CALIFORNIA ENERGY COMMISSION

California Energy Commission

COMMISSION REPORT

2019-2020 Investment Plan Update for the Clean Transportation Program

Gavin Newsom, Governor

December 2019 | CEC-600-2018-005-CMF

California Energy Commission

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Vice Chair

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Karen Douglas, J.D.
J. Andrew McAllister, Ph.D.
Patty Monahan

Patrick Brecht
Primary Author

Patrick Brecht
Project Manager

Charles Smith
Office Manager
TRANSPORTATION POLICY AND ANALYSIS OFFICE

Kevin Barker
Deputy Director
FUELS AND TRANSPORTATION DIVISION

Drew Bohan
Executive Director

ACKNOWLEDGEMENTS

The following California Energy Commission staff members contributed to the development of this Investment Plan Update:

Jennifer Allen

Jane Berner

Jean Baronas

Jonathan Bobadilla

Joji Castillo

Phil Cazel

Miki Crowell

Susan Ejlalmaneshan

Brian Fauble

Jesse Gage

Tami Haas

Thanh Lopez

Hieu Nguyen

Tim Olson

Larry Rillera

Gordon Schremp

Charles Smith

Sarah Williams

Alexander Wong

Taiying Zhang, Ph.D.

ADVISORY COMMITTEE MEMBERS

The California Energy Commission thanks the Clean Transportation Program (also known as the Alternative and Renewable Fuel and Vehicle Technology Program) Advisory Committee members for their guidance in helping identify opportunities and priorities for consideration in the investment plan:

Joy Alafia—Western Propane Gas Association

Shannon Baker-Branstetter—Consumers Union

William Barrett—American Lung Association

Matthew Barth—University of California, Riverside

Steve Cliff—California Air Resources Board

Will Coleman—OnRamp Capital

Peter Cooper—California Employment Training Panel

Tyson Eckerle—California Governor's Office of Business and Economic Development

Vacant—The Greenlining Institute

Casey Gallagher—California Labor Federation

Joe Gershen—California Advanced Biofuel Alliance

Brian Goldstein—Energy Independence Now

Ellen Greenberg—California Department of Transportation

Irene Gutierrez—Natural Resources Defense Council

Vacant – California Natural Resources Agency

Steve Kaffka—California Biomass Collaborative, University of California, Davis

Ralph Knight—Consultant for Alternative-Fueled School Buses

Thomas Lawson—California Natural Gas Vehicle Coalition

Vacant – California Department of Resources Recycling and Recovery

Jack Michael—Recreational Boaters of California

Jananne Sharpless—member at large

John Shears—Center for Energy Efficiency and Renewable Technologies

Chris Shimoda—California Trucking Association

Eileen Tutt, Hannah Goldsmith—California Electric Transportation Coalition

Justin Ward—California Fuel Cell Partnership, Toyota Motor Corporation

DISADVANTAGED COMMUNITIES ADVISORY GROUP MEMBERS

The California Energy Commission thanks the Disadvantaged Communities Advisory Group members for providing feedback on how this investment plan update, and the Clean Transportation Program in general, can further promote equity and access for all Californians.

Stan Greschner (Chair)—GRID Alternatives

Angela Islas (Vice Chair)—Self-Help Enterprises

Phoebe Seaton (Secretary)—Leadership Counsel for Justice and Accountability

Stephanie Chen—Greenlining Institute

Jana Ganion—Blue Lake Rancheria

Roger Lin—Environmental Law Clinic, UC Berkeley School of Law

Adriano Martinez—Earthjustice

Jodi Pincus—Rising Sun Center for Opportunity

Andres Ramirez—Pacoima Beautiful

Tyrone Roderick Williams—Sacramento Promise Zone

ABSTRACT

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

This *2019-2020 Investment Plan Update* establishes funding allocations based on identified needs and opportunities, including a near-term focus on zero-emission vehicles and infrastructure.

This Energy Commission report represents the final step in developing the *2019-2020 Investment Plan Update*, following the draft staff report, revised staff report, lead commissioner report, revised lead commissioner report, and second revised lead commissioner report that were published in November 2018, January 2019, March 2019, July 2019, and August 2019, respectively. This report was adopted at the September 11, 2019, Energy Commission business meeting.

Keywords: California Energy Commission, Clean Transportation Program, 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

Please use the following citation for this report:

Brecht, Patrick. 2019. *2019-2020 Investment Plan Update for the Clean Transportation Program*. California Energy Commission. Publication Number: CEC-600-2018-005-CMF.

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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 Clean Transportation Program (also known as the Alternative and Renewable Fuel and Vehicle Technology Program) was one of the first transportation-focused 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 the eleventh year, the Clean Transportation Program has provided nearly $830 million to more than 600 agreements covering a broad spectrum of alternative fuels and technologies. In this time, California has experienced rapid growth in the sales of plug-in electric vehicles, the introduction of hydrogen fuel cell electric vehicles, and a notable increase in the in-state production and use of low-carbon alternative fuels. The Clean Transportation Program has supported this emerging revolution in the transportation sector with significant investments in alternative fuel vehicles and supporting infrastructure and will continue to do so with this *2019-2020 Investment Plan Update*.

Purpose of the Clean Transportation Program

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

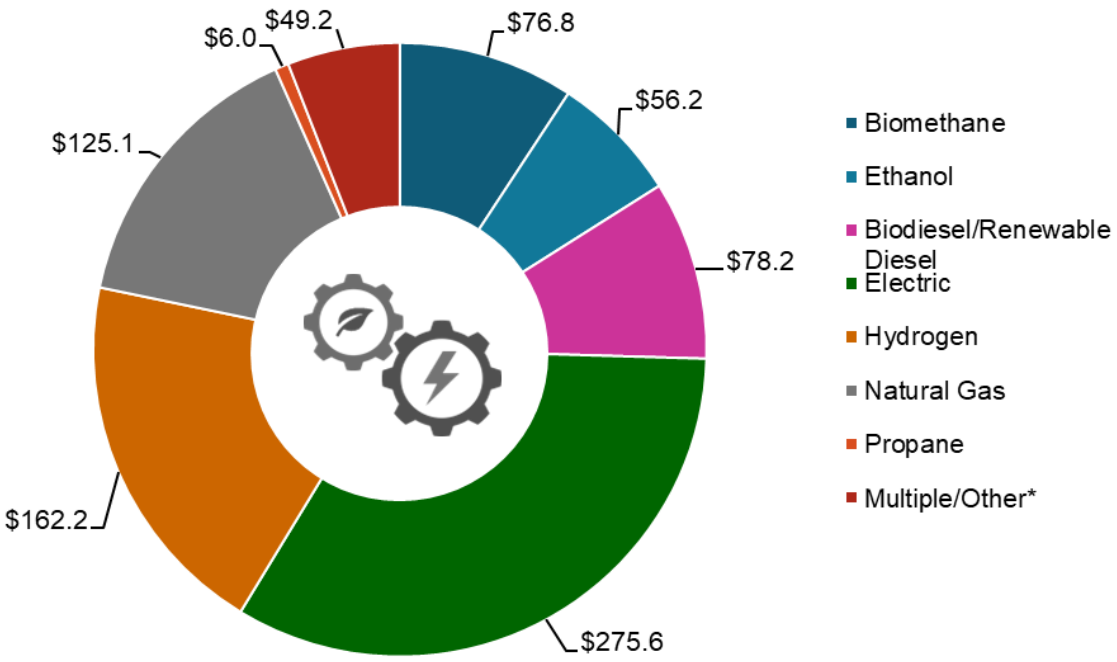
- Reducing GHG emissions to 1990 levels by 2020.
- Reducing GHG emissions to 40 percent below 1990 levels by 2030.
- Reducing short-lived climate pollutant emissions, such as methane, to 40 to 50 percent below 2013 levels by 2030.
- Achieving a carbon-neutral economy by 2045.
- Setting specific goals to boost the supply of zero-emission vehicles and charging and refueling stations, including:
- Putting at least 1.5 million zero-emission vehicles on the road by 2025 and 5 million by 2030.
- Installing 200 hydrogen-fueling stations and 250,000 battery electric vehicle chargers, including 10,000 direct current fast chargers, by 2025.

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

In addition to these greenhouse gas emission reduction goals, the state must comply with requirements under the federal Clean Air Act to reduce emissions of criteria air pollutants. Reducing air pollution is of particular importance from an equity context, given that air quality burdens fall disproportionately on vulnerable and disadvantaged communities within the state.

To help address these goals, the California Legislature passed Assembly Bill 118 (Núñez, Chapter 750, Statutes of 2007). This legislation created the Alternative and Renewable Fuels and Vehicle Technology Program (now known as the Clean Transportation Program), which is administered by the Energy Commission. With funds collected from vehicle and vessel registration, vehicle identification plates, and smog-abatement fees, the Clean Transportation Program funds projects that will "transform California's fuel and vehicle types to help attain the state's climate change policies." Assembly Bill 8 (Perea, Chapter 401, Statutes of 2013) subsequently extended the collection of fees that support the Clean Transportation Program through January 1, 2024. Figure ES-1 illustrates the types of projects funded by the Clean Transportation Program, sorted by the fuel or technology type.

Figure ES-1: Clean Transportation Program Funding by Fuel Type as of March 1, 2019 (in Millions)



Source: California Energy Commission. As of March 1, 2019. Totals may not match due to rounding. *Some agreements, such as those focused on multiple fuel types, regional readiness plans, or workforce training, cannot be categorized by fuel type.

Investments to Date

Since the first Clean Transportation Program 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 Clean Transportation Program, has provided funding to cities, counties, school districts, universities, private companies, and other organizations throughout the state to pursue a wide variety of alternative fuel and advanced vehicle technology projects. A detailed summary of all projects funded to date by the Clean Transportation Program can be found in Table ES-1, which is sorted by each specific funding area.

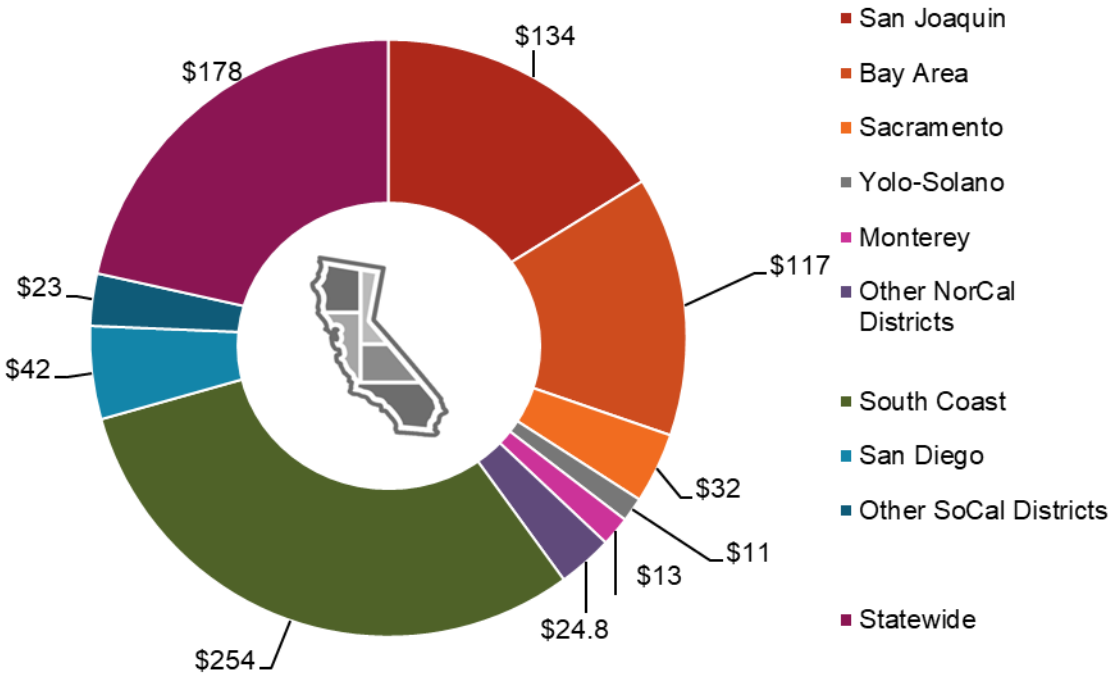
Table ES-1: Clean Transportation Program Awards as of March 1, 2019

Funded Activity	Cumulative Awards to Date (in Millions)*	# of Projects or Units
Alternative Fuel Production		
Biomethane Production	$76.8	27 Projects
Gasoline Substitutes Production	$39.5	16 Projects
Diesel Substitutes Production	$74.2	26 Projects
Renewable Hydrogen Production	$7.9	2 Projects
Alternative Fuel Infrastructure		
Electric Vehicle Charging Infrastructure**	$94.9	9,655 Charging Connectors
Hydrogen Refueling Infrastructure	$140.6	64 Public Fueling Stations, plus Fleets
E85 Fueling Infrastructure	$13.7	59 Fueling Stations
Upstream Biodiesel Infrastructure	$4.0	4 Infrastructure Sites
Natural Gas Fueling Infrastructure	$24.1	70 Fueling Stations
Alternative Fuel and Advanced Technology Vehicles		
Natural Gas Vehicle Deployment***	$86.8	3,152+ Vehicles
Propane Vehicle Deployment	$6.0	514 Trucks
Hybrid and ZEV Deployment (Including CVRP, HVIP, and Low-Income Mobility Incentives)	$32.0	10,700 Cars and 150 Trucks
Advanced Technology Freight and Fleet Vehicles****	$126.3	54 Demonstrations
Related Needs and Opportunities		
Manufacturing	$43.6	21 Manufacturing Projects
Workforce Training and Development	$30.2	17,440 Trainees
Fuel Standards and Equipment Certification	$3.9	1 Project
Sustainability Studies	$2.0	2 Projects
Regional Alternative Fuel Readiness	$11.4	52 Regional Plans
Centers for Alternative Fuels	$5.6	5 Centers
Technical Assistance and Program Evaluation	$5.7	n/a
Total	**$829.4**	

Source: California Energy Commission. Totals may not match due to 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 the Clean Transportation Program, which may be smaller than initial award. Due to rounding, "total" may not match sum of rows. **Includes $38.8 million for the California Electric Vehicle Infrastructure Project to provide EV incentives throughout California, which will fund a yet-to-be-determined number of EV chargers. ***Funding includes both completed and pending vehicle incentives, as well as funds reserved for future incentives. ****Includes projects from the former Medium- and Heavy-Duty Vehicle Technology Demonstration category.

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

Figure ES-2: Clean Transportation Program Funding by Air District (in Millions)



Source: California Energy Commission. As of March 1, 2019. Totals may not match due to rounding.

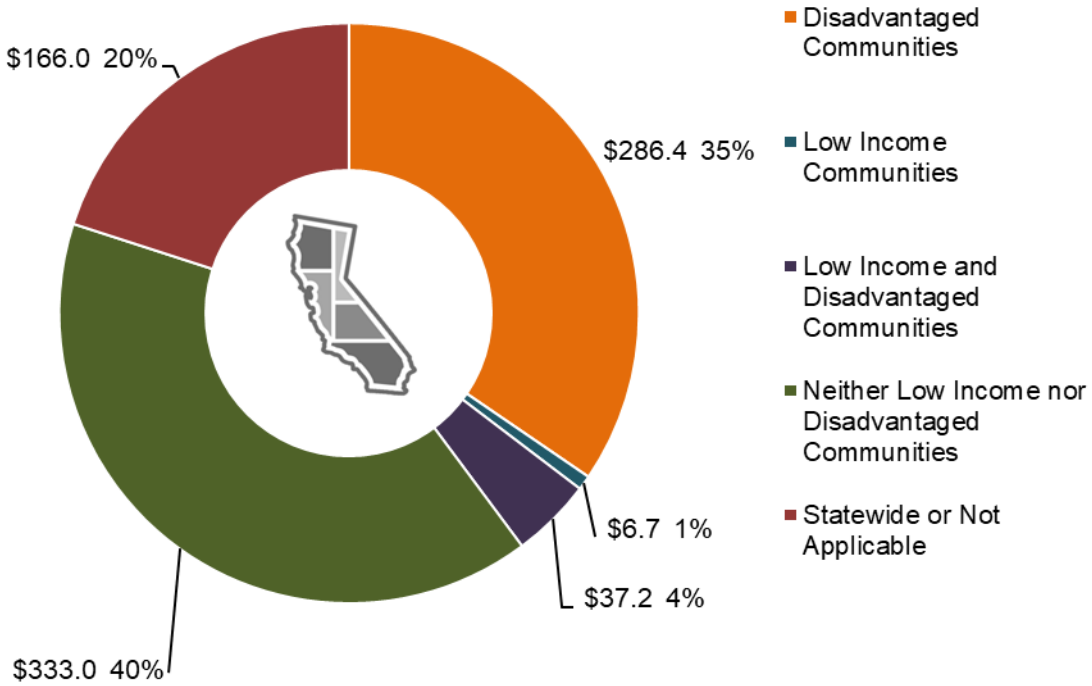
The Energy Commission is committed to ensuring all Californians have an opportunity to participate in and benefit from programs and services. In 2015, the Energy Commission adopted a resolution that committed the agency to optimizing fair and equal opportunities for economically disadvantaged and underserved communities (among others) to participate in and benefit from Commission programs. As depicted in Figure ES-3, roughly 40 percent of Clean Transportation Program project funds have been awarded to projects within disadvantaged or low-income communities or both. When excluding Clean Transportation Program projects that occur statewide or without an applicable site address, this funding share is closer to 50 percent.

