP Projects

Fuel Type	Pathway Description	Estimated GHG Emission Reduction [56]	# of Projects	Annual Capacity for Individual Projects (DGE or GGE)
Biomethane	Anaerobic codigestion of wastewater; manure; or food, beverage, or green waste	89% - 150%	4	57,000 – 328,000
Diesel Substitutes	Esterification or transesterification of algae, manure, or food waste	45% - 55%	2	Nominal
Diesel Substitutes	Gasification of green waste or manure	67%	2	Nominal – 365,000
Gasoline Substitutes	Fermentation or gasification of cellulosic or agricultural residues*	76% - 85%	4	Nominal

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

The most recently completed solicitation for biofuel production projects, 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, and 11 of these were selected for funding in Phase Two of the solicitation to receive a total of $38.5 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 of ARFVTP funding. As such, this investment plan will retain the single allocation for all low-carbon fuels as used in previous years to allow greatest flexibility for funding solicitations.

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-

56 Ibid.

producing projects in 2014 and awarded an additional $12 million to three biomethane-producing projects in 2017. In addition, the California budget for fiscal year 2016-2017 appropriated a $50 million GGRF allocation to the California Department of Food and Agriculture (CDFA), with between $29 million and $36 million expected to fund anaerobic digesters at dairies through the Dairy Digester Research and Development Program.[57] 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. Figure 4 illustrates the amount of funding available from the State for biofuel production projects in California.

Figure 4: Major Funding Sources for Biofuel Production Projects in California

Source: California Energy Commission. All funding in millions of dollars. ARFVTP funding is for FY 2017-2018; CalRecycle and CDFA funding is for FY 2016-2017. *CalRecycle and CDFA funding is limited to anaerobic digester projects that produce biomethane gas.

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

To encourage the use of very-low-carbon biomethane as a transportation fuel, the Energy Commission may consider future funding solicitations that use funding from multiple investment plan categories to deploy vertically integrated biomethane production and distribution facilities, as well as low-NO_x natural gas vehicle fleets to use the renewable fuel. Combining all three aspects of fuel production, distribution, and use into one project may ease the barriers associated with biomethane use by providing a dedicated renewable fuel source and a dedicated market for the fuel. Such a solicitation

57 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.

may combine funding from any or all of the Biofuel Production and Supply, Natural Gas Fueling Infrastructure, Natural Gas Vehicles, or Advanced Freight and Fleet Technologies funding categories, as appropriate.

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

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 decline in the health of California forests and resulted in increased tree mortality. The potential supply of woody biomass feedstock from dead trees exceeds that of any other source of waste material in the state, and the sustainable harvesting and use of this biomass can avoid carbon emissions from wildfire and decomposition. Through the ARFVTP, the Energy Commission seeks to attract technologies that can economically convert this feedstock into low-carbon biofuels.

Some fuel types and pathways have shown minimal improvement in carbon intensity or cost-effectiveness in recent funding solicitations, which may indicate that the technology or process has fully matured. The Energy Commission may evaluate renewable fuel types and production pathways to determine when state incentives are no longer necessary. To this end, incentives may be reduced or altered by placing a higher emphasis on using cost-effectiveness scoring criteria or pathway efficiency, or requiring increased benefits from repeat applicants. As the market for low-carbon fuels continues to develop, the Energy Commission may also consider alternative funding mechanisms, such as revolving loan or loan guarantee programs, which may be more suitable for large projects and developed industries. For FY 2018-2019, Energy Commission staff proposes a $25 million allocation for low-carbon fuel production and supply to continue support for renewable fuel production facilities in California.

Summary of Alternative Fuel Production and Supply Allocations

Table 13: Proposed FY 2018-2019 Funding for Alternative Fuel Production and Supply

Low-Carbon Production and Supply Relevant Policy Goals: – GHG Reduction – Petroleum Reduction – In-State Biofuels Production – Low Carbon Fuel Standard	$25 Million	$5.6 million increase relative to FY 2017-2018 (Biofuel Production and Supply)
Total	**$25 Million**	

Source: California Energy Commission.

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. Most of these ZEVs are expected to be plug-in electric vehicles (PEVs) since CARB manufacturer surveys forecast that 13,400 fuel cell electric vehicles will be on California roads by 2020.[58] 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 334,000 sold through September 2017.[59] Though many first-generation PEVs were restricted in electric drive range by battery technology and cost limitations, newer-model PEVs can provide an electric drive range at or near that of a comparable gasoline-powered car. A convenient, reliable network of public electric vehicle charging stations (EVCS) will be critical to support the expansion of PEV ownership in California and achieve the goals of the *ZEV Action Plan*.

To date, the Energy Commission has led state efforts in ZEV infrastructure deployment and has supported the rollout of PEVs by awarding nearly $80 million in ARFVTP funding for electric charging infrastructure. 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.[60] ARFVTP investments have funded EVCS at many types of locations, as detailed in Table 14.

58 California Air Resources Board. *2017 Annual Evaluation of Fuel Cell Electric Vehicle Deployment and Hydrogen Fuel Station Network Development*. August 2017. Available at http://www.arb.ca.gov/msprog/zevprog/ab8/ab8_report_2017.pdf.

59 Veloz. *Detailed Monthly Sales Chart*, October 5, 2017. Available at http://www.veloz.org/wp-content/uploads/2017/07/9_september_2017_Dashboard_PEV_Sales_veloz.pdf.

60 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 September 1, 2017

Status	Private Access			Publicly Accessible			Total
	Residential	Fleet	Workplace	Multifamily Housing	Public	Corridor	
Installed	3,936	104	246	228	2,292	114	**6,920**
Planned	-	-	57	15	352	354	**778**
Total	**3,936**	**104**	**303**	**243**	**2,644**	**468**	**7,698**

Source: California Energy Commission. Does not include projects that have yet to be approved at an Energy Commission business meeting.

More than 94 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 and can provide about 12 to 30 miles of range per hour of charging. More than half of these Level 2 charging stations were installed at homes to support the early deployment of the first PEVs in the state. Fewer than 2 percent of chargers funded by the ARFVTP have been Level 1 chargers, which use alternating current electricity at 120 volts to provide about 5 miles or less of range per hour of charging.[61] The residential, fleet, workplace, multifamily housing, and public charging stations as 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 to date, with the majority installed at single-family homes. These chargers were funded through FY 2011-2012 and, as at-home Level 2 chargers became readily available and affordable, the Energy Commission discontinued funding for charging stations at single-family homes. Charger stations located at multifamily housing, however, still face barriers that impede PEV adoption. This area has also been historically underrepresented by project applicants despite efforts to target incentives toward EVCS installations in multifamily housing.

Workplace and public charging stations are another major component of the ARFVTP portfolio of charging stations. Public chargers, as identified in Table 14, include stores, parking garages, universities, municipal governments, curbside locations, and other common, publicly accessible destinations. When residents of multifamily housing are unable to charge at home, having an available site to charge at work or access to other public locations can serve as an alternative. If located far from home, workplace and public charging can also help BEV owners extend their range and PHEV owners increase their electric miles driven.