The Energy Commission is also committed to ensuring that the Clean Transportation Program provides direct benefits for disadvantaged communities, who are disproportionately burdened by pollution and socioeconomic challenges. On June 21, 2019, Clean Transportation Program staff solicited feedback on the March 27, 2019, draft of this investment plan from the Disadvantaged Communities Advisory Group, which was established under Senate Bill 350 (De León, Chapter 547, Statutes of 2015) to review and advise the Energy Commission and the California Public Utilities Commission to determine whether proposed programs will be effective and useful in disadvantaged communities. The Disadvantaged Communities Advisory Group made a series of recommendations on the investment plan, including moving 100 percent of program funding toward zero-emission fuels; funding projects exclusively in and

benefiting disadvantaged communities; prioritizing and investing in community outreach and engagement; expanding support for workforce development; increasing transparency and metrics of how projects "benefit" disadvantaged communities; and expanding the Clean Transportation Program Advisory Committee to increase representation of program beneficiaries, environmental justice communities, rural communities, tribes, and others.

The Energy Commission will continue coordinating with the Disadvantaged Communities Advisory Group throughout the development of this and future investment plan updates, as well as the Clean Transportation Program in general, to promote equity and access for all Californians.

Figure ES-3: Proportion of Clean Transportation Program Funding Awarded to Projects Located in Disadvantaged or Low-Income Communities (in Millions)



Source: California Energy Commission. As of March 1, 2019. Totals may not match due to rounding. "Disadvantaged communities" are defined as communities within the top 25 percent scoring areas under CalEnviroScreen, as well as areas of high pollution and low population. "Low-income communities" are defined as communities that are at or below 80 percent of the statewide median income.

Context of the Clean Transportation Program Investment Plan Update

As part of the Clean Transportation Program, 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; and the effect of other investments, policies, programs, and statutes.

The funding recommendations in this report are guided by, and complementary to, energy policies and regulations. In particular, Executive Order B-48-18 directs the state government to

work with the private sector and other levels of government to deploy at least 5 million zero-emission vehicles in California by 2030. The executive order also calls for the installation and construction of 250,000 electric vehicle charging ports, including 10,000 direct current fast charging ports, and 200 hydrogen-refueling stations by 2025.

To date, the Clean Transportation Program has funded (or committed to funding) the installation of about 6,750 public charging connectors for California's 600,000 plug-in electric vehicles. The state's electric utilities and Electrify America (a company established in the wake of the Volkswagen emissions scandal) are also investing in public charging station installations. Despite these investments, Clean Transportation Program staff estimates that the sum of existing and expected future charging ports will not be sufficient to meet the state's goal of 250,000 charging connectors and 10,000 fast charging connectors by 2025. As depicted in Table ES-2, the currently identified investments still leave a gap of nearly 80,000 Level 2 charging connectors and 3,600 DC fast charging connectors by 2025. Level 2 chargers are capable of recharging about 5 miles or less of range per hour of charging, while direct current (DC) fast chargers are capable of fully recharging a battery electric vehicle to 80 percent capacity in about 30 minutes (depending on the size of the battery and the power level of the charger).

Table ES-2: Progress Toward 250,000 Charging Connectors by 2025

	Level 2 Charging Connectors	DC Fast Charging Connectors
Existing Charging Connectors (Estimated)*	37,400	2,900
Allocated Funding for Chargers (includes anticipated funding from Clean Transportation Program)	124,600	3,500
Total	162,000	6,400
2025 Goal (Executive Order B-48-18)	*240,000*	*10,000*
Gap From Goal	78,000	3,600

Source: California Energy Commission. Analysis as of March 8, 2019.*Existing charging ports estimated based on available data from U.S. Department of Energy's Alternative Fuels Data Center, as well as informal interviews with some (but not all) major charging infrastructure providers. **Estimate of ports from other state programs derived from public presentations and statements by utilities, California Public Utilities Commission, CARB, other entities, and Energy Commission.

2019-2020 Investment Plan Update

Assembly Bill 1314 (Wieckowski, Chapter 487, Statutes of 2011) reduced the scope of the annual Clean Transportation Program investment plan to an update. The update builds on the work of previous investment plans while highlighting differences from those previous years. The resulting funding allocations are intended to reflect the unique technological and market conditions for each of these fuels and technologies, as well as state goals, policies, and directives. These are discussed in Chapters 3 through 5 of this report, which describe the barriers and opportunities associated with zero-emission vehicle infrastructure, advanced technology freight and fleet vehicles, low-carbon fuel production, and other related activities.

For FY 2019-2020, a total of $95.2 million has been made available for the purposes described in this investment plan update. Table ES-3 shows the funding allocations for FY 2019-2020, and Table ES-4 outlines the funding allocations of the two most recent investment plan

updates. The emphasis on zero-emission vehicles and infrastructure for FY 2019-2020 reflects the state's goals for zero-emission vehicles and fuels, near- and long-term carbon reduction, and air quality, with a focus on providing benefits for disadvantaged communities.

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

Category	Funded Activity	2019-2020
Zero-Emission Vehicles and Infrastructure	Light-Duty Electric Vehicle Charging Infrastructure	$32.7
	Medium- and Heavy-Duty Zero-Emission Vehicles and Infrastructure	$30
	Hydrogen Refueling Infrastructure	$20
Alternative Fuel Production	Zero- and Near Zero-Carbon Fuel Production	$10
Related Needs and Opportunities	Workforce Development	$2.5
	Total	**$95.2**

Source: California Energy Commission

Table ES-4: Previously Approved Investment Plan Allocations (in Millions)

Category	Funded Activity	2017-2018*	2018-2019
Zero-Emission Vehicle Infrastructure	Electric Vehicle Charging Infrastructure	$16.6	$94.2**
	Hydrogen Refueling Infrastructure	$19.4	$20
	Manufacturing	$4.9	$8.5
	Workforce Training and Development	$3.4	
	Emerging Opportunities	$0.4	-
Advanced Technology Vehicle Support	Advanced Freight and Fleet Technologies	$17.5	$17.5
Alternative Fuel Production	Low-Carbon Fuel Production and Supply	$22.9	$12.5***
Natural Gas Vehicles and Infrastructure	Natural Gas Vehicles	$10.0	-
	Natural Gas Fueling Infrastructure	$2.1	-
	Total	**$97.2**	**$152.7**

Source: California Energy Commission. * Funding allocations for FY 2017-2018 were revised at the January 9, 2019, business meeting to the numbers shown here. **In FY 2018-2019, one-time legislative authority was granted for the Clean Transportation Program use about $57.5 million in older program funds for zero-emission vehicle infrastructure. ***For FY 2018-2019, the Clean Transportation Program fund and the Greenhouse Gas Reduction Fund each provided $12.5 million for Low-Carbon Fuel Production and Supply. Only the $12.5 million from the Clean Transportation Program is shown here.

CHAPTER 1: Introduction

California has been at the forefront of national efforts to combat climate change since the passage of the Global Warming Solutions Act of 2006, which established a goal of reducing statewide greenhouse gas (GHG) emissions to 1990 levels by 2020.[1] Senate Bill 32 established a goal of 40 percent below 1990 levels by 2030.[2] Executive Order B-55-18 established a goal to achieve carbon neutrality as soon as possible, and no later than 2045, and achieve and maintain net negative emissions thereafter.[3]

Despite the federal government's decision to cease participation in the Paris Agreement to limit global warming, the California state government has maintained its aggressive fight against climate change.[4] Governor Gavin Newsom, in responding to the federal government's decision, stated, "California does not have to wait for Washington to be a global leader on any issue—and certainly not when it comes to energy, the environment, and the economy."[5]

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

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

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

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

3 Executive Order B-55-18. September 10, 2018. Available at https://www.ca.gov/archive/gov39/wp-content/uploads/2018/09/9.10.18-Executive-Order.pdf

4 Paris Agreement. Available at https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement.

5 Gavin Newsom. December 5, 2017. "A Sustainable World Can Start in California." Available at https://medium.com/@GavinNewsom/a-sustainable-world-can-start-in-california-df8c0d1332d4.

consumption.[6] The transportation sector is the largest source of GHG emissions in California, with vehicles, oil extraction, and oil refining accounting for roughly 50 percent of in-state emissions.[7] To meet the goals set in international agreements, state laws, and executive orders, the state transportation sector will need to transition to low- and zero-carbon fuels and technologies. California has made progress in implementing low-carbon transportation options, with sales of low-carbon alternative fuels and zero-emission vehicles steadily increasing and new transportation technologies becoming commercially available. Even with these advances, petroleum-based fuels still account for about 90 percent of California ground transportation fuel and result in significant GHG emissions.[8]

In addition to greenhouse gases, the transportation sector is also a major emitter of criteria pollutants, with mobile sources responsible for nearly 80 percent of nitrogen oxide emissions and 90 percent of diesel particulate matter emissions statewide.[9] Protecting and improving public health in the state will require substantial reductions in criteria pollutant emissions. The California Air Resources Board (CARB) estimates that attaining federal air quality standards in 2023 and 2031 may require up to an 80 percent reduction of smog-forming emissions in parts of the state.[10]

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 (now known as the Clean Transportation Program), which is administered by the California Energy Commission (CEC). With funds collected from vehicle and vessel registration, vehicle identification plates, and smog abatement fees, the Clean Transportation Program funds projects that will "transform California's fuel and vehicle types to help attain the state's climate change policies." This program includes projects that:

- Reduce criteria and toxic air-pollutant emissions from vehicles.
- Reduce the use of and dependence on petroleum transportation fuels and increase the use of alternative and renewable fuels and advanced vehicle technologies.
- Produce sustainable alternative and renewable low-carbon fuels in California.
- Expand alternative fueling infrastructure and fueling stations available to the public, existing fleets, public transit, and transportation corridors.

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

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

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

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

10 Ibid.

- 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 installation.

The statute also calls for the CEC to "develop and deploy technology and alternative and renewable fuels in the marketplace, without adopting any one preferred fuel or technology."[11] However, funding priorities for the Clean Transportation Program may shift on a year-to-year basis while still aligning with a long-term portfolio approach. Assembly Bill 8 (Perea, Chapter 401, Statutes of 2013) extended the collection of fees that support the Clean Transportation Program through January 1, 2024.

As part of the Clean Transportation Program, the CEC 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; and the effect of other investments, policies, programs, and statutes. The investment plan update also describes how the allocations will complement existing public and private efforts, including related state programs.

This *2019-2020 Investment Plan Update* is the eleventh investment plan in the history of the Clean Transportation Program and builds on the analyses and recommendations contained in prior documents. This CEC report is the final version of the *2019-2020 Investment Plan Update*. The CEC held public workshops to discuss previous versions of the report with the Clean Transportation Program Advisory Committee on November 8, 2018, February 6, 2019, and August 5, 2019. Representatives from fuel and technology industry groups, nongovernmental entities, other state agencies, and the public were able to discuss and comment on drafts of this document during those meetings and through the CEC's docket system.[12] In accordance with state law, the CEC submitted a draft of this Investment Plan Update to the Legislature concurrent with the Governor's budget in January 2019. The CEC submitted this adopted investment plan update to the Legislature in September 2019.

Chapter 2 of this document provides an update on the CEC's implementation of the Clean Transportation Program to date, as well as a review of the most relevant goals, programs, and regulations that affect the allocations of this Investment Plan Update. The subsequent

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

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

chapters are organized by specific investment areas. Chapter 3 focuses on zero-emission vehicles and the infrastructure necessary to support them. Chapter 4 addresses the types of and opportunities for zero- and near-zero-emission fuel production within California. Chapter 5 describes related opportunities to support the development and deployment of alternative fuels and advanced technology vehicles. Finally, Chapter 6 summarizes the funding allocations for FY 2019-2020.

CHAPTER 2:
Context of the 2019-2020 Investment Plan

Implementation of the Clean Transportation Program

The CEC has followed a consistent approach toward implementing the Clean Transportation Program 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.[13] CEC staff initially proposes funding allocations based on consideration of policy priorities such as air quality standards, environmental justice, and zero-emission vehicle deployment; evaluation of complementary funding or regulations; identification of the primary market and technological opportunities and barriers; and the greenhouse gas (GHG) emission reduction potential of alternative fuels and technologies (both near-term and long-term). Before official adoption by the CEC at a public business meeting, the investment plan update is proposed and revised across several drafts and incorporates stakeholder input from public Clean Transportation Program Advisory Committee meetings.

Each investment plan update identifies funding allocations for particular segments of the supply chain for alternative fuel or vehicle technologies. The funding allocations typically do not determine the specific focus of future funding solicitations. Based on these funding allocations, the CEC subsequently issues a series of competitive solicitations, known as *grant funding opportunities* (GFOs, designated as "GFO-[Year]-XXX"). Each solicitation has a set of unique scoring criteria that reflect the selection preferences set by law.[14] 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.

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

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

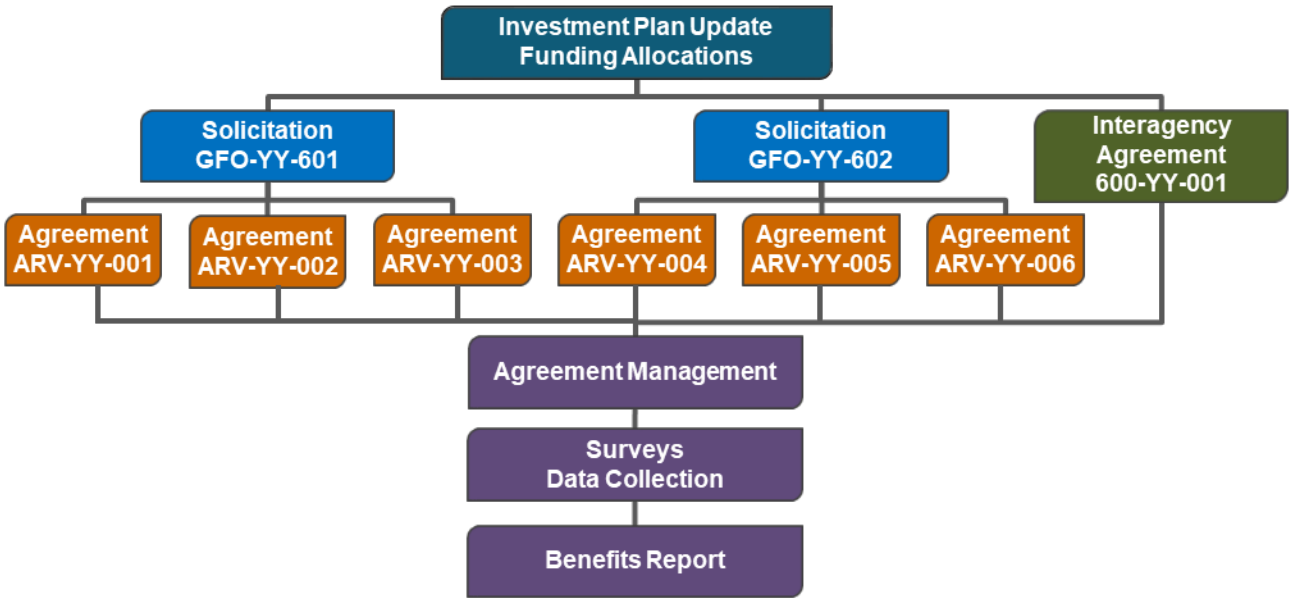
14 These preference criteria are listed in Health and Safety Code Section 44272 (c) and (d) and are applied when ranking funding proposals under Clean Transportation Program solicitations.

specialized agreements with certain partner agencies, the CEC 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 the CEC and the applicant. CEC 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 the Clean Transportation Program implementation. The CEC 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 CEC 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 Clean Transportation Program benefits report, as well as other Clean Transportation Program measurement, verification, and evaluation efforts.

Figure 1: Schematic of the Clean Transportation Program Implementation



Source: California Energy Commission

Alternative Financing Mechanisms

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

- **Competitive Solicitation for Grants**—This type of solicitation represents the most common funding mechanism for the Clean Transportation Program to date. It is flexible, as project requirements and scoring criteria can be adapted for a broad variety of commercial and technological maturity levels. Competitive scoring allows for increased scrutiny on key issues for each project type. Because of the amount of time and attention required to review each application and oversee each subsequent award, this approach is more manageable when funding larger projects, typically of at least several hundreds of thousands of dollars. The specific time window for applying under these solicitations, as well as the uncertainty of receiving an award, may also result in greater uncertainty for project investors and applicants.
- **First-Come, First-Served**—This type of funding mechanism has been used by the Clean Transportation Program for vehicle and infrastructure incentives. Once eligibility requirements are established, the funding can be administered relatively quickly and can provide greater market certainty for a project type. Although this funding mechanism requires the least amount of time and resources to apply for and approve, this incentive type has a higher likelihood of funding activities that would have already occurred as it lacks a method of evaluating the funding need for each project. For these reasons, this approach is most suitable for less expensive and high-volume projects, such as incentives for commercially available vehicles and small-scale infrastructure.
- **Production or Operation Incentives**—The CEC has used these types of incentives for in-state ethanol production and hydrogen refueling station operation and maintenance. The primary aim of these incentives is to provide greater market certainty, which allows 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 Clean Transportation Program 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 Clean Transportation Program as a way to potentially increase opportunities to leverage private financing and transition alternative fuel and vehicle investments from public to private sources. These funding mechanisms become more appropriate as technologies and markets mature and are being tested with a pilot program for electric vehicle charging equipment.
- **Block Grants**—The CEC has used this funding mechanism to distribute Clean Transportation Program funding through other organizations such as local and regional governments, academic institutions, or nonprofit groups. Block grants allow the CEC to select another organization to administer Clean Transportation Program funding while following set procedures for project and applicant eligibility. This mechanism may be preferable when these other organizations either have more experience issuing certain types of incentives or are more familiar with the needs and opportunities for specific project types or geographic areas.