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

Open access to public chargers in California is ensured by the Electric Vehicle Charging Stations Open Access Act, which prohibits requiring subscription fees or memberships as a condition of use for publicly accessible chargers.[62] The majority of charging at public locations is expected to occur during the daytime, which is likely to create opportunities for electricity demand management at these sites. Electric vehicle charging with demand-side management can reduce electricity use during peak times and shift use to periods of excess electricity supply. As more intermittent renewable energy is available to the electricity grid, such as solar and wind, the electricity supply available during the day will increase and possibly result in overgeneration. Vehicle-to-grid technologies and daytime PEV charging, especially at workplace and public charging stations, have the opportunity to reduce the negative effects of overgeneration.

A complete PEV charging network also requires fast chargers, which use direct current electricity at 480 volts to recharge a BEV to 80 percent capacity in about 30 minutes, though this depends on the size of the vehicle battery.[63] When located along major interregional routes, these chargers can enable long-distance travel by BEVs. The corridor charging stations reported in Table 14 consist mostly of fast chargers, but many sites also include some Level 2 charging stations.

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

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

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

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

Senate Bill 350 requires CARB, in consultation with the Energy Commission, to develop and release a study on the barriers faced by low-income customers in adopting zero-emission and near-zero-emission transportation options. As a result, in April 2017, CARB released a draft guidance document titled *Low-Income Barriers Study, Part B: Overcoming Barriers to Clean Transportation Access for Low-Income Residents*. The draft guidance document cited affordability, awareness, and a lack of permanent, long-term funding sources as barriers to increasing access to clean transportation and mobility options in underserved and disadvantaged communities. Energy Commission staff will take these barriers and the recommendations to overcome them into account when developing future funding opportunities.

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 of financing EVCS, the ARFVTP funded the Electric Vehicle Charging Station Financing Program, which is administered by the California Pollution Control Financing Authority. Because potential borrowers have shown limited interest in this demonstration-scale financing program, the Energy Commission may reevaluate the program to best meet the needs for charging infrastructure in the state. Other advanced financing mechanisms may also be considered as EVCS markets continue to mature.

In December 2014, the CPUC adopted Decision (D.) 14-12-079, which permits utility ownership of electric charging infrastructure, contingent upon an examination of the utility program through a balancing test.[64] A prior CPUC decision had prohibited utility ownership of charging infrastructure; however, utilities may now apply for ownership approval on a case-specific basis. Each of the three major investor-owned utilities applied to install electric vehicle chargers or supporting infrastructure for light-duty vehicles in their respective service territories, and these proposals were approved by the CPUC in 2016.

Southern California Edison launched its "Charge Ready" pilot program in May 2016, which provided up to $22 million over a one-year period to install an estimated 1,500 site host-owned charging stations at multifamily residences, workplaces, and other public locations.[65] San Diego Gas & Electric launched its "Power Your Drive" pilot program in 2017, which provides up to $45 million over three years to install an estimated 3,500 SDG&E-owned charging stations at multifamily residences and

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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.

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

workplaces.[66] Pacific Gas and Electric Company is expected to begin projects for its "EV Charge Network" pilot program in 2017, which will provide up to $130 million over three years to install an estimated 7,500 site-owned and PG&E-owned charging stations at multifamily residences and workplaces.[67] In addition, in June 2017, Bear Valley Electric Service, Liberty Utilities, and PacifiCorp filed applications with the CPUC to support transportation electrification through charging infrastructure installation and rebates as well as outreach and education activities. Energy Commission staff expects that ARFVTP projects and investor-owned utility projects will complement one another within each utility service territory.

Other organizations have also committed to provide substantial funding for light-duty charging infrastructure deployment in California. EVgo is expected to install at least 200 fast chargers by December 2017 and 10,000 Level 2 chargers by December 2018 as part of the energy crisis settlement reached between the CPUC and NRG Energy, Inc.[68] Volkswagen, through its subsidiary Electrify America, has also agreed to invest $800 million over a 10-year period for ZEV infrastructure, education, and access in California as part of a settlement with CARB. For the first 30-month cycle of the settlement, Electrify America is expected to invest roughly $45 million in community chargers in major metropolitan areas and $75 million in a highway fast charging network throughout the state.[69] 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. Figure 5 illustrates estimated annual averages of major sources of funding for electric vehicle charging infrastructure in California.

Figure 5: Major Funding Sources for Light-Duty Charging Infrastructure in California

Source: California Energy Commission. All funding amounts are estimated for FY 2017-2018 and measured in millions of dollars. *Funding from the VW Settlement, PG&E, and SDG&E will be disbursed over multiple years – reported amounts are annual averages of estimated total infrastructure funding. †The SCE Charge Ready pilot program stopped accepting reservations on January 3, 2017; however, SCE is expected seek authority from the CPUC to expand the program.

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

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

68 EVgo Services LLC. *2016 Annual Report*. March 5, 2017. Available at http://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=6442452815.

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

As more funding sources become available, all agencies, utilities, and companies providing EVCS funding will need to coordinate to expedite expansion of the charging network and to avoid duplication. The Energy Commission, recognizing the need to be nimble and flexible in the deployment of charging infrastructure, released GFO-16-603 in November 2016 to select a block grant administrator to distribute EVCS incentives throughout California. The Center for Sustainable Energy was selected as the most qualified administrator and is expected to begin providing the first targeted EVCS incentive funding in December 2017. The Energy Commission may implement voucher or rebate incentive projects through this block grant, since these incentives types can simplify the funding process and accelerate charger deployment.

The Energy Commission may also make funding available for the repair and upgrade of existing chargers. 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. In addition, many chargers from the early 2010s operate at low power levels that effectively render them obsolete for charging newer PEVs with larger capacity batteries. Similar to chargers with obsolete connectors, these underpowered chargers may be able to be replaced with new, higher-powered models at a lower cost than installing an entirely new charger.

The Energy Commission, through 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. Site owners have also voiced concern over charging stations that are no longer functional because of equipment failure, damage, or vandalism. The owners of these charging stations may not be able to pay for repairs and choose instead to leave the infrastructure non-operational. In situations such as these, the Energy Commission may fund maintenance and repair to return these charging stations to service.

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 expected 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, autonomous connected vehicles, and wireless charging, present other opportunities to expand the use of PEVs. Thus far, PEV use has been limited largely to those who have the means to purchase a new vehicle. Dedicated PEV car- and ride-sharing services, however, can provide zero-emission transportation options for drivers and passengers that would otherwise have no alternatives to conventional automobiles. To advance ZEV adoption, the Energy Commission may provide funding from this category to purchase and install charging infrastructure for demonstration PEV car- and ride-sharing services. These demonstrations may be targeted in disadvantaged and rural communities to provide further benefits to Californians who lack adequate transportation options.