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

Program Outreach and Inclusion

In 2015, the CEC adopted a resolution committing the agency to ensuring that a diverse range of applicants have the opportunity to participate in Clean Transportation Program projects, including small businesses, women, minorities, the LGBT community, and disabled veterans, and is similarly committed to increasing their Clean Transportation Program participation rates. The CEC also seeks to increase the participation of disadvantaged and underrepresented communities from a diverse range of geographical regions. The CEC, through the Clean Transportation Program, seeks to effectively reach and benefit communities disproportionately burdened by pollution and socioeconomic challenges, including rural and tribal communities. This effort includes:

- Initiating and implementing outreach to ensure that a diverse range of potential applicants know about, and understand how to participate in, Clean Transportation Program activities, especially solicitations for projects.
- Targeting particular 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 Clean Transportation Program Web page; and encouraging their presence and participation in Clean Transportation Program workshops.
- Distributing Clean Transportation Program information at key expositions and conferences throughout the state.
- Consultations with the Disadvantaged Communities Advisory Group[15] for guidance and recommendations on program effectiveness as it relates to disadvantaged communities and other vulnerable and underrepresented groups.
- Consultations with the CEC's Tribal Program and the Tribal Lead Commissioner for assistance with outreach and promoting transportation-related funding opportunities to tribes.

15 More information available at https://ww2.energy.ca.gov/sb350/DCAG/.

- Publishing Spanish-language translations of the 2016-2017, 2017-2018, and 2018-2019 Investment Plan Updates, as well as providing Spanish-language translations of the public notices for the Clean Transportation Program Advisory Committee workshops.[16]
- Offering zero-emission vehicle and infrastructure training for fleet owners and operators.
- Using technical support funding to develop outreach, education, and collaborative planning that will accelerate the adoption of alternative fuels and advanced technologies in California's Central Valley, with the goal of addressing greenhouse gas emissions, air-quality emission challenges, and equity issues.[17]
- Soliciting feedback from the Disadvantaged Communities Advisory Group (discussed later in this chapter) in preparing the *2019-2020 Investment Plan Update.*

In addition to the above actions, the CEC has provided a scoring preference for projects located in or benefitting disadvantaged communities, as defined by the CalEnviroScreen tool.[18] These preferences have been used in most recent Clean Transportation Program solicitations, where appropriate, and nearly half of site-specific Clean Transportation Program funding is located in or benefitting disadvantaged communities.

The CEC plans to continue and enhance existing efforts and implement new activities to ensure that participation in the Clean Transportation Program reflects the rich and diverse characteristics of California. These plans include:

- Targeting particular regions within California for program activities that will further CEC 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 learn how to submit stronger project proposals.

Proposal Selection

The statutes that established the Clean Transportation Program provide several directives and preferences that the CEC uses to evaluate and select prospective projects for funding. These directives and preferences include petroleum and GHG emission reductions, market transformation, technology advancement, sustainability, air-quality benefits, economic

16 *2018-2019 Actualización del Plan de Inversión para el Programa de Tecnologías Alternativas y Renovables para Combustibles y Vehículos – Informe de la Comisión*. Published May 25, 2018. Publication Number CEC-600-2017-010-CMF-Spanish. Available at https://efiling.energy.ca.gov/getdocument.aspx?tn=223585.

17 For more information, see Solicitation Number GFO-18-603, "Outreach, Education, and Collaborative Planning for California's Central Valley." Available at https://www.energy.ca.gov/contracts/transportation.html#GFO-18-603.

18 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.

development, and benefit-cost assessments. In competitive solicitations, the Clean Transportation Program 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.

AB 8 also added the GHG benefit-cost score to the list of policy and scoring preferences for the Clean Transportation Program. It is defined as "…a project's expected or potential greenhouse gas emissions reduction per dollar awarded by the Commission to the project."[19] AB 8 also directs the CEC to "give additional preference to funding those projects with higher benefit-cost scores."[20] CEC 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 Clean Transportation Program. The "benefit" is calculated as the amount of conventional fuel displaced per year by the resulting alternative fuel or technology, multiplied by the carbon intensity of that fuel or technology relative to conventional fuel. The "cost" is based on the requested Clean Transportation Program funding amount. Dividing the "benefit" by the "cost" produces a benefit-cost ratio that staff uses in ranking similar proposals within a competitive solicitation. The benefit-cost ratio is typically given greater scoring weight in solicitations that focus on technologically mature and commercially established project types. In recent solicitations, this preference has also been incorporated as part of the general scoring criteria and as a potential tiebreaker in the event of proposals receiving equal scores.

Summary of Program Funding

As of March 2019, the CEC has approved nearly $830 million in Clean Transportation Program funding. Figure 2 summarizes these agreements by fuel type, and Table 1 shows a more detailed listing of Clean Transportation Program awards to date. The agreements support a broad portfolio of fuel types, supply chain phases, and commercialization phases. In many cases, projects are in progress, with ongoing siting, installation, construction, and demonstrations. Major highlights of the Clean Transportation Program funding portfolio through March 1, 2019, include:

- 71 projects to promote the production of sustainable, low-carbon alternative fuels within California, with a cumulative annual production capacity equivalent to more than 158 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.
- 9,655 installed or planned charging connectors for plug-in electric vehicles, including 4,285 at multi- and single-family homes, 115 fleets, and 440 workplaces; 3,309 public

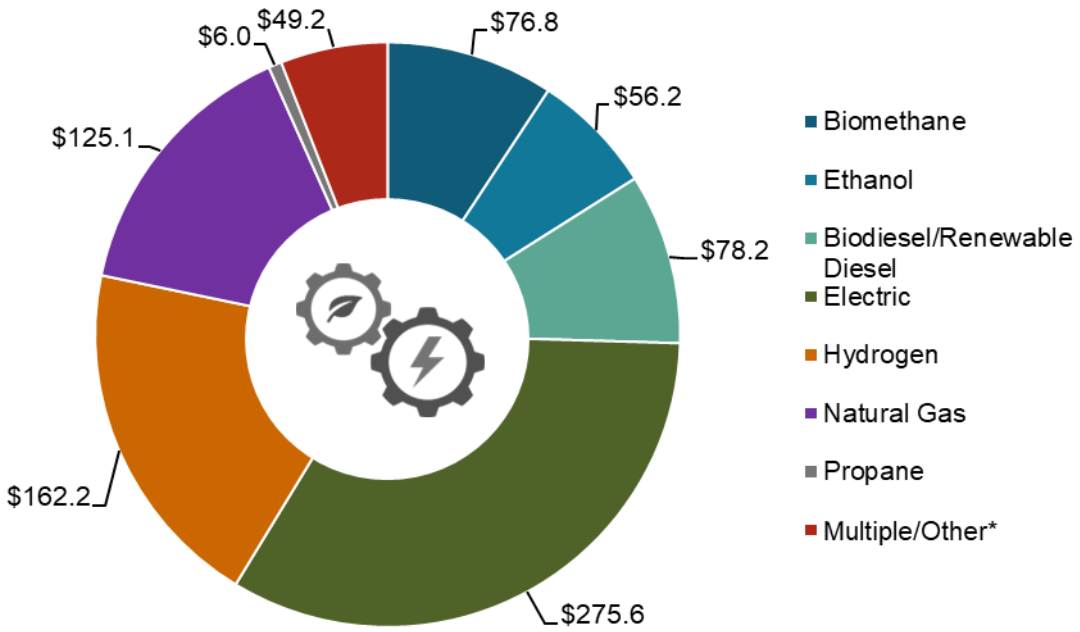
19 California Health and Safety Code, Sec. 44270.3 (a).

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

Level 2 charging connectors; and 1,506 public direct current (DC) fast charging connectors along highway corridors and urban metropolitan areas.

- 64 new or upgraded hydrogen-refueling stations that will help serve an emerging population of fuel cell electric vehicles, plus the development of retail fueling standards to enable hydrogen sales on a per-kilogram basis. Once built, these stations will represent two-thirds of the initial network of 100 hydrogen-refueling stations called for by AB 8.
- 54 projects to demonstrate zero- and near-zero-emission advanced technologies and alternative fuels in a variety of medium- and heavy-duty vehicle applications. This number includes five projects at major California seaports to support Executive Order B-32-15 on sustainable freight, which will deploy a variety of zero- and near-zero-emission freight vehicles.
- More than 3,000 natural gas vehicles operating or soon to be operating in a variety of applications.
- 70 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. Thirty of these stations serve California school districts and will help provide air quality benefits to children and local communities.
- $24.5 million to fund incentives for all-electric and plug-in hybrid electric vehicles via the California Air Resources Board Clean Vehicle Rebate Project (CVRP).
- More than 20 manufacturing projects that support in-state economic growth while reducing the supply-side barriers for alternative fuels and advanced technology vehicles, primarily in electric drive-related components and vehicles.
- Workforce training for 17,440 trainees and 277 businesses that translate clean technology investments into sustained employment opportunities.
- Five centers for alternative fuels and advanced vehicle technologies located throughout the state that are dedicated to expanding the role of alternative fuels and advanced vehicle technologies in California.
- More than 50 alternative fuels readiness planning and implementation grants to help regions plan for alternative fuel vehicle deployment, new fueling infrastructure, and permit streamlining.

Figure 2: Clean Transportation Program Awards by Fuel Type as of March 1, 2019 (in Millions)



Source: California Energy Commission. Totals may not match due to rounding. As of March 1, 2019. *Some agreements, such as those focused on multiple fuel types, regional readiness plans, or workforce training, cannot be readily categorized by fuel type.

Table 1: Clean Transportation Program Awards as of March 1, 2019

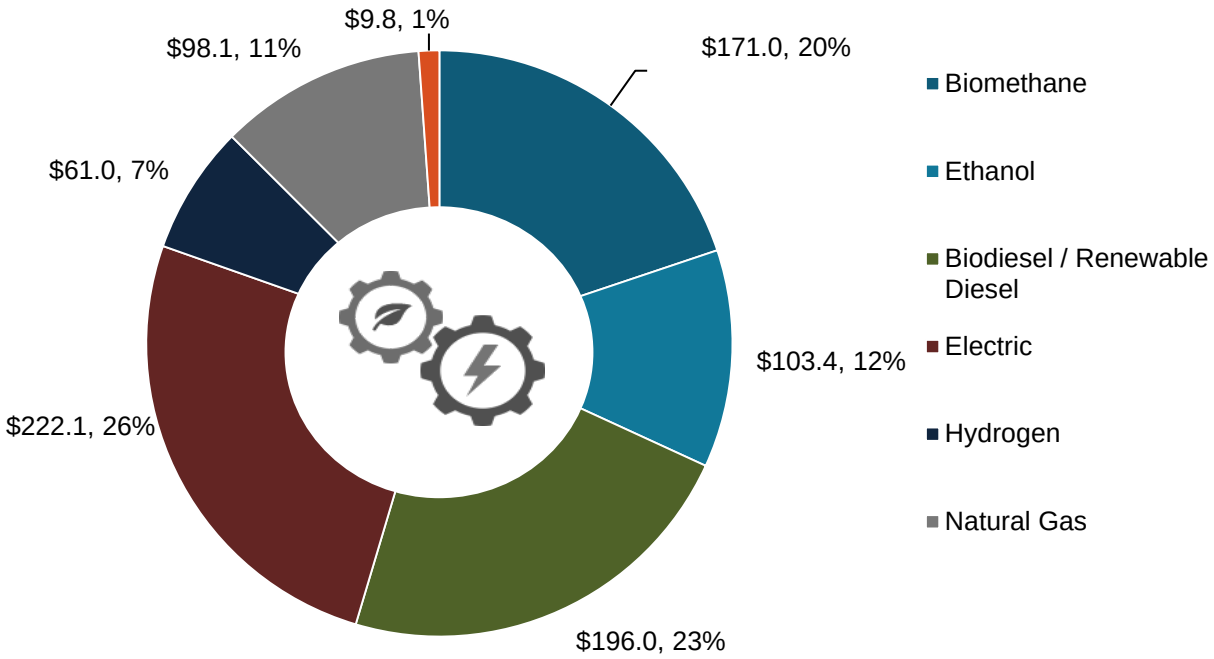
Funded Activity	Cumulative Awards to Date (in Millions)*	# of Projects or Units
Alternative Fuel Production		
Biomethane Production	$76.8	27 Projects
Gasoline Substitutes Production	$39.5	16 Projects
Diesel Substitutes Production	$74.2	26 Projects
Renewable Hydrogen Production	$7.9	2 Projects
Alternative Fuel Infrastructure		
Electric Vehicle Charging Infrastructure**	$94.9	9,655 Charging Connectors
Hydrogen Refueling Infrastructure	$140.6	64 Fueling Stations
E85 Fueling Infrastructure	$13.7	59 Fueling Stations
Upstream Biodiesel Infrastructure	$4.0	4 Infrastructure Sites
Natural Gas Fueling Infrastructure	$24.1	65 Fueling Stations and Upgrades
Alternative Fuel and Advanced Technology Vehicles		
Natural Gas Vehicle Deployment***	$86.8	3,152+ Vehicles
Propane Vehicle Deployment	$6.0	514 Trucks
Hybrid and ZEV Deployment (Including CVRP, HVIP, and low-income mobility incentives)	$32.0	10,700 Cars and 150 Trucks
Advanced Technology Freight and Fleet Vehicles****	$126.3	54 Demonstrations
Related Opportunities		
Manufacturing	$43.6	21 Manufacturing Projects
Workforce Training and Development	$30.2	17,440 Trainees
Fuel Standards and Equipment Certification	$3.9	1 Project
Sustainability Studies	$2.0	2 Projects
Regional Alternative Fuel Readiness	$11.4	52 Regional Plans
Centers for Alternative Fuels	$5.6	5 Centers
Technical Assistance and Program Evaluation	$5.7	n/a
Total	**$829.4**	

Source: California Energy Commission. Totals may not match due to 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 the Clean Transportation Program that may be smaller than initial award. Due to rounding, "total" may not match sum of rows. **Includes $38.8 million for the California Electric Vehicle Infrastructure Project to provide EV incentives throughout California, which will fund a yet-to-be-determined number of EV chargers. ***Funding includes both completed and pending vehicle incentives, as well as funds reserved for future incentives. ****Includes projects from the former Medium- and Heavy-Duty Vehicle Technology Demonstration category.

Using funds from the Clean Transportation Program, the CEC has also leveraged the additional investment of private and other public funds. Figure 3 shows the amount and percentage of match funding for Clean Transportation Program awards by fuel type, totaling just over $860

million. However, this amount represents only the minimal, contractually obligated amount of match funding provided toward Clean Transportation Program projects; the actual amount of investment prompted by the Clean Transportation Program funding exceeds this amount.

Figure 3: Match Funding and Percentage for Clean Transportation Program Projects by Fuel Type as of March 1, 2019 (in Millions)



Source: California Energy Commission. As of March 1, 2019. Totals may not match due to rounding. *Some agreements, such as those focused on multiple fuel types, regional readiness plans, or workforce training, cannot be readily categorized by fuel type.

The geographic distribution of Clean Transportation Program funding is shown in Table 2, sorted by air district.

Table 2: Clean Transportation Program Awards by Air District as of March 1, 2019

Air District	Cumulative Awards (in Millions)	Cumulative Number of Projects Sites*
San Joaquin	$301	171
Bay Area	$117	438
Sacramento	$32	101
Yolo-Solano	$11	65
Monterey	$13	50
Other Northern California Districts	$24.8	118
South Coast	$254	563
San Diego	$42	270
Other Southern California Districts	$23	154
Statewide	$12.2	12
Total	**$830**	**1,942**

Source: California Energy Commission. Totals may not match due to rounding. *Each agreement has one or more project site; each project site is a distinct location where agreement work is conducted.

Clean Transportation Program Funding for Disadvantaged Communities

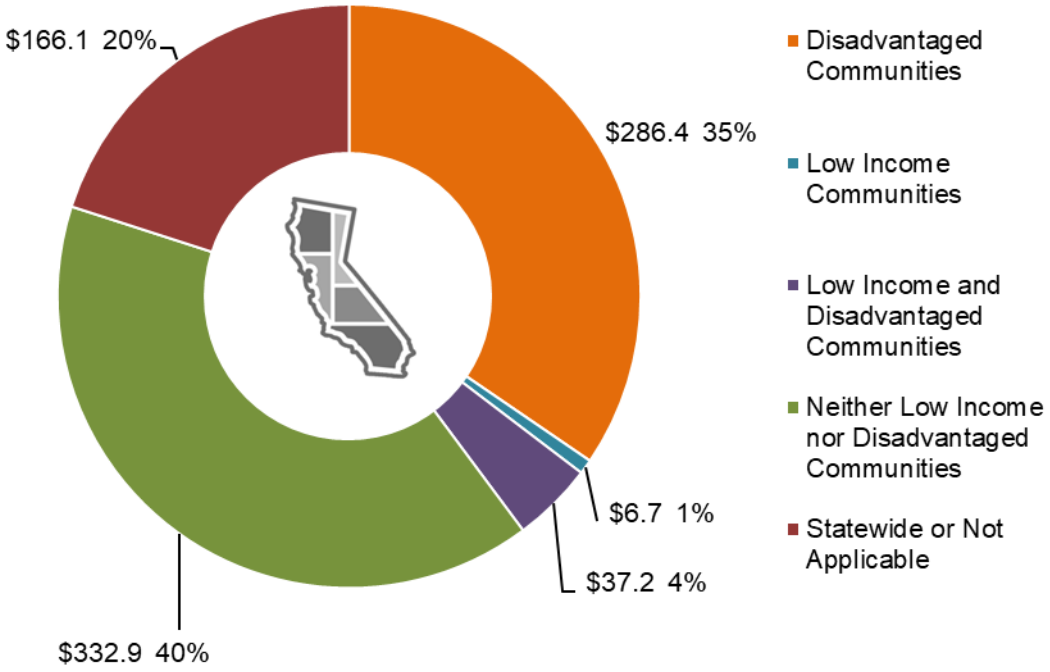
The CEC also seeks to increase the participation of disadvantaged and underrepresented communities from a diverse range of regions in implementing the Clean Transportation Program. As depicted in Figure 4, roughly 40 percent of Clean Transportation Program project funding has gone into disadvantaged communities as defined by CalEnviroScreen. When excluding Clean Transportation Program projects that occur statewide or without an applicable site address, this funding share is closer to 50 percent.

However, the funding amounts of projects are not a complete metric for assessing the benefit of a project to disadvantaged communities. For instance, investments into large-scale fuel production or vehicle manufacturing plants might provide economic benefit to a region but may also risk increasing localized criteria emissions from fuel production or vehicle manufacturing. Similarly, investing in zero-emission refueling infrastructure within a disadvantaged community might reduce local tailpipe emissions but might overlook the mobility needs of local residents. Given these realities, the Disadvantaged Community Advisory Group recommended that the CEC revise the approach of the program toward defining, measuring, and tracking the program benefits toward disadvantaged communities.[21] The CEC will explore new methods for advancing equity within the Clean Transportation Program, such as encouraging partnerships with community-based organizations and community organizers in grant applications, expanding the membership of the program Advisory Committee, and

21 SB 350 Disadvantaged Communities Advisory Group, "SB 350 Disadvantaged Communities Advisory Group Comments on 2019-2020 Investment Plan Update," June 28, 2019. Submitted to Docket 18-ALT-01, TN# 228878. Available at https://efiling.energy.ca.gov/GetDocument.aspx?tn=228878&DocumentContentId=60238.

identifying new metrics beyond project location to evaluate the effects of the program grants on local communities.

Figure 4: Clean Transportation Program Funding Toward Disadvantaged Communities (in Millions)



Source: California Energy Commission. Totals may not match due to rounding. As of March 1, 2019.

Funding Allocations

The funding allocations for FY 2019-2020 are outlined in Table 3, and the funding allocations of the two most recent investment plan updates are outlined in Table 4. In the event that a different amount of funding is available, the allocations in this document may be revised or amended after final adoption.

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

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

Category	Funded Activity	2019-2020
Zero-Emission Vehicles and Infrastructure	Light-Duty Electric Vehicle Charging Infrastructure	$32.7
	Medium- and Heavy-Duty Zero-Emission Vehicles and Infrastructure	$30
	Hydrogen Refueling Infrastructure	$20
Alternative Fuel Production	Zero- and Near-Zero-Carbon Fuel Production	$10
Related Needs and Opportunities	Workforce Development	$2.5
	Total	**$95.2**

Source: California Energy Commission

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

Funded Activity	2017-2018*	2018-2019	Unencumbered Funds**
Electric Vehicle Charging Infrastructure	$16.6	$94.2	$44.1
Hydrogen Refueling Infrastructure	$19.4	$20	$23.7
Manufacturing	$4.9	$8.5	$2.5
Workforce Training and Development	$3.4		
Emerging Opportunities	$0.4	-	-
Advanced Freight and Fleet Technologies	$17.5	$17.5	$17.5
Low-Carbon Fuel Production and Supply	$22.9	$12.5***	$12.5
Natural Gas Vehicles	$10.0	-	-
Natural Gas Fueling Infrastructure	$2.1	-	-
Total	**$97.2**	**$152.7**	**$100.3**

Source: California Energy Commission. *Funding allocations for FY 2017-2018 were revised at the January 9, 2019, business meeting to the numbers shown here. **Unencumbered funds include funding from FY 2017-2018 and FY 2018-2019 that has not yet been reserved for a funding solicitation or dedicated to a specific agreement. As of June 12, 2019. ***For FY 2018-2019, the Clean Transportation Program fund and the Greenhouse Gas Reduction Fund each provided $12.5 million for Low-Carbon Fuel Production and Supply. Only the $12.5 million from the Clean Transportation Program is shown here.

Clean Transportation Program Benefits and Evaluation

The CEC periodically reviews and evaluates its implementation of the Clean Transportation Program 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 Clean Transportation Program grantees, and performing other program analyses.

National Renewable Energy Laboratory Program Benefits Guidance Report

The CEC 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 Clean Transportation Program, which is required by Assembly Bill 109 (Núñez, Chapter 313, Statutes of 2008). In 2014, NREL issued a *Program Benefits Guidance* draft report that describes its method for categorizing and assessing a series of benefit categories.[22] The methods and results of this report are discussed in the *2014 Integrated Energy Policy Report (IEPR) Update*, and the assessment was subsequently updated in the *2015* and 2017 *IEPRs*. The most current and thorough discussion of the benefits report for the Clean Transportation Program can be found in Appendix D of the *2017 IEPR*.[23] The benefits report will subsequently be revised as part of the *2019 IEPR* toward the end of 2019.

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

Expected benefits are defined as the benefits most likely to occur from Clean Transportation Program projects being executed successfully, assuming a one-to-one substitution of existing fuel or technology with a new fuel or technology. Staff emphasizes that California's Low Carbon Fuel Standard requires carbon reduction from transportation fuels, which complicates the attribution of carbon reduction resulting from Clean Transportation Program investments. Within its analysis, NREL does not attempt to calculate whether these individual projects have resulted in emissions reductions beyond those already required by the Low Carbon Fuel Standard. The expected benefits from NREL's assessment of Clean Transportation Program projects awarded through June 2017 are shown in Table 5.

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22 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.

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

Table 5: Expected Annual Petroleum Fuel and GHG Emission Reduction Benefits From Clean Transportation Program-Funded Projects (as of June 2017)

Project Type	Petroleum Displacement (Million Gallons)			Greenhouse Gas Emission Reductions (Thousand Tonnes[24] CO_2e)		
Year	2020	2025	2030	2020	2025	2030
Fuel Production						
Biomethane	6.3	11.0	11.0	103.1	193.5	193.5
Diesel Substitutes	81.5	111.3	111.3	894.1	1,228.3	1,228.3
Gasoline Substitutes	4.4	15.6	15.6	737.5	161.1	161.1
Fuel Production Subtotal	*92.2*	*137.9*	*137.9*	*1,734.7*	*1,582.9*	*1,582.9*
Fueling Infrastructure						
Biodiesel	8.5	8.5	8.5	73.8	73.8	73.8
E85	11.1	11.2	11.2	33.7	33.8	33.8
Electric Vehicle Charging	2.8	2.6	2.6	20.9	20.0	20.0
Hydrogen	13.6	14.3	15.5	107.7	113.8	123.2
Natural Gas	35.3	35.3	35.6	87.1	87.8	87.8
Fueling Infrastructure Subtotal	*71.3*	*71.9*	*73.4*	*323.2*	*329.2*	*338.6*
Vehicles						
Electric Commercial Trucks	0.4	0.3	-	3.1	2.1	-
Light Duty BEVs & PHEVs	1.5	1.1	0.9	11.3	8.4	6.5
Manufacturing	65.1	108.8	97.8	543.8	919.7	841.6
Medium- & Heavy-Duty Trucks	0.9	1.2	1.0	7.1	8.5	6.9
Natural Gas Trucks	5.4	4.6	3.1	14.7	12.5	8.5
Vehicles Subtotal	*73.3*	*116.0*	*102.8*	*580*	*951.2*	*863.5*
Total	**236.8**	**325.8**	**314.1**	**2,637.9**	**2,863.3**	**2,785.0**

Source: NREL. Based on a sample size of Clean Transportation Program projects awarded through June 2017. This table reflects the expected benefits from projects funded by the Clean Transportation Program through June 2017. It is not a projection of all alternative fuel and advanced technology vehicle deployment in California through 2030. *Estimates of GHG emission reductions are not assumed exclusive to GHG emission reductions under the Low Carbon Fuel Standard.

Market transformation benefits correspond to the core mission of Clean Transportation Program to transform the California transportation system into a low-carbon, low-emission system of alternative fuel and vehicle technologies. Market transformation benefits are more challenging to quantify because they are assessments of how Clean Transportation Program-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 range of estimated market

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

transformation benefits of Clean Transportation Program projects awarded through June 2017 are shown in Table 6.

Table 6: Expected Annual Market Transformation Benefits in 2030 From Clean Transportation Program-Funded Projects (as of June 2017)

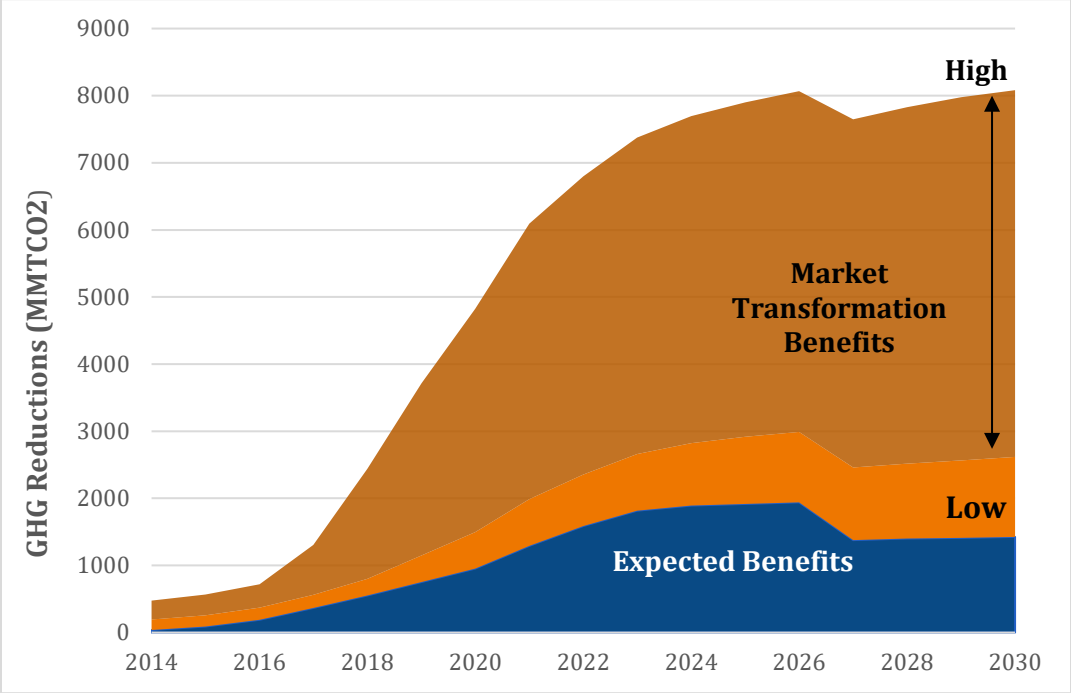
Market Transformation Influence	Case	Petroleum Displacement (Million Gallons)	Greenhouse Gas Emission Reductions (Thousand Tonnes CO_2e)
Vehicle Price Reductions	High	104.4	865.5
	Low	45.0	371.2
ZEV Industry Experience	High	10.9	83.4
	Low	9.6	71.1
Next-Generation Trucks	High	257.8	1,513.0
	Low	10.2	70.7
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. Based on a sample size of Clean Transportation Program projects awarded through June 2017.

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

Figure 5 depicts the expected GHG reductions per year from 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. More information on expected Clean Transportation Program benefits can be found in the *2017 IEPR*.

Figure 5: GHG Reductions From Expected and Market Transformation Benefits in Comparison to Required Market Growth Benefits



Source: NREL

NREL is updating estimated benefits for 2019 using a similar method. Given the challenges of calculating market transformation benefits—especially for zero-emission fuels and infrastructure—the CEC plans to explore more deeply additional analytical frameworks.

NREL also examined the expected tailpipe emission reduction of oxides of nitrogen (NO_X) and fine particulate matter ($PM_{2.5}$) from Clean Transportation Program projects. This analysis was limited to fuel and vehicle types recognized under the California Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (CA-GREET) and VISION models, which include electricity and hydrogen. A summary of the expected annual air pollution emission reduction benefits can be found in Table 7.

Table 7: Expected Annual Air Pollution Emission Reduction Benefits From Clean Transportation Program-Funded Projects (as of June 2017)

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

Source: NREL

Related Policies and Goals

The CEC's implementation of the Clean Transportation Program reflects the impact of numerous policies and goals. Table 8 highlights examples of the significant policy goals and milestones that have been developed to address these issues, reduce emissions, and reduce petroleum use in California. CEC staff consulted with other state agencies and considered these policies when developing this Investment Plan Update.

Table 8: Greenhouse Gas, Fuel, and Air Quality Goals and Milestones

Policy Origin	Objectives	Goals and Milestones
Assembly Bill 32	GHG Reduction	Reduce GHG emissions to 1990 levels by 2020
Senate Bill 32	GHG Reduction	Reduce GHG emissions to 40 percent below 1990 levels by 2030
Executive Order B-55-18	GHG Reduction	Achieve carbon neutrality by 2045
Low Carbon Fuel Standard	GHG Reduction	Reduce carbon intensity of transportation fuels in California by 10 percent by 2020 and 20 percent by 2030 Increase zero-emission vehicle infrastructure
Senate Bill 1383	GHG Reduction	Reduce emissions of short-lived climate pollutants to 40 to 50 percent below 2013 levels by 2030
Senate Bill 1368	GHG Reduction in Electricity Sector	Limits long-term investments in baseload generation by the state's utilities to power plants that meet an emissions performance standard
Renewables Portfolio Standard	Increase Renewable Electricity	Requires 60 percent of electricity retail sales be served by renewable resources by 2030 and 100 percent by 2045
Clean Air Act; California State Implementation Plans	Air Quality	80 percent reduction in NOx by 2031
Executive Order B-16-2012; Senate Bill 1275; Executive Order B-48-18	Increase Zero-Emission Vehicles	1 million zero-emission vehicles by 2023 1.5 million electric vehicles by 2025 5 million zero-emission vehicles by 2030 Infrastructure to accommodate 1 million electric vehicles by 2020 250,000 electric vehicle chargers, including 10,000 DC fast chargers, and 200 hydrogen refueling stations by 2025
Zero-Emission Vehicle Regulation	Increase Zero-Emission Vehicles	Increase the deployment of plug-in hybrid, battery, and fuel cell electric vehicles
Innovative Clean Transit Regulation	Increase Zero-Emission Vehicles	100 percent of all new transit buses will be zero-emission by 2029; all operating buses will be zero-emission by 2040
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
Energy Independence and Security Act of 2007 – Renewable Fuel Standard	Petroleum Reduction	36 billion gallons of renewable fuel by 2022 nationally

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.

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

Assembly Bill 32 (Núñez, Chapter 488, Statutes of 2006), also known as the Global Warming Solutions Act of 2006, required CARB to adopt a statewide GHG emission limit for 2020

equivalent to the statewide GHG emission levels in 1990. Executive Order S-3-05 also set an objective of reducing emissions to 80 percent below 1990 levels by 2050, which is consistent with an Intergovernmental Panel on Climate Change analysis of the emissions trajectory that would stabilize atmospheric GHG concentrations at 450 parts per million CO_2e and reduce the danger of catastrophic climate change.

Senate Bill 32 (Pavley, Chapter 249, Statutes of 2016) amended the Global Warming Solutions Act of 2006 to extend the emission targets of AB 32. The amendment set a statewide GHG emission limit for 2030 equivalent to 40 percent below emission levels in 1990. In September 2018, Executive Order B-15-18 established a new target to achieve carbon neutrality by 2045. AB 32 and SB 32 directed CARB to develop a climate change scoping plan to describe the approach that California will take to reduce GHG emissions and achieve the state's climate change goals. *California's 2017 Climate Change Scoping Plan*, published by CARB in November 2017, helped inform and guide the development of this investment plan update.[25]

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 is deposited in the Greenhouse Gas Reduction Fund (GGRF). The Governor and Legislature enact GGRF appropriations for state agencies to implement a variety of programs that reduce greenhouse gases. Assembly Bill 398 (Garcia, Chapter 135, Statutes of 2017) extended California's Cap-and-Trade Program through 2030.

Executive Order B-55-18

Executive Order B-55-18 established a goal to achieve carbon neutrality as soon as possible and no later than 2045. The executive order also requires the state to achieve and maintain net negative greenhouse gas emissions thereafter.

Low Carbon Fuel Standard

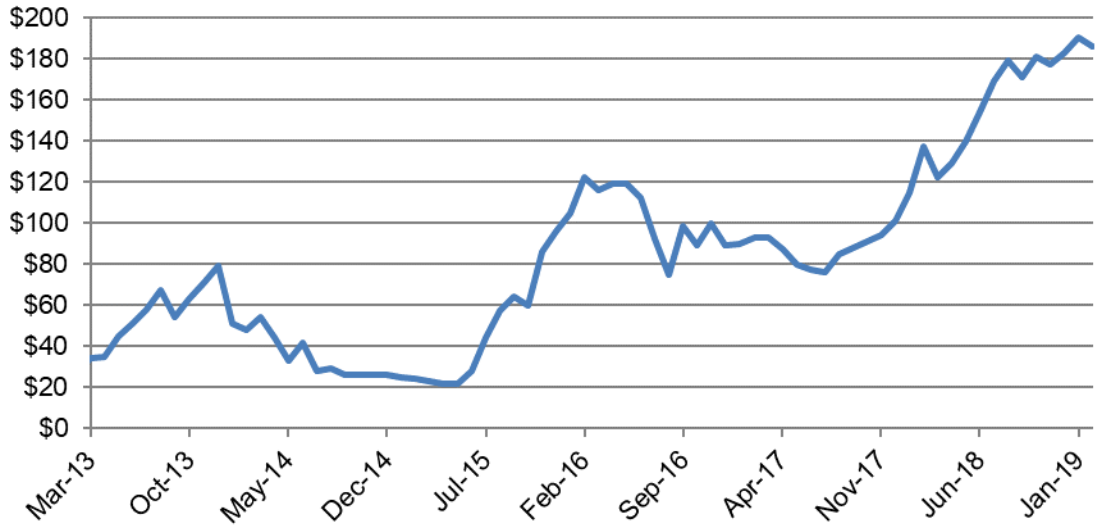
CARB adopted the Low Carbon Fuel Standard (LCFS) regulation in April 2009 with a goal of reducing the overall carbon intensity of fuel within the transportation sector by 10 percent by 2020. In September 2018, CARB set an additional goal of reducing carbon intensity by 20 percent by 2030. The LCFS sets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

LCFS credits and deficits are denominated in metric tons of CO_2e Credit prices reached all-time highs in 2017 and 2018, as shown in Figure 6, ranging from a low of $22 in May 2015 to a

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

high of $190 in January 2019.[26] As of March 2018, 459 certified transportation fuel pathways were available for use under the LCFS, and 255 parties were registered for transactions under the LCFS, including oil refiners, biofuel producers, and electric and natural gas utilities.[27]

Figure 6: Average Monthly Low Carbon Fuel Standard Credit Prices



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

The LCFS has significance for the Clean Transportation Program in several ways. Most important, the CEC frequently relies on LCFS-derived carbon intensity numbers in numerous phases of Clean Transportation Program 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 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 Clean Transportation Program benefits.