For FY 2018-2019, Energy Commission staff proposes a $20 million allocation for electric charging infrastructure. Despite the significant amount of funding for electric vehicle infrastructure expected from other sources, Energy Commission staff believes continued funding for this allocation is necessary for projects not covered by the geographic area or scope of other programs. Significant 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, also offer a zero-emission transportation option for Californians. Like electricity, hydrogen can be produced from a variety of pathways, including renewable sources of energy. When produced with one-third renewable energy, the hydrogen for a passenger FCEV can reduce GHG emissions by about 50 to 70 percent compared to a conventional gasoline vehicle, which is comparable to the GHG emissions benefits of BEVs that use electricity from the power grid.[70] 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 zero-emission vehicles to drivers who want or need more range or faster refueling.

Several automakers have launched mainstream FCEVs for lease or sale in California. In 2014, Hyundai became the first automaker to offer a production model FCEV, the Tucson Fuel Cell, for lease to private customers. Toyota subsequently released the Mirai FCEV in 2015, and Honda released its production Clarity FCEV in December 2016. Kia is also expected to release a new FCEV model by 2020, and in September 2017, Mercedes-

70 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 65.87-130.12 grams CO2e/MJ for hydrogen with one-third renewable content. Source: CARB. *LCFS Fuel Pathway Table*. July 10, 2017. Available at https://www.arb.ca.gov/fuels/lcfs/fuelpathways/pathwaytable.htm.

Benz presented a preproduction model of the hybrid GLC F-Cell, which combines hydrogen fuel cell and plug-in battery-electric powertrains.

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 September 2017, 31 ARFVTP-funded hydrogen refueling stations were operational in California. An additional four stations are expected to be operational in 2017. Through the ARFVTP, the Energy Commission has provided funding to install or upgrade 60 publicly available hydrogen stations capable of light-duty vehicle refueling. This network of 60 stations will have sufficient capacity to support the initial 13,400 FCEVs projected to be on the road in California by the end of 2020.

The most recent completed funding solicitation issued by the ARFVTP for hydrogen refueling stations was GFO-15-605, which made awards for 16 stations in February 2017. Thirteen applicants submitted proposals to install hydrogen refueling stations at 111 locations. The solicitation prioritized hydrogen refueling stations that filled gaps in coverage and capacity throughout California. The Energy Commission provided $33.4 million in grants for this solicitation with funds from multiple fiscal years.

As 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 37 percent renewable hydrogen content. The renewable hydrogen from these agreements is typically derived from either renewable electricity via electrolysis or biomethane via steam methane reformation at central production facilities. Of the 60 stations that have received ARFVTP funding, 6 are planned to use on-site electrolysis to generate hydrogen. Renewable hydrogen production is further discussed in the Low-Carbon Fuel Production and Supply section in Chapter 3 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. The Energy Commission, through the ARFVTP, has funded the development of hydrogen refueling regulations and test procedures, hydrogen refueling infrastructure test equipment, and regional readiness plans for FCEV and refueling station deployment. Other organizations have also supported the growth of hydrogen transportation fuel, including the Governor's Office of Business and Economic Development, which hosted workshops in 2014 and 2015 that brought 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. Caltrans is also identifying strategic locations in the state to develop at least three retail hydrogen stations and will consider the placement of hydrogen fueling stations at rest stops, as prompted by the *2016 ZEV Action Plan*.

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.[71] This application provides status information for hydrogen refueling stations to consumers, allowing them to avoid stations with insufficient fuel or offline equipment.

Assembly Bill 8 requires 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. CARB determines station and fuel cell vehicle projections for six years ahead, which are based on voluntary information provided by vehicle manufacturers.

CARB released the *2017 Annual Evaluation of Fuel Cell Electric Vehicle Deployment and Hydrogen Fuel Station Network Development* report in August 2017.[72] 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 annual evaluation report 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.*[73] The

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

72 California Air Resources Board. *2017 Annual Evaluation of Fuel Cell Electric Vehicle Deployment and Hydrogen Fuel Station Network Development.* August 2017. Available at http://www.arb.ca.gov/msprog/zevprog/ab8/ab8_report_2017.pdf.

73 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*

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 37,400 FCEVs projected by the end of 2023.

The joint report found that overall hydrogen refueling station development time has decreased from an average of more than four years for stations funded in 2009, to less than two years for the stations funded in 2013. 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.[74] To identify areas of the state with the greatest need for hydrogen refueling infrastructure, CARB developed the California Hydrogen Infrastructure Tool (CHIT). CHIT is a geospatial analysis tool used to analyze locations where potential refueling demand is not met with sufficient hydrogen refueling coverage or capacity. The most recent 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 operations and maintenance (O&M) funding for the initial network of hydrogen refueling stations. This funding provides ongoing support to station developers who build and operate stations 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 as much as $100,000 per year for up to five years' worth of O&M funding for each existing or planned station, once operational. As of September 2017, 31 stations have been eligible for this funding.

O&M reimbursements totaled $2.2 million in 2016 and are expected to increase in 2017 as additional stations begin operating. The Energy Commission is continuing to provide

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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.

74 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.

O&M funding in FY 2018-2019; however, this support will reduce the amount of funding that the Energy Commission has been authorized to use for new hydrogen station development.[75] 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.

As the market for hydrogen fuel matures and station developers become more experienced, the percentage of the total cost of hydrogen station capital expenses needed to be paid for by the ARFVTP may decrease. Given this, and factoring in other station development costs and projected O&M expenditures, Energy Commission staff estimates a $20 million allocation will be able to fund up to 10 new stations. Despite the projected reduced station costs and increased speed of construction, and assuming no investments are made from funding sources other than the ARFVTP, the state may experience capacity shortfalls as early as 2020 and the initial network of 100 stations is anticipated to be completed by 2023. To maximize the effectiveness of ARFVTP funding, the Energy Commission may alter the requirements and funding structure of future solicitations, such as offering incentives for higher capacity and more cost-effective stations. The Energy Commission may also consider alternative financing mechanisms and options to encourage private investment as the market for hydrogen fuel matures. Legacy stations with outdated or inoperable equipment may also be eligible for upgrade funding to return the stations to full usability.

For FY 2018-2019, Energy Commission staff proposes a $20 million allocation for hydrogen refueling infrastructure, which is consistent with the funding requirements for hydrogen refueling stations specified in AB 8. 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 nation in the number of CNG and LNG fueling stations, with 325 public or private CNG stations and 45 public or private LNG stations.[76] The technology necessary for natural gas fueling infrastructure is commercially mature, and fuel can be

75 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 expected, 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, $6.9 million of these grants were not eligible based on the incentive schedule set forth in the solicitation. These funds, however, may be able to fund O&M costs for other hydrogen stations.