The LCFS also provides a direct financial incentive per gallon, kilowatt-hour, therm, or kilogram to the producers and distributors of low-carbon alternative fuels. At the recent 12-month average price of about $144 per credit, the LCFS value of an alternative fuel offering a 50 percent GHG emission reduction compared to gasoline would be about $0.75 per gasoline

26 California Air Resources Board. March 13, 2019. *LCFS Monthly Credit Price and Transaction Volumes July 2018 Spreadsheet.* Available at https://www.arb.ca.gov/fuels/lcfs/dashboard/creditpriceserieswithoutargusopis.xlsx.

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

gallon equivalent (GGE).[28] This value complements the investments of the Clean Transportation Program by creating market incentives for near-term GHG reductions, allowing the Clean Transportation Program to focus more resources on longer-term market transformation goals.

In September 2018, CARB also adopted changes to the LCFS regulations that will benefit the launch of ZEVs and ZEV infrastructure. The amendments will allow hydrogen refueling stations to earn hydrogen refueling infrastructure credits based on the capacity of the station. The amendments will also provide credits for DC fast charging equipment based on the power rating of the equipment. On the vehicles side, the amendments also restructure the existing approach for providing PEV rebates through utilities to create a statewide rebate that would be offered at the dealership, funded through LCFS credit proceeds.

Senate Bill 1383 Short-Lived Climate Pollutants

Senate Bill 1383 (Lara, Chapter 395, Statutes of 2016) sets targets for reducing the state's short-lived climate pollutants by 2030, including methane (by 40 percent), hydrofluorocarbon gas (by 40 percent), and anthropogenic black carbon (by 50 percent).[29] To achieve these goals, the law requires CARB to adopt regulations to reduce methane from livestock and dairy operations, and similarly requires the California Department of Resources Recycling and Recovery (CalRecycle) to adopt regulations to reduce organic wastes in landfills. The law also requires the California Public Utilities Commission (CPUC) to direct investor-owned utilities' investments into dairy biomethane pilot projects to demonstrate pipeline interconnection. Specific to the CEC, the law required the *2017 Integrated Energy Policy Report* to include recommendations on the development and use of renewable gas, including biomethane and biogas.

Senate Bill 1368 Emission Performance Standards

Senate Bill 1368 (Perata, Chapter 598, Statutes of 2006) limits long-term investments in baseload generation by the state's utilities to power plants that meet an emissions performance standard jointly established by the CEC and the CPUC. The legislation was instrumental reducing electricity derived from coal-powered plants, and paved the way for a cleaner electricity mix and lower GHG emissions.

Renewables Portfolio Standard (RPS) Program

Senate Bill 1078 (Sher, Chapter 516, Statutes of 2002) established California's RPS program in 2002 by with the initial requirement that 20 percent of electricity retail sales must be served by renewable resources by 2017. The program was accelerated in 2015 with Senate Bill 350 (De León, Chapter 547, Statutes of 2015), which mandated a 50 percent RPS by 2030. SB 350 includes interim annual RPS targets with three-year compliance periods and requires 65

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28 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.

29 Methane, hydrofluorocarbons, and black carbon are all air pollutants with significantly higher global warming potential than carbon dioxide.

percent of RPS procurement to be derived from long-term contracts of 10 or more years. In 2018, Senate Bill 100 (De León, Chapter 312, Statutes of 2018) was signed into law, which increased the RPS to 60 percent by 2030 and requires all the state's electricity to come from carbon-free resources by 2045.

Clean Air Act, 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) for criteria air pollutants that are harmful to 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 controlling emissions from cars, trucks, other mobile sources, and consumer products. In March 2017, CARB adopted the state SIP strategy with a commitment to achieving the emission reductions from mobile sources and consumer products necessary to meet the NAAQS for ozone throughout California. In October 2018, CARB adopted a supplement to the state SIP strategy to address the $PM_{2.5}$ standards in the San Joaquin Valley.[30]

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

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

Clean Transportation Program investments frequently provide significant air quality benefits by replacing conventional gasoline- and diesel-fueled vehicles with near-zero- and zero-emission

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30 More information about the State SIP strategy, as well as the supplement for the San Joaquin Valley, is available at https://ww3.arb.ca.gov/planning/sip/2016sip/2016sip.htm.

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

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

vehicles, as well as providing the fueling infrastructure required for these vehicles to operate. These Clean Transportation Program-funded vehicle and infrastructure projects complement and assist other California efforts in achieving the goals of the federal Clean Air Act. Air quality benefits from Clean Transportation Program projects are further discussed in Chapters 3, 4, and 5 of this report.

Executive Orders on Zero-Emission Vehicles and Senate Bill 1275

Executive Order B-16-12 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.[33] Subsequently, in January 2018, Executive Order B-48-18 set an expanded target of 5 million zero-emission vehicles on the road by 2030, as well as a network of 200 hydrogen refueling stations and 250,000 electric vehicle charging stations, including 10,000 DC fast chargers, installed or constructed by 2025.[34] These executive orders have guided the electric vehicle charging and hydrogen refueling infrastructure investments of the Clean Transportation Program to date.

The Governor's Interagency Working Group on Zero-Emission Vehicles (ZEVs) developed the *ZEV Action Plan*, issued in 2013 and subsequently updated in 2016 and 2018, to identify actions that support the state's ZEV goals.[35] Some actions in the *ZEV Action Plan* that are particularly relevant to the Clean Transportation Program 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 Clean Transportation Program since the inception of the program and continue to be program priorities. The Electric Vehicle Charging Infrastructure, Hydrogen Refueling Infrastructure, and Advanced Freight and Fleet Technologies sections of this Investment Plan Update discuss proposed Clean Transportation Program 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.[36] 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. Building on this effort, the Governor's Office of Business and Economic Development released the *Electric Vehicle Charging Station*

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33 Executive Order B-16-12 available at https://www.ca.gov/archive/gov39/2012/03/23/news17463/index.html.

34 Executive Order B-48-18 available at https://www.ca.gov/archive/gov39/2018/01/26/governor-brown-takes-action-to-increase-zero-emission-vehicles-fund-new-climate-investments/index.html.

35 The ZEV Action Plan and updates are available at http://www.business.ca.gov/ZEV-Action-Plan.

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

Permitting Guidebook in July 2019. The purpose of the guidebook is to simplify the deployment of charging stations by fostering a shared understanding of how local agencies and stakeholders can "streamline the planning, permitting, installation, and ongoing operation of electric vehicle charging stations and supporting equipment."[37]

Senate Bill 1275 (De León, Chapter 530, Statutes of 2014) established the Charge Ahead California Initiative, administered by CARB in consultation with the CEC and related agencies. This statute establishes a goal of placing 1 million zero-emission and near-zero-emission vehicles in service by January 1, 2023, as well as increasing access to these vehicles for disadvantaged, low-income, and moderate-income communities and consumers. In implementing the initiative, CARB must include a three-year funding forecast for near-zero- and zero-emission vehicles. CARB released the first of these forecasts, the *Fiscal Year 2016-17 Funding Plan for Low Carbon Transportation and Fuels Investments and the Air Quality Improvement Program,*[38] in 2016. CARB also adopted revisions to the Clean Vehicle Rebate Project to phase down rebate levels based on cumulative sales, limit eligibility based on income, and consider other methods of incentives.

Executive Order on Sustainable Freight

Issued in 2015, Executive Order B-32-15 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.[39] The resulting *California Sustainable Freight Action Plan,* released in 2016, identifies state policies, programs, and investments to achieve these targets. The California State Transportation, California Environmental Protection, and California Natural Resources Agencies, including the CEC, CARB, the California Department of Transportation, and the Governor's Office of Business and Economic Development, in partnership with the public and stakeholders, developed the plan as a joint effort. In addition, the executive order directs the CEC 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 CEC released three solicitations for advanced freight vehicle and infrastructure projects between 2015 and 2017. These solicitations awarded $60 million to eight projects demonstrating advanced technology vehicles and infrastructure in the Ports of Los Angeles, Long Beach, and San Diego. These projects will launch 90 zero- and

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37 California Governor's Office of Business and Economic Development. 2019. *Electric Vehicle Charging Station Permitting Guidebook*. Available at http://businessportal.ca.gov/wp-content/uploads/2019/07/GoBIZ-EVCharging-Guidebook.pdf.

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

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

near-zero-emission vehicles, including yard trucks, drayage trucks, gantry cranes, top handlers, and forklifts, as well as install charging and refueling infrastructure for electric and hydrogen vehicles. Moreover, the CEC regularly engages with seaports in California through the Ports Energy Collaborative, which provides a forum for the CEC and the ports to discuss important energy issues, mutual challenges, and opportunities for transitioning to alternative and renewable energy technologies.

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. Table 9 summarizes the projected volumes and proposed percentages for renewable fuels to be used under the RFS program.[40]

Table 9: Proposed and Final RFS Fuel Volumes for 2018-2020

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

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

As with the LCFS, the RFS provides a per-gallon subsidy for alternative fuels through saleable RINs. This subsidy complements the goals of the Clean Transportation Program by encouraging credit-generating and regulated parties to invest in the lowest-cost means of increasing alternative fuel use. The market value of these RINs can be volatile. Pricing depends on the category of RIN, and for the first half of 2018, ethanol RINs averaged $0.44 and biodiesel RINs averaged $0.66, with one RIN representing the energy content of a gallon

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

of ethanol.[41] This volatility affects the income of biofuel producers and can negatively affect investments in projects.

Senate Bill 350 and the Disadvantaged Communities Advisory Group

SB 350, the Clean Energy and Pollution Reduction Act of 2015, requires that the CPUC and the CEC create a Disadvantaged Communities Advisory Group (DACAG) to advise on programs proposed to achieve clean energy and pollution reduction. In early 2018, the CPUC and the CEC jointly approved members of a new advisory group consisting of representatives of disadvantaged communities. As defined in Senate Bill 350, disadvantaged communities are the most burdened census tracts in California. Relative burden is determined by review of data on 20 pollution/health and socioeconomic factors. The DACAG will advise on programs related to renewable energy, energy efficiency, transportation electrification, distributed generation, and clean energy research and development and determine whether those proposed programs will be effective and useful in disadvantaged communities.

At a June 21, 2019, meeting of the DACAG, Clean Transportation Program staff solicited feedback on the March 27, 2019, draft of this Investment Plan Update from the DACAG members.[42] In response, the DACAG provided comments on the *2019-2020 Investment Plan Update* on June 28, 2019.[43] These comments included recommendations on how the *2019-2020 Investment Plan Update* can effectively benefit communities disproportionately burdened by pollution and socioeconomic challenges. Recommendations from the DACAG included:

- Moving 100 percent of program funding toward zero-emission fuels.
- Funding projects exclusively in and benefiting disadvantaged communities.
- Expanding the definition of disadvantaged communities beyond the CalEnviroScreen definition.
- Increasing transparency and tracking expanded metrics to measure how projects "benefit" disadvantaged communities.
- Prioritizing and investing in community outreach and engagement.
- Expanding support for workforce development.

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

42 DACAG meeting materials available at https://www.cpuc.ca.gov/DACAG/. The previous version of this investment plan update (Lead Commissioner Report version) is available at https://www.energy.ca.gov/altfuels/2018-ALT-01/documents/.

43 SB 350 Disadvantaged Communities Advisory Group, "SB 350 Disadvantaged Communities Advisory Group Comments on 2019-2020 Investment Plan Update," June 28, 2019. Submitted to Docket 18-ALT-01, TN# 228878. Available at https://efiling.energy.ca.gov/GetDocument.aspx?tn=228878&DocumentContentId=60238.

- Expanding the Clean Transportation Program Advisory Committee to increase representation of program beneficiaries, environmental justice communities, rural communities, tribes, and others.

The CEC will continue coordinating with the DACAG throughout the development of future Investment Plan Updates, as well as the Clean Transportation Program in general, to achieve equity and access for all Californians.

Complementary Funding Programs

Air Quality Improvement Program and Low Carbon Transportation Investments

In addition to the Clean Transportation Program, AB 118 also created the Air Quality Improvement Program (AQIP), which CARB administers. While the Clean Transportation Program 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 Incentive Project (HVIP), as well as funding for other advanced emission reduction technologies for vehicles. Before the availability of appropriations from the GGRF, the Clean Transportation Program provided $49.1 million in funding to backfill CVRP needs, as well as $4 million for HVIP incentives.

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

In October 2018, CARB approved the *Proposed FY 2018-2019 Funding Plan for Clean Transportation Incentives* that includes funding totaling $483 million for LCTI and AQIP projects.[44] Table 10 summarizes the funding allocations.

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

Table 10: FY 2018-2019 CARB Clean Transportation Incentives Allocations

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

Source: California Air Resources Board

Many project categories listed above have particular importance to the goals and strategies of the Clean Transportation Program and are further discussed in subsequent chapters of this Investment Plan Update.

CPUC Transportation Electrification Activities

In 2014, the CPUC adopted Decision 14-12-079 to allow consideration of utility ownership of electric vehicle charging stations and infrastructure on a case-specific basis. Subsequently, the CPUC approved infrastructure pilot programs for Pacific Gas and Electric Company (PG&E), San Diego Gas & Electric Company (SDG&E), and Southern California Edison (SCE) to install 7,500, 3,500, and 1,500 charging stations, respectively.[45] The utility programs for light-duty infrastructure are described further in the Electric Vehicle Charging Infrastructure section in Chapter 3 of this report.

The CPUC is also working to implement provisions of SB 350 by directing the six investor-owned electric utilities under the CPUC's jurisdiction to propose portfolios of transportation electrification programs and investments that can be implemented over the next five years. The three major investor-owned utilities submitted more than $1 billion in applications to the CPUC for electric vehicle charging infrastructure projects, with $780 million of these projects approved in January and May 2018. These projects include roughly $592 million for medium- and heavy-duty vehicle infrastructure and $171 million for light-duty vehicle infrastructure. The projects for medium- and heavy-duty electric vehicle infrastructure are discussed further in the Medium- and Heavy-Duty Zero-Emission Vehicles and Infrastructure section in Chapter 3 of this report.

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

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

School Bus Replacement Program

In the November 2012 California general election, voters approved Proposition 39 to improve energy efficiency and expand clean energy generation in schools and community colleges. This proposition provided 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) allocated 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 $75 million for the retrofit or replacement of school buses.

The CEC administers this funding, and priority is given to school districts operating the oldest and most polluting diesel school buses, as well as to school buses operating in disadvantaged and low-income communities. The CEC has developed strong relationships with every local education agency in California through the successful implementation of Proposition 39 and will use these established relationships to expedite the replacement of school buses statewide. The $75 million in funding provided by SB 110 will be used exclusively for the purchase of battery-electric school buses, and this amount will be supplemented with up to $13 million in Clean Transportation Program funds to provide the necessary charging infrastructure to operate the buses. For circumstances in which battery-electric propulsion is not feasible, nearly $4 million in Clean Transportation Program natural gas vehicles funding and $2.1 million in Clean Transportation Program natural gas fueling infrastructure funds from previous fiscal years are being made available for natural gas-powered school buses and necessary fueling infrastructure.

Community Air Protection Program

In 2017, Assembly Bill 617 (C. Garcia, Chapter 136, Statutes of 2017) was signed into law establishing the Community Air Protection Program.[46] The law requires new community-focused and community-driven action to reduce air pollution and improve public health in communities that experience disproportionate burdens from exposure to air pollutants. In September 2018, CARB adopted a *Community Air Protection Blueprint* describing how it will work with local residents, air districts, and other partners to identify local air quality problems, develop solutions, and track progress together.[47] CARB also selected the first 10 communities that will be the focus of additional targeted actions—either increased community air

46 Information on CARB's Community Air Protection Program is available at https://ww2.arb.ca.gov/index.php/our-work/programs/community-air-protection-program.

47 California Air Resources Board. October 2018. "Community Air Protection Blueprint." Available at https://ww2.arb.ca.gov/sites/default/files/2018-10/final_community_air_protection_blueprint_october_2018.pdf.

monitoring, development of community emissions plans, or both. Located across the state and varying in size and population, these communities have high cumulative impacts from multiple air pollution sources in California. More communities will be added to the program.

The Legislature has also appropriated funding to support early actions to address localized air pollution through targeted incentive funding to use cleaner technologies in these communities. Between Fiscal Years 2017-2018 and 2018-2019, the state budget has allocated $495 million of GGRF funding for early actions under AB 617 to be administered by air districts in partnership with local communities. This funding emphasizes cleaner vehicles, equipment, and stationary sources of emissions, with a priority on zero-emission projects. In April 2018, CARB approved guidelines for the 2017-2018 Community Air Protection funds and updated the guidelines in May 2019 to address additional direction from the Legislature for the 2018-2019 funds.[48] In addition, the Legislature has provided $15 million in community assistance grants to support community participation in the AB 617 process, and CARB has already awarded the first $10 million to 28 groups.

Settlement Agreements

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 $423 million from a national Environmental Mitigation Trust for projects to reduce fully the lifetime excess NO_X emissions caused by the illegal devices. In May 2018, CARB approved a Beneficiary Mitigation Plan outlining how these funds will be spent.[49] The plan targets a minimum of 50 percent of funding 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.[50] In addition, Volkswagen will invest $800 million in ZEV-related projects in the state and must offer and sell additional battery-electric vehicle models in California between 2019 and 2025.

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

48 Information on CARB's Community Air Protection incentives: https://www.arb.ca.gov/msprog/cap/capfunds.htm.

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

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

investment plans, each of which will cover 30 months and total $200 million, to CARB for approval. The first of these plans was approved in July 2017. In December 2018, CARB approved Electrify America's investment plan for the second 30-month cycle, which began July 1, 2019.[51] The ZEV infrastructure funding will complement Clean Transportation Program investments in electric vehicle charging infrastructure. In addition, CARB allocated $10 million from the Environmental Mitigation Trust for light-duty zero-emission vehicle infrastructure projects. The CEC will monitor the development of the Volkswagen settlement investment plans to ensure that investments are coordinated. Details from the Volkswagen settlement investment plans are discussed in the Electric Vehicle Charging Infrastructure section in Chapter 3 of this report.[52]

California Public Utilities Commission (CPUC) / NRG Settlement Agreement

In 2012, the Federal Energy Regulatory Commission approved an agreement between NRG Energy and the CPUC to settle outstanding legal issues regarding the California energy crisis. The settlement required NRG to invest $102.5 million (original settlement amount) to install electric vehicle charging infrastructure across the state. The NRG settlement included project designs with four key components: public fast charging stations, electrical upgrades for electric vehicle charging stations at existing buildings, research and development on advanced charging technologies, and programs to increase electric vehicle access for underserved communities. The CPUC and NRG have agreed to amendments that have extended and increased the public benefits related to the settlement agreement.

51 Electrify America, October 3, 2018. *California ZEV Investment Plan: Cycle 2.* Available at https://www.arb.ca.gov/msprog/vw_info/vsi/vw-zevinvest/documents/c2zevplan_100318.pdf.

52 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:
Zero-Emission Vehicles and Infrastructure

The mass adoption of zero-emission vehicles (ZEVs), including plug-in electric vehicles (PEVs) and fuel cell electric vehicles (FCEVs), is a critical component in California's decarbonization goals, in addition to its air quality standards and petroleum reduction goals. This mass adoption has been recognized in several state laws and policies, including SB 1275, which established a target of 1 million ZEVs and near-ZEVs in California by 2023, and Executive Order B-16-2012, which calls for 1.5 million ZEVs on California roads by 2025. Most recently, Executive Order B-48-18 set a goal of achieving 5 million ZEVs by 2030.

However, the expansion of ZEVs will depend on the availability of refueling infrastructure that meets consumers' needs and expectations. In recognizing this dependence, Executive Order B-48-18 also set goals for installing 250,000 electric vehicle chargers (including 10,000 DC fast chargers) and 200 hydrogen refueling stations by 2025.

Relative to most previous investment plan updates, the FY 2019-2020 funding allocations for zero-emission vehicle infrastructure represent a drastic increase in funding, specifically for electric vehicle charging infrastructure. (The FY *2018-2019 Investment Plan Update* included a larger amount of funding for this allocation; however, this larger amount was due to an atypical amount of total funding.) The increase reflects a near-term need to achieve the number of charging points needed to support the state's goals of 1.5 million zero-emission vehicles by 2025, as well as a long-term commitment to decarbonizing the transportation sector as a whole.

Light-Duty Electric Vehicle Charging Infrastructure

Cumulative sales of PEVs, which include battery-electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs), are growing rapidly in California, with annual sales increasing 84 percent in 2018[53] and more than 600,000 sold through June 2019.[54] These sales account for half of the vehicles sold in the United States. In the first half of 2019, the third-most purchased model vehicle in California was the Tesla Model 3, which indicates the rapid pace of electric vehicle adoption by consumers.[55] Furthermore, the CEC forecasts that between 1.5 million and 2.4 million ZEVs will be in the state by 2025, setting California on track to meet or

53 Veloz. January 11, 2019. *CA Electric Car Sales Broke Year-Over-Year Increases Every Month in 2018.* Available at http://www.veloz.org/wp-content/uploads/2019/01/Veloz-2018-Sales-Year-in-review-Release-FINAL.pdf.

54 Veloz. March 4, 2019. *Detailed Monthly Sales Chart*. Available at http://www.veloz.org/wp-content/uploads/2019/03/2_feb_2019_Dashboard_PEV_Sales_veloz.pdf.

55 Mulkern, Anne C. *E&E News*. August 2019. "Plug-Ins Are a Best-Seller in Calif. for the Time." Available at https://governorswindenergycoalition.org/plug-ins-are-a-best-seller-in-calif-for-the-first-time/.

exceed the state ZEV deployment goals for 2025.[56] A convenient, reliable network of public electric vehicle charging stations (EVCS) will be critical to continue supporting the expansion of PEV ownership in California and ensure state ZEV deployment goals are realized. (Most California ZEVs in the near term are expected to be PEVs, as CARB manufacturer surveys forecast 47,200 FCEVs on California roads in 2024.)[57]

Technology Overview

Charging infrastructure is typically categorized into three power ratings: Level 1, Level 2, and direct current (DC) fast charging. More than 90 percent of charging connectors funded to date by the Clean Transportation Program 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.[58] Fewer than 3 percent of charging connectors funded by the Clean Transportation Program 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.[59] Finally, DC fast charging uses DC electricity at 480 volts to recharge a BEV to 80 percent capacity in about 30 minutes, though the time required depends on the size of the vehicle battery and the power level of the charger.[60]

In addition to varying by charging rate, charging infrastructure varies by location type. Residential projects account for 45 percent of the Level 2 charging connectors funded by the Clean Transportation Program to date, with most 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 CEC discontinued funding for private-use residential charging stations. Shared-use residential charging stations, which are predominantly used in multifamily housing, still face barriers that impede PEV adoption. Projects at multifamily housing have been historically underrepresented by applicants despite efforts to target incentives toward electric vehicle charging station installations at these locations. However, increased DC fast charging could be one solution to help integrate lack of residential charging at multiunit dwellings.

Workplace and public charging stations are another major component of the state's portfolio of charging stations. Public chargers include charging locations at stores, parking garages,

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

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

58 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.

59 Ibid.

60 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.

universities, municipal governments, curbside locations, and other common, publicly accessible destinations. When residents of multifamily housing are unable to charge at home, having an available site to charge at work or access to other public locations can serve as an alternative. If located far from home, workplace and public charging can also help BEV owners extend their range and PHEV owners increase their electric miles driven. Open access to public chargers in California is ensured by the Electric Vehicle Charging Stations Open Access Act, which prohibits requiring subscription fees or memberships as a condition of use for publicly accessible chargers.[61]

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

Assessing Charging Infrastructure Needs for Light-Duty Vehicles

In an attempt to quantify the number of charging stations needed to service the growing number of PEVs in California, the CEC and NREL developed the Electric Vehicle Infrastructure Projections (EVI-Pro) tool. EVI-Pro estimates the number of charging connectors that will be needed at the local level while accounting for differing charger power levels, location types, and PEV adoption rates. This tool allows the CEC 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. The EVI-Pro estimates of the amount of charging infrastructure needed to support 1.5 million ZEVs by 2025 helped inform Executive Order B-48-18, which calls for 250,000 charging points (including at least 10,000 DC fast chargers) by 2025.

To track progress toward this 2025 goal, CEC staff sought data and estimates regarding the number of public or shared charging connectors that exist within California, as well as the recent and proposed charging infrastructure investments of the Clean Transportation Program and other key state funding mechanisms.[62] Table 11 below provides estimates of the existing number of public or shared Level 2 and DC fast charging connectors or a combination within the state. The table also provides estimates of the number of connectors to be installed with previous years' Clean Transportation Program funds and announced plans from other major

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

62 The number of existing charging ports within California is difficult to measure and imprecise, as available data and reporting requirements vary widely. Notably, these estimates do not include private, nonshared charging ports, such as household garages or private (nonshared) fleets or workplaces.

funding programs. Finally, the table summarizes the estimated shortfall in charging infrastructure relative to the goals of Executive Order B-48-18.

Table 11: Progress Toward 250,000 Charging Connectors by 2025

	Level 2 Charging Connectors	DC Fast Charging Connectors
Existing Charging Connectors (Estimated)*	37,400	2,900
Allocated Funding for Chargers (includes anticipated funding from Clean Transportation Program)**	124,600	3,500
Total	162,000	6,400
2025 Goal (Executive Order B-48-18)	*240,000*	*10,000*
Gap From Goal	78,000	3,600

Source: California Energy Commission. Analysis as of March 8, 2019. *Existing charging ports estimated based on available data from U.S. Department of Energy's Alternative Fuels Data Center, as well as informal interviews with some (but not all) major charging infrastructure providers. **Estimate of ports from other state programs derived from public presentations and statements by utilities, California Public Utilities Commission, CARB, other entities, and the Energy Commission.

As indicated in the final row of Table 11, CEC staff estimates that there is a sizable gap (more than 80,000) between the number of charging connectors needed in 2025 and the number of expected charging connectors available that year. Stakeholders have expressed concern over relying on public funds for long-term investments in charging infrastructure with regard to issues around ownership, maintenance, liability, and stranded investments. Indeed, some portions of this gap might be addressed without further public investment, especially if innovative business models evolve or equipment and installation costs decline with scale or both. The near-term gap might also be reduced by the introduction of new technologies that reduce the ratio of necessary charging connectors per PEV (such as mobile chargers or faster charging rates).

Collectively, however, electric vehicle infrastructure investments are following at a slower pace compared to trajectories of PEV adoption. It is also possible that California will exceed the goal of 1.5 million zero-emission vehicles on the road by 2025, and the state will need more chargers to meet the expanded market. It is likely that the gap will continue to grow beyond 2025 as PEV adoption continues to grow.

CEC staff conducted EVI-Pro modeling to estimate the number of charging connectors needed to support 1.5 million ZEVs; staff did not take into account the accelerating market for electric vehicles in the transportation network company (TNC) sector. With announcements from Lyft to offer a "Green Mode" to allow customers to ride in a ZEV, more TNC vehicle miles will be fully electric, which increases demands on overly used charging infrastructure. In the future, the EVI-Pro model should account for the unique demands of TNCs charging infrastructure.

The CEC expects that additional (and significant) public funding is still appropriate and necessary toward meeting the needs of prospective PEV buyers through 2025. In recognition of this need, the funding allocation for this activity in the *2019-2020 Investment Plan Update* is notably higher than in most previous investment plan updates to meet the growing needs of

PEV charging, as well as demonstrate the state's commitment to the mass market adoption of ZEVs.

Innovations in Charging Technology and Business Strategies

Most 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.

The CEC is seeking ways to advance innovative and transformative technologies and transportation trends that can increase the efficiency and the effectiveness of zero-emission charging infrastructure. Newer recharging technologies, such as robotic charging (which can initiate charging sessions without human involvement), pantograph charging (which can provide electricity to vehicles while in motion via contact), and wireless charging (which can recharge vehicles without direct contact) have shown great potential to improve upon the speed and cost-effectiveness of charging infrastructure. Such advancements could greatly increase use of existing equipment and enable new private investments. Supporting innovative technologies and emerging transportation trends, such as TNCs and autonomous vehicles, can have a real effect in accelerating zero-emission vehicles toward broader commercialization. The CEC is also committed to enabling "smart" charging and vehicle-grid integration with the grid, which help reduce costs for PEV drivers and all electricity customers.

As the market for PEVs becomes more developed, financing for electric vehicle charging stations will eventually need to shift from government incentives to private sector lending. Electric vehicle chargers, however, may require innovative business models because of uncertain long-term payoff and risk, and these uncertainties may reduce the willingness of lenders to fund EVCS with competitive financing terms. To validate the profitability and feasibility of financing charging stations, the Clean Transportation Program 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, CEC staff expects to reevaluate and modify this program to best meet the needs for charging infrastructure development in the state. Other advanced financing mechanisms may also be considered as EVCS markets continue to mature.

New mobility services, including car- and ridesharing and autonomous and connected vehicles, present other opportunities to expand the use of ZEVs. Thus far, ZEV use has been limited largely to those who have the means to purchase a new vehicle. Dedicated ZEV car- and ridesharing services, however, can provide zero-emission transportation options for drivers and passengers who would otherwise have no alternatives to conventional automobiles. To advance ZEV adoption, the CEC may provide funding from this category to purchase and install charging infrastructure for demonstration PEV car- and ridesharing services. These demonstrations may be targeted in disadvantaged and rural communities to provide further

benefits to Californians who lack adequate transportation options. The $46 million CARB is investing in car- and ridesharing in disadvantaged communities with its Low Carbon Transportation funding would further complement Clean Transportation Program investments in this area.

Planning and Readiness

The CEC has provided funding to other project types that can indirectly achieve the goals of the Clean Transportation Program, including regional alternative fuel readiness plans. The Regional Alternative Fuel Readiness Planning allocation provided a funding source for planning that prepares for and expedites the launch of alternative fuel infrastructure and vehicles.

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

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

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

Clean Transportation Program Funding to Date

The CEC has supported the rollout of PEVs by awarding nearly $95 million in Clean Transportation Program funding for electric vehicle charging infrastructure. Due in part to these investments, California has the largest network of publicly accessible electric vehicle chargers in the nation.

Clean Transportation Program investments have funded EVCS at many types of locations, as detailed in Table 12. More than half of these Level 2 charging stations were installed at homes to support the early deployment of the first PEVs in the state. The residential, fleet, workplace, multifamily housing, and public charging connectors, as reported in Table 12, consist entirely

of Level 1 and Level 2 charging stations. The corridor charging stations consist mostly of fast chargers, but many sites also include some Level 2 charging stations.

Table 12: Charging Connectors Funded by the Clean Transportation Program as of March 1, 2019

Status	Private Access			Publicly Accessible			Total
	Residential (Single & Multifamily)	Fleet	Workplace	Multifamily Housing	Public	Corridor/ Urban Metro	
Installed	3,936	115	364	341	3,118	226	**8,100**
Planned	0	-	76	8	191	1,280	**1,555**
Total	**3,936**	**115**	**440**	**349**	**3,309**	**1,506**	**9,655**

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

California Electric Vehicle Infrastructure Project (CALeVIP)

In December 2017, the CEC introduced the California Electric Vehicle Infrastructure Project (CALeVIP) to provide streamlined Clean Transportation Program incentives for light-duty electric vehicle charging infrastructure. The incentives provided through CALeVIP simplify the funding process and accelerate charger deployment compared to the previously used grant solicitations. Each CALeVIP project provides incentives for infrastructure in specific regions throughout the state, with funding targeted at regions that have low rates of infrastructure installation or lack adequate incentives from utilities and other sources.

Through June 2019, the CEC has allocated $51 million for charger rebates through CALeVIP, and the Commission may make up to $200 million available through this funding mechanism depending on demand, project performance, and funding availability. CALeVIP incentives have been available for businesses and public agencies in Fresno County for Level 2 chargers; in Los Angeles, Orange, Riverside, and San Bernardino Counties for DC fast chargers; in Sacramento County for DC fast chargers and Level 2 chargers; and in Humboldt, Shasta, and Tehama Counties for DC fast chargers and Level 2 chargers. In late 2019, the Fresno County incentive project is expected to be rolled into a larger San Joaquin Valley project. Also in 2019, the Central Coast incentive project will launch, which will include the counties of Monterey, Santa Cruz, and San Benito. In 2020, additional CALeVIP project areas are expected for funding and may include the southern Bay Area, San Diego County, and the Sonoma coastal area. Dedicated funding amounts or higher incentive amounts or both are also available under CALeVIP for project sites within disadvantaged communities. CEC staff continues to coordinate closely with local councils of governments, local governments, and municipalities to leverage other funding opportunities to increase chargers in focused locations to maximize the effectiveness of limited Clean Transportation Program funds. To this end, there are no plans to make CALeVIP a statewide program.

Other Sources of Funding for PEV Infrastructure

In 2014, the CPUC adopted Decision (D.) 14-12-079, which permits utility ownership of electric vehicle charging infrastructure, contingent upon an examination of the utility program through

a balancing test.[63] 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 the respective service territories, and these proposals were approved by the CPUC in 2016.

Southern California Edison (SCE) launched Phase 1 of its "Charge Ready" pilot program in 2016, which provided roughly $22 million over a year to install an estimated 1,500 site host-owned charging stations at multifamily housing, workplaces, and other public locations.[64] In 2018, SCE received approval for an additional $22 million in Charge Ready bridge funding.[65] San Diego Gas & Electric (SDG&E) launched its "Power Your Drive" pilot program in 2017, which provides up to $45 million over three years to install an estimated 3,500 SDG&E-owned charging stations at multifamily housing and workplaces.[66] Pacific Gas and Electric Company (PG&E) began projects under its "EV Charge Network" pilot program in 2017, which will provide up to $130 million over three years to install an estimated 7,500 site-owned and PG&E-owned charging stations at multifamily housing and workplaces.[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.

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

Other organizations have also committed to providing substantial funding for light-duty charging infrastructure installations in California. NRG Energy, Inc., and EVgo continue to

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

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

65 Southern California Edison. "Business Update July 26, 2019." Available at https://www.edison.com/content/dam/eix/documents/investors/events-presentations/eix-july-2019-business-update.pdf.