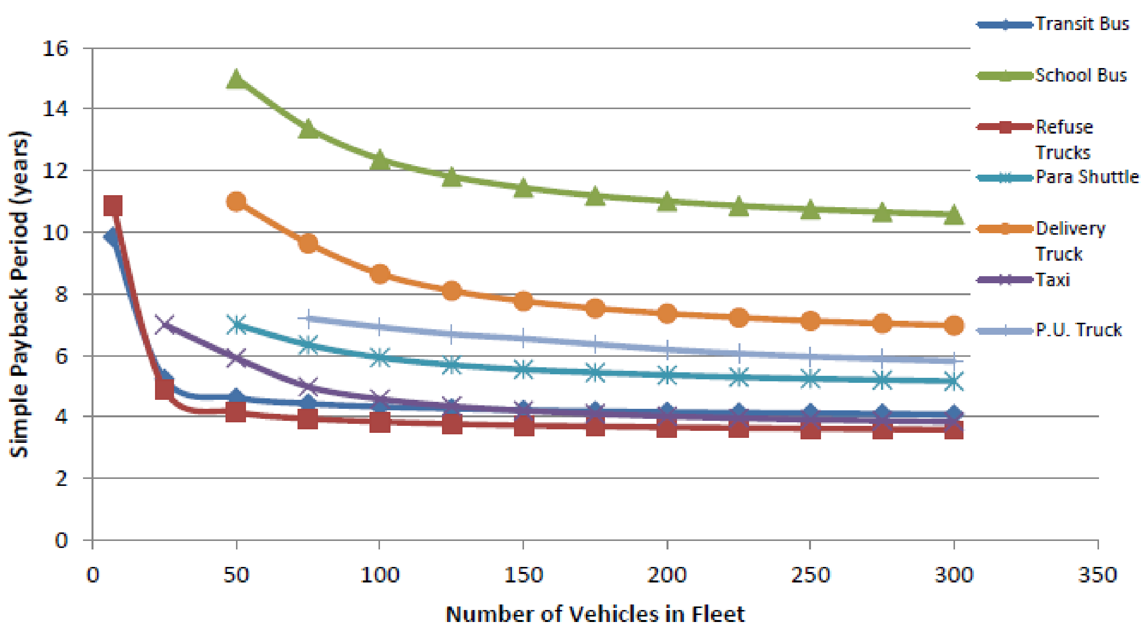
76 U.S. Department of Energy Alternative Fuels Data Center. "Alternative Fuel Station Locator". Accessed August 14, 2017. Available at http://energy.gov/maps/alternative-fueling-station-locator.

sourced through the existing natural gas pipeline infrastructure throughout the state or directly from biomethane production facilities.

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 as little as $500,000 for smaller CNG-only stations to several million dollars for larger fueling stations or combined LNG-CNG stations. Based on this range of costs and the needs of funding recipients, the Energy Commission has historically 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 the simple payback period for CNG fleets based on different vehicle types and fleet sizes, which can be seen in Figure 6.[77] School buses, which typically travel fewer miles annually than other vehicle types, have the longest payback period under this analysis.

Figure 6: 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

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

or diesel fuel. Other financing methods, such as the Compression Services Tariff offered by the Southern California Gas Company (SoCalGas), are also available. This tariff allows SoCalGas to plan, design, procure, construct, own, operate, and maintain compression equipment on customer premises in exchange for a fee on natural gas dispensed. 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.

Conventional natural gas offers modest GHG reductions of about 14 percent compared to gasoline and diesel and has been an early source of GHG reductions for ARFVTP investments.[78] 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. The risk of methane leakage can be significantly reduced with the use of biomethane, since biomethane is most frequently used at the point of production, whereas natural gas is transported through a pipeline. In addition, unlike conventional natural gas, biomethane can have one of the lowest carbon intensities of any alternative fuel.

The most recent solicitation for natural gas fueling infrastructure projects, GFO-16-602, made $3.5 million available to public K-12 school districts in California. This solicitation was undersubscribed, as the Energy Commission received four applications, and only three were eligible and awarded a total of $1.5 million in funding. Currently, $4.4 million of Natural Gas Fueling Infrastructure funding from FY 2016-2017 and 2017-2018 is available for new projects. Given the low demand for funding in the prior natural gas infrastructure solicitation and the high level of unencumbered funds, Energy Commission staff is not proposing additional funding for natural gas fueling infrastructure for FY 2018-2019. Future projects pairing renewable natural gas infrastructure with natural gas vehicles using low-NO_x engines may be funded from the Advanced Freight and Fleet Vehicles category.

78 CA-GREET 2.0 lists EER-Adjusted (0.9 EER for spark ignition natural gas) carbon intensity values of 102.01 gCO_2e/MJ for ultra-low-sulfur diesel, 99.78 gCO_2e/MJ for CARBOB, and 87.08 gCO_2e/MJ for North American CNG. Data obtained from the "Low Carbon Fuel Standard Final Regulation Order," available at https://www.arb.ca.gov/regact/2015/lcfs2015/finalregorderlcfs.pdf.

Summary of Alternative Fuel Infrastructure Allocations

Table 15: Proposed FY 2018-2019 Funding for Alternative Fuel Infrastructure

Electric Charging Infrastructure Relevant Policy Goals: – GHG Reduction – Petroleum Reduction – Low-Carbon Fuel Standard – Air Quality – ZEV Regulations	$20 Million	$3.4 million increase relative to FY 2017-2018
Hydrogen Refueling Infrastructure Relevant Policy Goals: – GHG Reduction – Petroleum Reduction – Low-Carbon Fuel Standard – Air Quality – ZEV Regulations	$20 Million	$0.6 million increase relative to FY 2017-2018
Natural Gas Fueling Infrastructure Relevant Policy Goals: – Petroleum Reduction – Air Quality (with use of low-NO_X engines) – Low-Carbon Fuel Standard – GHG Reduction (with incorporation of biomethane)	-	$2.4 million decrease relative to FY 2017-2018
Total	**$40 Million**	

Source: California Energy Commission.

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.[79] In addition, there are more than 16,000 light-duty natural gas cars, trucks, and vans within the state.[80] Low-carbon biomethane and the latest natural gas vehicle emission control technologies can also 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 April 2017, the average price of CNG per diesel-gallon equivalent (DGE) in West Coast states ranged from $2.55 to $2.78, with a price of $2.78 in April 2017. The average price per gallon of diesel fuel during this same period decreased from $3.97 in April 2014 to $2.89 in April 2017.[81] 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. As a result, vehicle owners may be less likely to shift to CNG, while the price of petroleum fuels remains low. Fleets, however, may be able to obtain significantly lower CNG prices than those offered at retail stations by contracting directly with local natural gas providers.[82]

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

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

80 Ibid.

81 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.

82 Ibid.

biomethane…, as an energy source, helping the state realize the environmental costs and benefits afforded by natural gas."[83] 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.[84] The first of these reports was completed November 2015, and the report will be updated every four years thereafter.