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.

implement the 2012 settlement agreement between the CPUC and certain NRG-affiliated entities to install electric vehicle charging infrastructure across the state. A total of 562 fast chargers will be installed under the settlement, more than twice the originally specified 259 fast chargers due to cost efficiencies. In addition, as of March 2019, EVgo and NRG completed 6,875 make-ready stubs for 792 sites.[68] Volkswagen, through its subsidiary Electrify America, has also agreed to invest $800 million over 10 years for ZEV infrastructure, education, and access in California as part of a settlement with CARB. For the first 30-month cycle of the settlement, Electrify America is expected to invest roughly $45 million in community chargers in major metropolitan areas and $75 million in a highway fast-charging network throughout the state.[69] For the second cycle, Electrify America is expected to invest from $95 million to $115 million in community chargers in major metropolitan areas, $25 million to $30 million in highway fast chargers, and $16 million to $29 million for pilot projects including rural and residential Level 2 chargers and autonomous vehicle and transit agency fast chargers.[70] CEC staff will continue to monitor and coordinate with other EVCS deployment projects to ensure the strategic placement of electric vehicle infrastructure and avoid duplication of efforts. As more funding sources become available, all agencies, utilities, and companies providing EVCS funding will need to coordinate to expedite expansion of the charging network and avoid duplication. Figure 7 illustrates recent annual funding from major sources for electric vehicle charging infrastructure in California.

Figure 7: Major Funding Sources for Light-Duty Charging Infrastructure in California

Source: California Energy Commission. Non-Clean Transportation Program funding amounts are estimated for FY 2018-2019 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.

Senate Bill 350 (De León, Chapter 547, Statutes of 2015) established new goals to reduce greenhouse gas emissions and air pollution for 2030 and beyond. This legislation tasked the CPUC with directing investor-owned utilities to submit applications to support widespread transportation electrification. PG&E, SCE, and SDG&E submitted more than $790 million in proposals for a variety of infrastructure projects for medium- and heavy-duty vehicles and equipment. In January and May 2018, the CPUC approved $592 million of these proposals.

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68 EVgo Services LLC. April 5, 2019. *Settlement Year 7 – First Quarter Progress Report to the California Public Utilities Commission.* Available at https://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=6442461481.

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

70 Electrify America, October 3, 2018. *California ZEV Investment Plan: Cycle 2.* Available at https://www.arb.ca.gov/msprog/vw_info/vsi/vw-zevinvest/documents/c2zevplan_100318.pdf.

The resulting projects are expected to support the electrification of at least 15,000 medium- and heavy-duty vehicles at transit agencies, ports, and warehouses.[71] Though this investment is significant, 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.

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

Related State Policy

Senate Bill 350 requires CARB, in consultation with the CEC, to develop and release a study on the barriers faced by low-income customers in adopting zero-emission and near-zero-emission transportation options. As a result, in April 2017, CARB released a draft guidance document titled *Low-Income Barriers Study, Part B: Overcoming Barriers to Clean Transportation Access for Low-Income Residents.* CARB subsequently issued the final guidance document in February 2018 after incorporating comments received on the draft.[72] The guidance document cited affordability, awareness, and a lack of permanent, long-term funding sources as barriers to increasing access to clean transportation and mobility options in underserved and disadvantaged communities. CEC staff will take these barriers and the recommendations to overcome them into account when developing future funding opportunities.

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

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

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

In September 2018, Governor Brown signed Senate Bill 1000 (Lara, Chapter 368, Statutes of 2018). The legislation requires the CEC, in consultation with CARB, to assess whether electric vehicle charging station infrastructure is disproportionately deployed. As used in the legislation, "disproportionate" refers to population density, geographical area, or income level. If the infrastructure is found to be disproportionately deployed, the Commission must use Clean Transportation Program funding to install more proportionately new charging station infrastructure, unless the Energy Commission finds the disproportionate deployment reasonable and in furtherance of state energy or environmental policy goals.[73] CEC staff is beginning to identify and collect the requisite data that will inform this analysis (and other transportation electrification analysis) as part of the *2019 Integrated Energy Policy Report.*

Summary

Issued in January 2018, Executive Order B-48-18 set a directive to install 250,000 zero-emission vehicle charging ports, including 10,000 DC fast charging ports, in California by 2025. CEC staff, using NREL's EVI-Pro modeling, estimates that the sum of existing charging ports and charging ports funding across all state funding programs will result in 162,000 Level 2 charging ports and 6,400 DC fast charging ports by 2025, leaving gaps of nearly 78,000 Level 2 charging ports and 3,600 DC fast charging ports by 2025. Staff recommends an aggressive near-term funding solution to help close this gap. Even if the gap is ultimately closed by the 2025 time frame, it is important to have funding available to ensure the public adoption of EVs is not stymied by the lack of charging infrastructure in the intervening years. To help achieve this adoption, the CEC allocates $32.7 million for light-duty electric vehicle charging infrastructure for FY 2019-2020. This funding will complement the efforts made by the private sector and electric utilities by increasing statewide investments and funding projects not covered by the geographic area or scope of other programs. These significant investments in electric vehicle charging infrastructure from multiple sources will be necessary to keep pace with expected deployment of PEVs in the state and meet the goals of Executive Order B-48-18.

Medium- and Heavy-Duty Zero-Emission Vehicles and Infrastructure

Freight and transit vehicles serve as a pillar to the California economy, providing indispensable functions for domestic goods movement, international trade, mass transportation, and other essential services. Clean Transportation Program funding in this sector has historically focused on medium- and heavy-duty vehicles, defined here as vehicles with a gross vehicle weight rating above 10,000 pounds. These vehicles represent a small share of California registered vehicle stock, accounting for about 1 million out of 31 million vehicles, or 3 percent; however, this small number of vehicles is responsible for about 23 percent of on-road GHG emissions in the state because of comparatively low fuel efficiency and high number of miles traveled per

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

year.[74] Medium- and heavy-duty vehicles additionally account for nearly 60 percent of NO_X and 52 percent of $PM_{2.5}$ emissions from on-road transportation in California.[75] For these reasons, medium- and heavy-duty vehicles represent a significant opportunity to reduce GHG emissions and criteria emissions while focusing on a small number of vehicles. Nonroad freight vehicles, such as forklifts and other cargo handlers, have similar or supporting purposes and potential for emission reductions.

As mentioned in the previous section, the CEC has used the EVI-Pro tool to estimate charging infrastructure needs for the light-duty sector. However, the EVI-Pro tool is not configured to provide similar estimates for medium- and heavy-duty vehicles, due to comparative lack of information regarding travel patterns and preferred approaches for recharging. As the CEC prepares to conduct its inaugural charging infrastructure assessment as part of Assembly Bill 2127 (Ting, Chapter 365, Statutes of 2018), estimating the charging needs of medium- and heavy-duty vehicles will be one of the key areas of analysis.

However, in anticipation of the need to ramp up charging infrastructure drastically for this sector, the funding allocation for this activity in the *2019-2020 Investment Plan Update* has been increased dramatically, to meet the growing needs of medium- and heavy-duty zero-emission vehicles and charging infrastructure, as well as demonstrate the state's commitment to improving air quality.

Clean Transportation Program Funding to Date

The CEC has provided more than $125 million in Clean Transportation Program funding for a wide variety of alternative fuel and advanced technology powertrains that can be incorporated into California trucks and buses. Table 13 summarizes the portfolio of the advanced technology freight and fleet vehicle projects supported through the Clean Transportation Program.

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

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

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

Table 13: Advanced Freight and Fleet Vehicle Projects Supported by the Clean Transportation Program as of March 1, 2019

Medium- and Heavy-Duty Vehicle Demonstrations	# of Demonstration Projects
Medium-Duty BEVs	5
Medium-Duty PHEVs	2
Medium-Duty Hybrids	1
Heavy-Duty BEVs	10
Heavy-Duty PHEVs	7
Heavy-Duty Hybrids	4
Electric Buses	4
Natural Gas Trucks	7
Fuel Cell Trucks	2
Fuel Cell Buses	5
Off-Road Hybrids	1
E85 Hybrids	1
Vehicle-to-Grid	3
Intelligent Transportation Systems	2
Total	**54**

Source: California Energy Commission

Other Sources of Funding

Other state programs provide funding for the vehicle types discussed in this section, though often at different stages of commercialization and at different scales. CARB's Clean Transportation Incentives are designed to accelerate the transition to advanced technology, low-carbon freight and passenger transportation with a priority on providing health and economic benefits to California's most disadvantaged communities. CARB's approved *FY 2018-2019 Funding Plan Clean Transportation Incentive*s include a $55 million allocation for freight equipment advanced demonstration and pilot commercial deployment projects.[76] The $55 million will be used to fund additional projects from the oversubscribed $150 million Zero- and Near Zero-Emission Freight Facilities Project competitive solicitation held in 2018 using Fiscal Year 2017-18 funds. In addition to the aforementioned funds, most California's $423 million Volkswagen Environment Mitigation Trust funds will be directed to advanced technology heavy-duty vehicles, including zero-emission freight and port trucks, zero-emission buses, and other zero-emission or cleaner-combustion freight and port equipment projects. Funding will be available over multiple years starting later in 2019.

Assembly Bill 1073 (E. Garcia, Chapter 632, Statutes of 2017) extends the requirement at least 20 percent of available truck funding in the California Clean Truck, Bus, and Off-Road Vehicle

76 California air Resources Board. *Proposed Fiscal Year 2018-19 Funding Plan for Clean Transportation Incentives for Low Carbon Transportation Investment and the Air Quality Improvement Program*. September 21, 2018. Available at https://ww3.arb.ca.gov/msprog/aqip/fundplan/proposed_1819_funding_plan.pdf.

and Equipment Technology Program funding (funded by GGRF) go to support early commercial development of existing zero- and near-zero-emission heavy-duty truck technology. Moreover, Senate Bill 1403 (Lara, Chapter 370, Statutes of 2018) requires CARB to develop a three-year investment strategy for zero-emission and near-zero-emission heavy-duty vehicles and equipment. This bill also requires CARB to provide information on milestones achieved by the state's school bus incentive programs and the projected need for funding. The CEC will closely follow the progress by CARB on these subjects.

Furthermore, California's Beneficiary Mitigation Plan for the Volkswagen Environmental Mitigation Trust will provide $90 million for zero-emission Class 8[77] freight and port drayage trucks and $60 million for combustion freight and marine projects. (The solicitation is tentatively scheduled to open in December 2019.)[78]

Allocations from the Clean Transportation Program in this area focus on ZEVs and ZEV infrastructure, as there are other programs with additional funds for near-zero-emission vehicle technologies. During the November 2018 Advisory Committee meeting for the Investment Plan Update, CARB representatives reiterated that there is considerable funding available for low-NO_x engine incentives through the Clean Truck and Bus Voucher Program which incorporates HVIP and low-NO_x engine incentives.[79] Furthermore, CARB's Carl Moyer Program provides about $60 million for projects each year statewide through the state's regional air quality management districts. The program helps reduce air pollution, especially from diesel exhaust, by providing incentive funds to private companies and public agencies to purchase cleaner heavy-duty on-road and off-road vehicle engines and equipment.

Related State Policy

Public transit is critical to meeting California's goals of reducing greenhouse gas emissions, reducing per-capita vehicle miles traveled, and increasing the use of public transportation. California transit agencies operate and maintain about 12,000 transit buses, and the current zero-emission bus fleet is growing. There are about 150 zero-emission buses operated by transit agencies on California roads.[80] However, CARB's Innovative Clean Transit regulation set a statewide requirement for public transit: by 2040, public transit agencies' bus fleets must be entirely zero-emission buses. CARB's new regulation requires all new bus purchases be zero-emission starting January 1, 2029, if specified zero-emission bus deployment targets are not achieved.

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77 Class 8 trucks include all trucks with weight limits more than 33,000 pounds.

78 California Air Resources Board. "California's Beneficiary Mitigation Plan for the Volkswagen Environmental Mitigation Trust." Available at https://ww2.arb.ca.gov/resources/documents/californias-beneficiary-mitigation-plan.

79 Advisory Committee Meeting and Public Workshop on November 8, 2018. Meeting materials and transcript are available at https://ww2.energy.ca.gov/altfuels/2018-ALT-01/documents/.

80 California Air Resources Board. December 14, 2018. "California Transitioning to All-Electric Public Bus Fleet by 2040." Available at https://ww2.arb.ca.gov/es/node/2594.

Furthermore, the California Department of Transportation's (Caltrans) California Transportation Plan 2040 also recognizes transit as key to California reaching its climate and clean transportation goals. Supported by funding from the Greenhouse Gas Reduction Fund, Caltrans and the California State Transportation Agency assist transit operators with acquiring zero-emission buses through programs such as the Low Carbon Transit Operations Program and the Transit and Intercity Rail Capital Program. To date, the Transit and Intercity Rail Capital Program has awarded funding for the purchase of 365 zero-emission buses.[81]

Executive Order B-32-15, issued by Governor Brown in 2015, noted the effects that freight transportation has on GHG emissions and air quality and ordered the development of the *California Sustainable Freight Action Plan*. The plan, released in 2016, discusses potential statewide actions to improve freight efficiency, transition to zero-emission technologies, and increase the competitiveness of the California freight system. The CEC 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. The Ports Energy Collaborative gives port representatives and CEC staff the opportunity to coordinate and share lessons learned from clean transportation projects. This category is expected to be the primary source of CEC funding support for *Sustainable Freight Action Plan* strategies and ports collaborative activities.

Charging for Medium- and Heavy-Duty Vehicles

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

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

The CEC is seeking ways to assist transit agencies with their transition to zero-emission buses. The objective would be to provide targeted capital assistance to install transit zero-emission fueling infrastructure (in other words, "make-ready" equipment and infrastructure for battery

81 California Department of Transportation. August 2018. "Expanding Public Transportation Options: Transit and Intercity Rail Capital Program." Available at https://ww3.arb.ca.gov/cc/capandtrade/auctionproceeds/ccidoc/tircp_082718_ada.pdf.

charging systems and hydrogen fueling equipment) throughout the state where transit buses operate. By providing funding assistance for fueling infrastructure and grid infrastructure improvements needed to support zero-emission transit buses and equipment, the CEC would accelerate the modernization of California's public transport system, support compliance with CARB's Innovative Clean Transit bus regulation for buses, and spread the benefits of transportation electrification to diverse communities.

Hydrogen Refueling Infrastructure for Medium- and Heavy-Duty Vehicles

Fuel cell electric vehicles using hydrogen fuel offer another zero-emission transportation option for California's medium- and heavy-duty sectors and for short-range and long-range applications. The CEC has funded projects that use hydrogen infrastructure for freight vehicles at California seaports and inland warehouses and distribution centers, and the Commission continues to explore new options for advancing this technology.

Companies are also producing or are planning to produce heavy-duty vehicles with hydrogen fuel cell electric powertrains, including transit buses and tractor-trailer trucks. These vehicles, and the fleets that operate them, may require dedicated refueling infrastructure to ensure the safety, security, and fuel supply of the vehicles. CEC staff expects that some portion of Clean Transportation Program funding will be used to support the construction and installation of hydrogen refueling infrastructure specifically for medium- and heavy-duty FCEVs.

Planning and Readiness for Medium- and Heavy-Duty Vehicle Infrastructure

The CEC is seeking ways to assist commercial and bus fleet operators with transitioning to zero-emission medium- and heavy-duty vehicles by providing funding for zero-emission vehicle readiness blueprints. Funding can promote planning efforts that prepare for and expedite the deployment of zero-emission vehicles and infrastructure that are integrated smartly into the grid to reduce charging costs, provide grid benefits, and reduce costs for all electricity users. Commercial and bus fleets throughout the state are facing significant barriers with infrastructure installation as they prepare to incorporate electrification or fuel cell technology or both. Guidance is critical, and CEC staff is working on ways to provide a mechanism for planning, as well as outreach and education to help achieve this transition.

Summary

To meet state GHG and air quality goals, this sector will need to transition to zero-emission technologies, and the resources required for this transition far exceed available funding. CEC staff expects an increasing demand for dedicated charging and refueling infrastructure for medium- and heavy-duty zero-emission freight and fleet vehicles funded through the Clean Transportation Program and by other state incentives programs. As the state's lead agency for fueling infrastructure deployment, the CEC will focus on the infrastructure needs of medium- and heavy-duty zero-emission vehicles; however, the option to fund medium- and heavy-duty zero-emission vehicle demonstrations will remain eligible. In addition to vehicle and infrastructure investments, the CEC will seek ways to include grid integration, integrated storage solutions, and charging management as complementary technologies.

For FY 2019-2020, the CEC allocates $30 million for this category dedicated to medium- and heavy-duty zero-emission vehicles and infrastructure. Staff intends to balance the need to

continue demonstration projects while taking into account similar funding available from other sources and an increasing need for charging and refueling infrastructure. Staff expects that funding from this category will also be necessary to address CEC-specific actions outlined in the *California Sustainable Freight Action Plan* and help achieve GHG and air pollution reduction goals through investments in public transit. These projects may include propulsion and nonpropulsion aspects, such as alternative-fueled vehicles, infrastructure, and other advanced freight and fleet technologies.

Hydrogen Refueling Infrastructure

Assembly Bill 8 (Perea, Chapter 401, Statutes of 2013) directs the CEC to allocate $20 million annually, not to exceed 20 percent of the funds appropriated by the Legislature, from the Alternative and Renewable Fuel and Vehicle Technology Fund for planning, developing, and building hydrogen-refueling stations until there are at least 100 publicly available stations in California. The Clean Transportation Program funds the development of hydrogen refueling stations to support the early fuel cell electric vehicle (FCEV) market and the increasing population of on-road FCEVs.

Executive Order B-48-18 directs that all state entities work with the private sector and all appropriate levels of government to put at least 5 million ZEVs on California roads by 2030 and spur the construction and installation of 200 hydrogen fueling stations by 2025.