In September 2015, CARB readopted the LCFS, which included a switch from the California Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation Model (CA-GREET) 1.8b to CA-GREET 2.0. As part of the revised calculations in CA-GREET 2.0, the carbon intensity values for conventional natural gas increased because of higher pipeline energy intensity, higher methane leakage estimates, and higher tailpipe emissions.[85] 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 use of biomethane, which has some of the lowest carbon intensity values established by the LCFS. Biomethane from wastewater biogas offers life-cycle GHG emission reductions of as much as 92 percent compared to diesel, while biomethane derived from high solids anaerobic digestion can reduce life-cycle GHG emissions by upward of 125 percent.[86] Use of biomethane as a transportation fuel has steadily increased, averaging 62 percent of the total reported natural gas volume under the LCFS for 2016.[87] The potential for in-state renewable natural gas production is high, and companies offer this fuel commercially.

Ongoing research into methane leakage from production and transmission infrastructure will provide opportunities to refine the GHG emission reduction potential

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83 California Public Resources Code Section 25303.5(b).

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

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

86 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.

87 California Air Resources Board. "LCFS Quarterly Data August 2, 2017." Accessed August 21, 2017. Available at https://www.arb.ca.gov/fuels/lcfs/dashboard/figure2_080217.xlsx.

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.[88]

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, 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.[89]

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.[90] These engines, referred to as low-NO_x engines, are now available for purchase. Technologies such as these have the potential to 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.

The ARFVTP has provided significant support for the deployment of natural gas vehicles, as summarized in Table 16. Two large awards for natural gas vehicle deployment came from the ARFVTP cost-sharing of successful projects under the American Recovery and Reinvestment Act of 2009. Subsequently, the Energy Commission released 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

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

89 California 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.

90 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.

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 16: 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, PON-11-603, and PON-13-610)	Up to 8,500 GVW	362	$0.9
	8,501-16,000 GVW	437	$4.9
	16,001-26,000 GVW	136	$2.1
	26,001-33,000 GVW	53	$1.5
	33,001 GVW and up	746	$20.2
Natural Gas Vehicle Incentive Project	Up to 8,500 GVW	0	$0.0
	8,501-16,000 GVW	55	$0.3
	16,001-26,000 GVW	16	$0.2
	26,001-33,000 GVW	5	$0.1
	33,001 GVW and up	371	$9.3
	TBD*	537*	$11.9
Total		**3,052**	**$65.8**

Source: California Energy Commission. *Estimated number of incentives that can be provided under the Natural Gas Vehicle Incentive Project with encumbered, unspent funding.

Beginning in 2015, the Energy Commission has provided ARFVTP incentives for the purchase of natural gas vehicles through the Natural Gas Vehicle Incentive Project (NGVIP), which is administered by the Institute of Transportation Studies at the University of California, Irvine. Similar to prior solicitations, the NGVIP provides incentives on a first-come, first-served basis at varying levels, depending on the gross vehicle weight. Unlike previous incentive programs, however, the NGVIP provides the incentives directly to vehicle purchasers. The NGVIP allows potential purchasers 210 days to use a reservation, and if no vehicle is purchased, the reservation is cancelled, and the funding is made available to those on a waitlist.

Although consumers initially showed strong demand for these incentives by placing reservations in excess of available funding, use of the reservations has been slower than expected, and only $9.9 million has been provided by the NGVIP through July 2017, or nearly $5.0 million per year. Energy Commission staff believes that the minimal price difference between CNG and diesel fuel has reduced demand for natural gas vehicles and these incentives, and staff is investigating ways of modifying the NGVIP to increase the effectiveness of the incentives and better encourage the use of natural gas as a transportation fuel. 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, CARB's draft FY 2017-2018 funding plan for Clean Transportation Incentives includes low-NO_x natural gas vehicles as an eligible powertrain under the $188 million Clean Truck and Bus Voucher project. Incentives for natural gas vehicles are also provided by the Carl Moyer Memorial Air Quality Standards Attainment program, which is administered by local California air districts. Funding priorities for the Carl Moyer program are determined by each air district, and the amount spent on natural gas vehicle projects varies by year. In the four-year period covering FY 2010-2011 through FY 2013-2014, California air districts provided an average of $1.2 million annually for natural gas vehicles through the Carl Moyer program.[91]

The differential upfront costs for natural gas engines vary significantly by engine size and supplier and can be up to tens of thousands of dollars. As a result, natural gas engines are most economical in vehicle applications where fuel costs constitute a higher share of overall vehicle costs, such as heavy-duty trucks that travel tens of thousands of miles per year. To offset the additional upfront costs, natural gas must be obtained at a lower price than gasoline or diesel fuel. When natural gas is significantly cheaper than diesel fuel, as was the case in 2014, the payback period for investing in a natural gas engine can be two years or less. Lower relative petroleum fuel prices, however, can extend the payback period or make natural gas a more expensive option.

The long-term goal for ARFVTP vehicle incentives has been 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 of September 1, 2017, the NGVIP has $11.9 million in unspent funds,

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

including $10.6 million reserved for vehicle incentives and $1.3 million available for new reservations. The natural gas vehicle incentive allocation has an additional $19.7 million in unencumbered funds from FY 2016-2017 and 2017-2018. Because of the lower-than-expected uptake of incentives from the NGVIP and the high level of unallocated funds, Energy Commission staff proposes suspending any additional funding for this category in FY 2018-2019 until the existing funding is used.

Advanced Freight and Fleet Technologies

Freight and fleet vehicles serve as a pillar to the California economy, providing indispensable functions for domestic goods movement, international trade, public transit, and other essential services. ARFVTP funding in this sector has historically focused on medium- and heavy-duty vehicles, defined here as vehicles with a GVWR above 10,000 pounds. These vehicles represent a small share of California registered vehicle stock, accounting for about 981,000 out of 29.8 million vehicles, or 3 percent; however, this small number of vehicles is responsible for about 22 percent of on-road GHG emissions because of comparatively low fuel efficiency and high number of miles traveled per year.[92,93] For this reason, medium- and heavy-duty vehicles represent a significant opportunity to reduce GHG emissions while focusing on a small number of vehicles. Nonroad freight vehicles, such as forklifts and other cargo handlers, have similar or supporting purposes and potential for emission reductions.

Providing zero- and near-zero-emission options for freight and fleet vehicles can be challenging because the fuel and technology must be closely matched to the needs of the particular vehicle duty cycle and vocation. For example, 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, such as a school bus, but may be 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 can nevertheless provide an early market, cost-effective option for emission reductions when other advanced technologies are not practical.

Many alternative-fueled freight and fleet vehicles also 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 can require charging systems that

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

93 California Air Resources Board. *California Greenhouse Gas Inventory for 2000-2015*. June 6, 2017. Available at https://www.arb.ca.gov/cc/inventory/data/tables/ghg_inventory_ipcc_sum_2000-15.pdf.

provide significantly higher voltage and power levels. Medium- and heavy-duty PEV manufacturers have not yet agreed to standardize electric vehicle chargers, and some use specialized charging systems that can be significantly more expensive than light-duty counterparts. In addition, fleets may require dedicated refueling infrastructure in areas that cannot provide public access because of security or safety concerns. This specialized and dedicated electric, hydrogen, or natural gas refueling infrastructure can add significant cost and affect the financial viability of alternatively fueled vehicle projects.

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 six ports throughout California to identify and implement transportation project concepts that will help attain California's climate and clean air goals while meeting the needs of the ports. This category is expected to be the primary source of Energy Commission funding support for *Sustainable Freight Action Plan* strategies and ports collaborative activities.

The Energy Commission has provided more than $130 million in ARFVTP funding for a wide variety of fuel and technology types that can be incorporated into California trucks and buses. Table 17 summarizes the portfolio of advanced vehicle technology demonstration projects that the ARFVTP has supported in the medium- and heavy-duty vehicle sectors.

Table 17: Advanced Freight and Fleet Vehicle 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	$7.7
Off-Road Hybrids	2	$4.5
E85 Hybrids	1	$2.7
Intelligent Transportation Systems	110	$2.0
Total	**462**	**$130.1**

Source: California Energy Commission.

While the projects funded by this category are expected to significantly reduce GHG and criteria pollutant emissions on a per-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.

Other state programs provide funding for the vehicle types discussed in this section, though often at different stages of commercialization and at different scales. The Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP), administered by CARB, provides deployment incentives for hybrid, battery-electric, fuel cell, and low-

NO_x trucks and buses. Since 2010, HVIP has provided more than $101 million in incentives to help California fleets purchase 761 zero-emission trucks and buses, 2,360 hybrid trucks, and 337 vehicles with low-NO_x engines, with each incentive averaging $33,264.[94] The draft FY 2017-2018 funding plan for CARB's Clean Transportation Incentives includes a proposed $188 million allocation for Clean Truck and Bus Vouchers, which combines both HVIP and incentives for low-NO_x engines.

In addition to the HVIP, CARB also funds other demonstration and deployment projects through its Clean Transportation Incentives. These investments include a proposed $190 million in FY 2017-2018 for advanced demonstration and pilot commercial deployment projects for freight equipment. Funding for the Clean Transportation Incentives far exceeds that available to the ARFVTP; however, the Clean Transportation Incentives funding depends largely on revenues from California's cap-and-trade auction proceeds, which have historically fluctuated from year to year. 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 and infrastructure projects in FY 2018-2019, and CARB and the Energy Commission are working closely together to minimize any potential overlap with the activities of the Clean Transportation Incentives. Sustained funding from the ARFVTP will provide a degree of stability in incentive funding to this critically importation component of the transportation sector. Figure 7 illustrates the major sources of funding available for demonstration and deployment of advanced freight and fleet vehicles in California.

Figure 7: Major Funding Sources for Advanced Freight and Fleet Vehicles in California

Source: California Energy Commission. All funding in millions of dollars and for FY 2017-2018. CARB funding is as proposed in the September 26, 2017 draft *Fiscal Year 2017-18 Funding Plan for Clean Transportation Incentives* and may change. Historical ARFVTP funding has targeted demonstration projects whereas CARB funding has targeted vehicle deployment.

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.

94 California Air Resources Board. *Draft Fiscal Year 2017-18 Funding Plan for Clean Transportation Incentives.* September 26, 2017. Available at https://www.arb.ca.gov/msprog/aqip/fundplan/1718_draft_funding_plan_workshop_100417.pdf.

Senate Bill 513 (Beall, Chapter 610, Statutes of 2015) modified state law that regulates the Carl Moyer Memorial Air Quality Standards Attainment Program, allowing the program to fund alternative fuel and electric infrastructure projects. Previously, all projects funded under the Carl Moyer Program were required to meet cost-effectiveness criteria that could not be achieved by infrastructure projects. The 2017 revisions to the Carl Moyer Program guidelines permit air districts to fund commercial battery charging and alternative fueling stations for on- and off-road vehicles and equipment, provided the greatest penetration of commercially available advanced technology vehicles exists.[95]

Senate Bill 110 (Committee on Budget and Fiscal Review, Chapter 55, Statutes of 2017) provides up to $75 million for the retrofit or replacement of school buses. This funding will be administered by the Energy Commission, and priority will be given to school districts operating the oldest school buses, as well as to school buses operating in disadvantaged communities, as directed by legislation. The Energy Commission has developed strong relationships with nearly every local education agency in California through the successful implementation of Proposition 39, and will use these established relationships to expedite the replacement of school buses statewide. Energy Commission staff anticipates that these replacement buses will use alternative fuel powertrains to reduce criteria pollutant emissions by the greatest extent possible and maximize health benefits to school children and the public. These alternative fuel school buses may require new or upgraded fueling infrastructure at additional cost that may be funded through this category.

Senate Bill 350 (De León, Chapter 547, Statutes of 2015) established new goals to reduce greenhouse gas emissions and air pollution for 2030 and beyond. This legislation tasked the CPUC with directing investor-owned utilities to submit applications to support widespread transportation electrification. PG&E, SCE, and SDG&E submitted proposals totaling roughly $1 billion, of which more than $790 million is proposed for a variety of infrastructure for medium- and heavy-duty vehicles and equipment. Though this is a significant investment, the total funding needed in this sector to attain state air quality and climate change goals is far greater. The Ports of Long Beach and Los Angeles estimate that more than $1.5 billion in infrastructure investments will be needed to fully electrify their freight terminals.[96]

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95 California Air Resources Board. *2017 Revisions to the Carl Moyer Memorial Air Quality Standard Attainment Program Guidelines*. March 10, 2017. Available at https://www.arb.ca.gov/msprog/moyer/april2017_boarditem_moyerstaffreport.pdf.

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

Medium- and heavy-duty vehicles account for 22 percent of GHG, 60 percent of NO_x, and 52 percent of $PM_{2.5}$ emissions from on-road transportation in California.[97,98] To meet state GHG and air quality goals, this sector will need to transition to zero- and near-zero-emission technologies, and the resources required for this transition far exceed available funding. Energy Commission staff expects an increasing demand for dedicated charging and refueling infrastructure for alternative fuel and advanced technology freight and fleet vehicles funded both through this category and by other state incentives programs. As the state's lead agency for fueling infrastructure deployment, the Energy Commission will take into account the need to develop this infrastructure alongside the vehicles.

For FY 2018-2019, Energy Commission staff proposes a $17.5 million allocation for this category. Energy Commission staff expects this allocation will continue to support the demonstration of advanced technology freight and fleet vehicles; however, staff intends to balance the need to continue vehicle demonstration and deployment projects while taking into account similar funding available from other sources and an increasing need for charging and refueling infrastructure. Staff expects that funding from this category will also be necessary to address Energy Commission-specific actions outlined in the *California Sustainable Freight Action Plan* and to help achieve GHG and air pollution reduction goals.

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97 California Air Resources Board. *California Greenhouse Gas Inventory for 2000-2015*. June 6, 2017. Available at https://www.arb.ca.gov/cc/inventory/data/tables/ghg_inventory_ipcc_sum_2000-15.pdf.

98 California Air Resources Board. "Almanac Emission Projection Data." Accessed 26 October 2017. https://www.arb.ca.gov/app/emsinv/2017/emssumcat_query.php?F_YR=2012&F_DIV=-4&F_SEASON=A&SP=SIP105ADJ&F_AREA=CA#7.

Summary of Alternative Fuel and Advanced Technology Vehicles Allocations

Table 18: Proposed FY 2018-2019 Funding for Alternative Fuel and Advanced Technology Vehicles

Natural Gas Vehicle Deployment Relevant Policy Goals: – Petroleum Reduction – Air Quality (with use of low-NO_X engines) – Low-Carbon Fuel Standard – GHG Reduction (with incorporation of biomethane)	-	$9.7 million decrease relative to FY 2017-2018
Advanced Freight and Fleet Technologies Relevant Policy Goals: – GHG Reduction – Air Quality – Petroleum Reduction – Low-Carbon Fuel Standard – Sustainable Freight Action Plan	$17.5 Million	No change relative to FY 2017-2018
Total	**$17.5 Million**	

Source: California Energy Commission.

CHAPTER 6:
Related Needs and Opportunities

Manufacturing

Emerging technologies face a long path to commercialization, beginning with research and development, progressing to prototyping, advancing to demonstrations, and finally achieving commercialization and technological maturity. In later stages, product commercialization requires substantial capital to sustain low-volume production. During this time, the technology must gain market acceptance, and the production process must attain financial margins capable of sustaining business operations. Moreover, companies must also address their workforce needs and scale growth to bring products forward.

Funding support is critical at all stages of product and business development to successfully bring emerging technologies to market. The state and federal governments continue to fund research and development 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 87 percent of these investments nationwide being made in California in 2016.[99] Grant funding from the ARFVTP and the CARB Low Carbon Transportation Investments continues to support demonstration and deployment of alternative fuel vehicles, technologies, and infrastructure.

Despite the financial and technical support available to 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."[100] 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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99 Thornberg, Christopher, Hoyu Chong, Adam Fowler (Beacon Economics). 2017. *California Green Innovation Index 9th Edition*. NEXT 10.

100 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 19.

Table 19: 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, which also reduces the cost of charging by charging at the most economical time. ChargePoint placed the communications processor in commercial production after completing the ARFVTP project.
- Proterra, Inc., which received a $3 million grant to design and build a new manufacturing line for battery-electric transit buses. Proterra produces the Catalyst battery-electric bus, which is available in both 35- and 40-foot variants and has a nominal range of up to 350 miles. The manufacturing line is located at Proterra's production facility in the City of Industry (Los Angeles County).

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 development of the *2016-2017 Investment Plan Update*, stakeholders provided comments requesting dedicated funding for manufacturing projects, and the Energy Commission subsequently reintroduced the Manufacturing category into the *2017-2018 Investment Plan Update*.

For FY 2018-2019, Energy Commission staff proposes a $5 million allocation for this category. This category is expected to provide support for projects to expand in-state manufacturing capabilities for light-, medium-, and heavy-duty advanced technology vehicles; vehicle components; and refueling infrastructure. This funding can also provide incentives for companies to locate manufacturing projects in California, which otherwise may have been undertaken elsewhere, and is expected to help cultivate a California-based supply chain for advanced technology and alternative fuel products. 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 advanced technology 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 fund 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 provided 11 grants and contracts totaling $19.5 million through this funding category. These agreements include a variety of projects, such as the research and development of innovative renewable fuel production methods and the development and demonstration of unique zero-emission vehicle types. In addition, funding from this allocation has been used to augment solicitations, such as the intelligent transportation systems activities funded under solicitation GFO-15-604 for freight transportation projects at California seaports.

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.[101] Energy Commission staff expects some federal FAST Act funding opportunities to complement ARFVTP activities, and Emerging Opportunities funding 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.

Similarly, California air districts frequently release solicitations and fund projects that complement the goals of the ARFVTP. These projects commonly include incentives for zero-emission freight vehicles or grants for alternative fuel infrastructure, but can involve almost any aspect of the alternative fuel or vehicle supply chain. These air district funding opportunities, however, may not cover the entire cost of the project. In these situations, the Energy Commission can increase the effectiveness of these air district programs and improve the chances of project success by providing ARFVTP funding in combination with air district funding.

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. For FY 2018-2019, Energy Commission staff proposes a $4.2 million allocation for the Emerging Opportunities category. In proposing this increased allocation, staff assumes historical demand for funding will continue for unanticipated project types and federal cost sharing, and additional demand for funding will result from the expanded scope of this category.

Workforce Training and Development

The Energy Commission, through the ARFVTP, continues its support of alternative transportation workforce training and development throughout California. Workforce efforts funded by the ARFVTP are growing in size and scope with expanded programs from longstanding partner agencies as well as efforts from new partner agencies. Demand for workforce training and development in alternative transportation remains robust across many vehicle and technology types, particularly with plug-in electric and hydrogen fuel cell vehicles. The Energy Commission continues to engage organizations and industry partners through the ARFVTP to train, develop, and support a qualified alternative transportation workforce.

Beginning in 2009, the Energy Commission partnered with the Employment Development Department (EDD), Employment Training Panel (ETP), and the California Community Colleges Chancellor's Office (CCCCO) with the intent of providing for and better understanding the state's alternative transportation workforce needs. In addition to growing work within those agencies, the Energy Commission contracted with the Advanced Transportation and Technology Energy (ATTE) Centers, an initiative of

101 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.

CCCCO. The ATTE Centers are hosted by two California community college districts that serve the alternative transportation needs for community colleges across the state. The first ATTE agreement, hosted by San Diego Community College District, awarded multiple California community colleges with funds to purchase specialty equipment required for essential hands-on training and advanced technical training for instructors and trainers to stay at the forefront of ever-evolving technologies. The second ATTE agreement, with Cerritos Community College District, focuses on developing a high school clean transportation career pilot program for underserved communities and is expected to complete by spring 2018.

The College of San Mateo is working on internships, preapprenticeships, and apprenticeships for transit agency programs using ARFVTP funding. This new transit training apprenticeship model is designed to meet the growing demand for transit workers with alternative fuel and vehicle expertise. The California Workforce Development Board (CWDB) is proposing the development of a transferable model that will be available across California's multiple Workforce Investment Opportunity Agencies (formerly known as Workforce Investment Boards). These efforts benefit greatly from leveraged funding through the Governor's Office to the colleges for a strong workforce.

A summary of ARFVTP workforce training and development efforts can be found in Table 20.

Table 20: Workforce Training and Development Funding From FY 2008-2009 Through FY 2016-2017

Partner Agency	Funding (in Millions)	Match Contributions (in Millions)	Trainees	Businesses Assisted	Municipalities Assisted
ETP*	$13.5	$11.3	16,441	173+	18+
EDD	$8.2	$7.5	999	36+	-
CCCCO	$5.75	$0.5	N/A	68+	-
CWDB	$0.25	$0.5	N/A**	N/A**	-
ATTE	$4.0	-	N/A**	N/A**	-
Total	**$31.7**	**$19.8**	**17,440**	**277+**	**18+**

Source: California Energy Commission. The number of trainees includes completed, partially completed, and anticipated participants from approved contracts. *ETP funding from two contracts. **Participant data are not yet available because these are new agreements.

Examples of current workforce training funding recipients include the following:

- **ATTE/San Diego Community College District**, provided 15 community colleges across seven regions of California with $2.8 million to enhance their clean transportation training efforts. The colleges include: Cerritos College, Rio Hondo College, Cypress College, Los Angeles Trade-Tech College, Saddleback College, American River College, Bakersfield College, San Diego Miramar College, College of the Desert, Victor Valley College, Copper Mountain College, City College of San Francisco, Chabot College, Foothill De-Anza Community College District, and Hartnell College.

- **ETP/Buster Biofuels, LLC** was approved for a $58,500 grant 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.

Workshops are planned for late fall 2017 that will seek input from stakeholders and interested parties on developing future workforce plans. The workshops will focus on moving forward with existing clean transportation training and development, seek to address increasing benefits in disadvantaged communities from clean transportation, and seek new opportunities for advancing clean transportation workforce. Workshop participation will help guide and directly affect ARFVTP workforce efforts.

Based on expectations of needed funds from partner agencies in FY 2018-2019, Energy Commission staff proposes a $3.5 million allocation 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

The Energy Commission has provided funding to regions to prepare for and expedite the deployment of alternative fuel infrastructure and vehicles. 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 advance these goals, the Energy Commission conducted five 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 most recent solicitation for regional readiness plans, GFO-16-601, was released by the Energy Commission in October 2016. Proposals were approved on a first-come, first-served basis, and the Energy Commission funded nine regional readiness plans with $2.1 million in grants. Counties, air districts, energy authorities, and other regional governmental agencies throughout the state received grants to develop and implement regional readiness plans for zero-emission vehicles.

The results of the regional readiness solicitations are summarized in Table 21.

Table 21: Regional Alternative Fuel Readiness and Planning Awards

Readiness Plan Fuel Type	Agreements in Progress	Agreements Completed	ARFVTP Funding (in Millions)
Electricity	20	11	$5.6
Hydrogen	3	1	$0.8
Electricity & Hydrogen	2	-	$1.4
Multiple Fuels/Other	-	6	$1.8
Total	**25**	**18**	**$9.6**

Source: California Energy Commission.

The Energy Commission has allocated $11.6 million from the ARFVTP for regional alternative fuel readiness plans since FY 2011-2012. In this time, the alternative fuel and zero-emission vehicle sectors have matured significantly. Most regions in California have developed regional readiness plans because of this funding, and this has aided the deployment of the first generation of zero-emission vehicles. The need for these planning grants, however, has diminished because of the statewide success of ZEV deployment efforts. For this reason, Energy Commission staff does not propose providing additional funding for this category in the investment plan.

Energy Commission staff expect to allot the remaining funding in this category to a competitive solicitation that will challenge California communities to become EV-ready. The challenge activities may focus on defining specific milestones and developing a comprehensive approach required to electrify the transportation sector. Subsequent solicitations may also provide funding to implement the strategies developed in these plans.

Summary of Related Needs and Opportunities Allocations

Table 22: Proposed FY 2018-2019 Funding for Related Needs and Opportunities

Manufacturing Relevant Policy Goals: – GHG Reduction – Petroleum Reduction – Air Quality	$5 Million	$0.1 million increase relative to FY 2017-2018
Emerging Opportunities Relevant Policy Goals: – GHG Reduction – Petroleum Reduction – Air Quality	$4.2 Million	$0.3 million increase relative to FY 2017-2018
Workforce Training and Development Relevant Policy Goals: – GHG Reduction – Petroleum Reduction – Air Quality – Equitable Economic Development	$3.5 Million	$0.1 million increase relative to FY 2017-2018
Regional Alternative Fuel Readiness and Planning Relevant Policy Goals: – GHG Reduction – Petroleum Reduction – Air Quality	-	No change relative to FY 2017-2018
Total	**$12.7 Million**	

Source: California Energy Commission.

CHAPTER 7: Summary of Funding Allocations

Beginning with FY 2017-2018, the ARFVTP is now required to fund program support costs from the motor vehicles registration fees that provide funding for the program. Historically, these program support costs were paid from a different funding source that was supported by commercial and residential utility surcharges. Because of these additional expenses that are now borne by the ARFVTP appropriation, Energy Commission staff expects that $95.2 million will be available for ARFVTP projects for FY 2018-2019. This draft staff report of the *2018-2019 Investment Plan Update* reflects $95.2 million for program funding. In the event that a different amount of funding is available, the allocations in this document may be revised in subsequent versions or amended after final adoption.

Funding allocations for FY 2018-2019 are summarized in Table 23. For details on each allocation, please see the relevant section of the preceding chapters.

Table 23: Summary of Funding Allocations for FY 2018-2019

Category	Funded Activity	Funding Allocation
Alternative Fuel Production	Low-Carbon Fuel Production and Supply	$25 million
Alternative Fuel Infrastructure	Electric Charging Infrastructure	$20 million
	Hydrogen Refueling Infrastructure	$20 million
Alternative Fuel and Advanced Technology Vehicles	Advanced Freight and Fleet Technologies	$17.5 million
Related Needs and Opportunities	Manufacturing	$5 million
	Emerging Opportunities	$4.2 million
	Workforce Training and Development	$3.5 million
	Total	**$95.2 million**

Source: California Energy Commission.

GLOSSARY

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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
CDFA	California Department of Food and Agriculture
CHIT	California Hydrogen Infrastructure Tool
CNG	compressed natural gas
CO_2e	carbon dioxide-equivalent greenhouse gases
CPUC	California Public Utilities Commission
CVRP	Clean Vehicle Rebate Project
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
EVI-Pro	Electric Vehicle Infrastructure Projections
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 greenhouse gases 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
IEPR	Integrated Energy Policy Report
LCFS	Low Carbon Fuel Standard
LCTI	Low Carbon Transportation Investments
LNG	liquefied natural gas
MJ	megajoule
$MMTCO_2e$	million metric tons of carbon dioxide-equivalent greenhouse gases
NAAQS	National Ambient Air Quality Standards
NGVIP	Natural Gas Vehicle Incentive Project
NO_x	oxides of nitrogen
NOPA	notice of proposed award
NREL	National Renewable Energy Laboratory
O&M	operations and maintenance
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