Technology Overview

FCEVs using hydrogen fuel offer another zero-emission transportation option for Californians. Like electricity, hydrogen can be produced from a variety of pathways, including renewable sources of energy. When produced with one-third renewable energy, the hydrogen for a passenger FCEV can reduce GHG emissions by about 50 to 70 percent compared to a conventional gasoline vehicle, and this percentage is comparable to the GHG emissions benefits of BEVs that use electricity from the power grid.[82] FCEVs can also travel farther and be refueled more quickly than BEVs. Fuel cells enable electrification of a broad range of vehicles, including passenger cars, light-duty trucks and SUVs, transit buses, and heavy-duty trucks and can complement BEVs by offering zero-emission vehicles to drivers who need more range or faster refueling.

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

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

powertrains. CARB manufacturer surveys forecast that 47,200 hydrogen fuel cell electric vehicles will be on California roads by the end of 2024.[83]

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

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

The CEC, through the Clean Transportation Program, has supported the development of hydrogen refueling regulations and test procedures, hydrogen refueling infrastructure test equipment, and regional readiness plans for FCEV and refueling station development. The CEC also provides data on Clean Transportation Program-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 installation.

Clean Transportation Program Funding to Date

Through the Clean Transportation Program, the CEC has provided more than $130 million of funding to install or upgrade 64 publicly available hydrogen stations capable of light-duty vehicle refueling. As of the August 2019, 40 hydrogen-refueling stations were operational in California, with 39 funded by the Clean Transportation Program. The most recent completed funding solicitation issued by the Clean Transportation Program 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 CEC provided $33.4 million in grants for this solicitation with funds from multiple fiscal years.

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

As with previous awards, the 16 stations funded under GFO-15-605 will provide at least 33 percent of the hydrogen from renewable sources. Four hydrogen refueling stations previously funded by the Clean Transportation Program will provide 100 percent of the hydrogen from renewable resources. Overall, stations funded by the Clean Transportation Program are expected to dispense fuel with an average of 37 percent renewable hydrogen content. The renewable hydrogen from these agreements is typically derived from either renewable electricity via electrolysis or biomethane via steam methane reformation at central production plants. Of the 64 stations that have received Clean Transportation Program funding, 5 are planned to use on-site electrolysis to generate hydrogen. CEC staff may consider providing Clean Transportation Program funds to support additional on-site renewable hydrogen production at refueling stations. Larger-scale, off-site renewable hydrogen production is discussed in the Low-Carbon Fuel Production and Supply section in Chapter 4 of this report.

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

Since 2014, the CEC offered as much as $100,000 per year for up to three years' worth of O&M funding for each existing or planned station, once operational. Stations that operate without O&M support can face an average annual operating loss of up to $218,000, and this loss must be paid with private capital to keep the station operational. In the long term, station operators must increase hydrogen fuel sales to eliminate operating losses, and this is possible only through greater FCEV development by automakers.

Other Sources of Project Support

In September 2018, CARB's board approved for adoption Resolution 18-34 that modifies the LCFS to allow hydrogen refueling stations to earn hydrogen refueling infrastructure (HRI) credits based on the capacity of the hydrogen station, in addition to credits earned for the fuel dispensed.[84] These credits will provide a subsidy to hydrogen refueling station owners that can supplant CEC O&M funding, thereby increasing the amount of Clean Transportation Program funding available for new station construction. The expected value of these proposed HRI credits and the duration of the incentive exceed what can be offered through the Clean Transportation Program, and the value and duration should reduce investment risk and provide a stable source of operating capital. The CEC will continue discussions with CARB and

84 California Air Resources Board Resolution 18-34 information is available at https://www.arb.ca.gov/fuels/lcfs/rulemakingdocs.htm. This modification to the LCFS provides credits to hydrogen refueling station owners for 15 years, with the credits being calculated based on the nameplate capacity of the station not to exceed 1,200 kilograms of hydrogen per day, and the availability (or uptime) of the station relative to the permitted hours of operation. The amount of dispensed hydrogen is subtracted from the calculation of HRI credits so that credits are not double earned.

stakeholders to ensure that all available funding for hydrogen refueling is used in the most effective manner for encouraging early FCEV adoption.

The California Fuel Cell Partnership (CaFCP) has supported the growth of hydrogen as a transportation fuel since the partnership's inception in 1999. Members of the CaFCP have worked with local fire departments and the California Office of the State Fire Marshal to develop emergency response guides for hydrogen vehicles. The CaFCP has also trained first responders since 2002 on how to respond to fuel cell electric vehicles and hydrogen stations. In addition, to keep FCEV drivers informed of the real-time availability of the hydrogen-fueling network, the CaFCP developed the Station Operational Status System mobile Web application.[85] This application provides status information for hydrogen refueling stations to consumers, allowing them to avoid stations with insufficient fuel or offline equipment.

Related State Policy

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

CARB released the *2018 Annual Evaluation of Fuel Cell Electric Vehicle Deployment & Hydrogen Fuel Station Network Deployment* report in July 2018 to comply with the requirements of Assembly Bill 8.[86] In this assessment, CARB found that California's hydrogen refueling network is continuing to mature with sustained growth in the number of operational refueling stations, and that recent station development progress has remained almost completely on schedule. Manufacturer surveys project 47,200 FCEVs will be on California roads by the end of 2024. CARB also conducted a scenario analysis for the report, which looked at the station deployment needed through 2030 to ensure up to 1 million FCEVs can be deployed in California, providing at least basic coverage to all communities and a capacity sufficient to meet projected FCEV deployment.

In December 2018, the CEC and CARB released the *Joint Agency Staff Report on Assembly Bill 8: 2018 Annual Assessment of Time and Cost Needed to Attain 100 Hydrogen Refueling*

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

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

Stations in California.[87] This annual joint report evaluates progress in establishing a network of 100 hydrogen refueling stations, the factors affecting timely station development, the time and public funding needed to reach the 100-station goal by 2024, and the ability of the hydrogen refueling network to serve the anticipated 47,200 FCEVs projected by the end of 2024. Among the key findings of the joint report:

- Hydrogen refueling station development time has decreased substantively from 2009, with the average time spent before station developers filed an initial permit application for the most recently funded stations at nearly 85 percent less than in the past.
- By 2024, California's hydrogen refueling station network will need to provide nearly double today's capacity, with about 110 open retail stations needed.
- The recent LCFS update, incorporating HRI credits, offers a new incentive to encourage private sector investment and accelerate station development by augmenting Clean Transportation Program funds. Combined with purchasing station equipment in larger quantities, the LCFS update may help achieve economies of scale.
- CARB and the CEC are working to identify conditions under which the hydrogen refueling market could be self-sufficient.
- A long-term vision of up to 1 million FCEVs by 2030 could involve 1,000 hydrogen-refueling stations.
- Future Clean Transportation Program funding allocations will be needed to meet and exceed the 100-station goal by 2024.

Summary

As the market for hydrogen fuel matures and station developers become more experienced, the percentage of the total cost of hydrogen station capital expenses needed to be paid for by the Clean Transportation Program may decrease. Capital expenses may also decrease as more stations are installed and equipment manufacturers are able to achieve economies of scale. To maximize the effectiveness of Clean Transportation Program funding, the CEC may alter the requirements and funding structure of future solicitations, such as offering incentives for higher-capacity and more cost-effective stations. The CEC 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 the hydrogen refueling infrastructure funding allocation, the CEC is considering colocating refueling for commercial vehicles and buses with light-duty vehicle refueling. This approach has the potential to aid in the transition of California's commercial vehicle and bus fleets to a zero-emission alternative while strengthening the business case for light-duty hydrogen refueling through increased station throughput and stations with common designs and fuel

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

supply. This strategy also reduces costs of hydrogen production and distribution as hydrogen-powered commercial fleet and bus vehicles are deployed in greater numbers.

Some stakeholders have expressed concerns about colocating refueling stations. In response, the intent is not to make colocation mandatory, but rather encourage sensible site sharing for commercial vehicles and buses at locations prioritized based on light-duty vehicle owners' needs without diminishing the light-duty customer experience. The increased throughput could make for more sustainable stations, given that manufacturers' projections for on-the-road FCEVs through 2025 lag behind earlier projections.[88]

For FY 2019-2020, the CEC allocates $20 million for hydrogen refueling infrastructure, which is the maximum allocation allowable under current law.[89] With this funding restriction, CEC staff analysis predicts that the Clean Transportation Program will be able to fund a statewide network of up to 110 hydrogen refueling stations that will be operational by the end of 2024. These stations are expected to be able to provide fueling for between 46,900 and 59,300 FCEVs, which should be adequate to support the number of FCEVs that CARB predicts will be on the roads in 2024.

88 California Air Resources Board. July 2019. *2019 Annual Evaluation of Fuel Cell Electric Vehicle Deployment & Hydrogen Fuel Station Network Development*. Available at https://ww2.arb.ca.gov/sites/default/files/2019-07/AB8_report_2019_Final.pdf.

89 California Health and Safety Code Section 43018.9.

Summary of Zero-Emission Vehicles and Infrastructure Allocations

Table 14: FY 2019-2020 Funding for Zero-Emission Vehicles and Infrastructure

Light-Duty Electric Vehicle Charging Infrastructure Relevant Policy Goals: – GHG Reduction – Petroleum Reduction – Low Carbon Fuel Standard – Air Quality – ZEV Regulations – Environmental Equity	$32.7 Million	$61.5 million decrease relative to FY 2018-2019*,**
Medium- and Heavy-Duty Zero-Emission Vehicles and Infrastructure Relevant Policy Goals: – GHG Reduction – Air Quality – Petroleum Reduction – Low Carbon Fuel Standard – Sustainable Freight Action Plan	$30 Million	$12.5 million increase relative to FY 2018-2019***
Hydrogen Refueling Infrastructure Relevant Policy Goals: – GHG Reduction – Petroleum Reduction – Low Carbon Fuel Standard – Air Quality – ZEV Regulations	$20 Million	No change relative to FY 2018-2019**
Total	**$82.7 Million**	

Source: California Energy Commission. *For FY 2018-2019, the Clean Transportation Program received an increased funding appropriation, resulting in a one-time increase in available funds. **The FY 2018-2019 funding allocations for Electric Vehicle Charging Infrastructure and Hydrogen Refueling Infrastructure were most recently modified at an Energy Commission business meeting on October 3, 2018. ***This activity is redirected from the Advanced Technology Vehicle Support category, and now falls under the Zero-Emission Vehicles and Infrastructure category.

CHAPTER 4:
Alternative Fuel Production

Zero- and Near-Zero-Carbon Fuel Production

The California transportation sector depends largely on petroleum, which accounts for 89 percent of ground transportation fuel used in the state.[90] Any low-carbon substitute fuel that can displace the roughly 14 billion gallons of petroleum-based gasoline and 3.3 billion gallons of petroleum-based diesel used per year in California can provide an immediate and long-term opportunity to reduce GHG emissions and petroleum use.[91] 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.[92] In addition, production of and demand for renewable hydrogen are expected to increase in the coming years as more hydrogen fuel cell electric vehicles are sold.

The carbon intensity of renewable fuels can vary significantly depending on the pathway, which accounts for the specific feedstock and production process of the fuel. CARB provides carbon intensity values for most transportation fuels as part of the LCFS. The carbon intensity value accounts for the life-cycle GHG emissions of the fuel, including production, transportation, and consumption, and is reported in grams of carbon dioxide equivalent greenhouse gases per megajoule (gCO_2e/MJ).[93] Maximizing renewable fuel production from the lowest carbon pathways represents a key opportunity to reduce near-term GHG emissions in combustion engines and fuel cell electric vehicles. Biofuels derived from waste-based feedstocks typically have the lowest carbon intensity of all transportation fuels. Clean Transportation Program funding uniquely drives innovative biofuel production plants to California, which may otherwise come from out of state through other funding mechanisms.

Past Clean Transportation Program fuel production awards have been disproportionately located in disadvantaged communities. The projects were funded due to the various possible economic benefits associated with the installation, expansion and operation of the plants. Such anticipated benefits included increases of tax bases and job creation. However, local pollution costs and benefits are less certain. The CEC will seek to further ensure that alternative fuel

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

91 Ibid.

92 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 and renewable diesel. 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.

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

production projects provide economic and environmental benefits within disadvantaged communities.

Fuel Type Overview

Renewable Diesel and Biodiesel

In 2018, renewable diesel was the most common diesel substitute in California with 384 million gallons used, most of which was supplied through overseas imports.[94] Two renewable diesel production plants are operating in California and produced 33 million gallons of renewable diesel fuel in 2017.[95] 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. In 2017, California biodiesel production plants produced 41 million gallons of biodiesel, and 171 million gallons of biodiesel were registered with the LCFS.[96] Renewable diesel and biodiesel have carbon intensities up to 92 percent lower than diesel fuel, depending on the pathway used.[97] Together, renewable diesel and biodiesel accounted for about 50 percent of LCFS credits in 2018, increasing from 9 percent of LCFS credits in 2011.[98]

Ethanol and Renewable Gasoline

Ethanol is the only widely available gasoline substitute, and it is used primarily as a fuel additive with gasoline. California limits ethanol blends in conventional gasoline to 10 percent, although the U.S. Environmental Protection Agency permits blends of up to 15 percent. Though ethanol continues to be the largest volume alternative fuel used in California,

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94 California Air Resources Board. April 30, 2019."LCFS Quarterly Data Spreadsheet." Available at http://www.arb.ca.gov/fuels/lcfs/lrtqsummaries.htm.

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

96 Ibid. California Air Resources Board. April 30, 2019. "LCFS Quarterly Data Spreadsheet." Available at http://www.arb.ca.gov/fuels/lcfs/lrtqsummaries.htm.

97 Compared to California diesel (102.01 gCO2e/MJ), with biodiesel carbon intensity as low as 8.63 gCO2e/MJ and renewable diesel carbon intensity as low as 16.89 gCO2e/MJ. Based on data from the LCFS Fuel Pathway Table (April 16, 2019), available at https://www.arb.ca.gov/fuels/lcfs/fuelpathways/current-pathways_all.xlsx.

98 California Air Resources Board. April 30, 2019. "LCFS Quarterly Data Spreadsheet." Available at http://www.arb.ca.gov/fuels/lcfs/lrtqsummaries.htm.

in-state ethanol use has not substantially changed since 2011. California has the capacity to produce about 223 million gallons of ethanol per year within the state, using primarily corn as a feedstock.[99]

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

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

Biomethane

Biomethane is a commercially mature biofuel that serves as a low- or negative-carbon substitute for conventional natural gas. According to the most recently listed LCFS carbon intensity values, biomethane from anaerobic digestion of wastewater sludge can reduce GHG emissions by as much as 92 percent below diesel, and biomethane derived from high-solids anaerobic digestion of prelandfill food and green wastes possesses a negative carbon intensity roughly 125 percent below diesel.[102] Biomethane derived from dairy biogas has the lowest carbon intensity approved under the LCFS—about *negative* 255 grams of carbon dioxide equivalent greenhouse gases per megajoule (-255 gCO_2e/MJ), indicating that the pathway contributes a net GHG emission reduction.[103]

For gaseous fuels, such as biomethane, producers may have difficulty finding purchasers for the fuel, as biomethane cannot be economically transported by truck or rail, and the complexities and regulations associated with pipeline injection often make this option uneconomical for all but the largest projects. Most often, biomethane fuel must be distributed

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

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

101 Ibid.

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

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

to vehicles at or near the site of production, which can limit the potential of this fuel, especially in rural areas that lack infrastructure and existing natural gas vehicle fleets.

The potential of low-carbon biomethane to replace natural gas in the transportation sector is based on the availability of waste-based feedstocks, and estimates vary on technical and economical availability. Based on a 2013 study from the National Renewable Energy Laboratory, the Union of Concerned Scientists suggests that capturing biomethane from all potential sources of organic waste in California could represent up to 450 million diesel gallon equivalents (DGE), or roughly, 15 percent of diesel fuel use in California.[104] In the *2017 Integrated Energy Policy Report (IEPR)*, the CEC cited a study from the 2016 University of California, Davis, Institute of Transportation Studies indicating a slightly higher economically feasible potential of roughly 623 million DGE. However, based on other studies cited in the *2017 IEPR*, the technical availability (under preferable market conditions) could be four times higher.[105] Regardless, given the limited availability, the carbon reduction benefits from biomethane need to be prioritized for specific transportation applications (as well as other purposes) in which no zero-emission alternative is available.

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

Renewable Hydrogen

Senate Bill 1505 (Lowenthal, Chapter 877, Statutes of 2006) requires that 33 percent of hydrogen used for transportation come from renewable sources. As part of the Low Carbon Fuel Standard credits for ZEV infrastructure that took effect in January 2019, qualifying stations must have a renewable content of 40 percent or higher. 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. (However, lack of access to wholesale electricity could present a market barrier.) 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

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

105 California Energy Commission staff. 2017. *2017 Integrated Energy Policy Report.* California Energy Commission. Publication Number: CEC-100-2017-001-CMF. Available at https://www.energy.ca.gov/2017_energypolicy/.

50 percent.[106] Renewable hydrogen production is being investigated as a viable technology for beneficial use of this surplus renewable energy. Several Clean Transportation Program projects already use electrolysis to generate modest volumes of hydrogen at fueling stations. Potential renewable hydrogen production projects may include using renewable energy to produce large volumes of renewable hydrogen through electrolysis, or commercial-scale steam reformation plants that exclusively use biomethane as a feedstock.

Feedstock Availability

Feedstock availability must also be considered when determining the potential of biofuels. In 2016, the U.S. Department of Energy released Volume I of the *2016 Billion-Ton Report*, which assesses potential available biomass resources in the United States and analyzes associated economic and technological characteristics.[107] 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.

Clean Transportation Program Funding to Date

To date, the CEC has awarded nearly $200 million to 71 low-carbon fuel production projects. These awards are summarized by fuel type in Table 15.

Table 15: Summary of Low-Carbon Fuel Production Awards to Date

Fuel Type	Qualifying Proposals* Submitted	Funds Requested by Qualifying Proposals* (in Millions)	Awards Made	Funds Awarded (in Millions)
Gasoline Substitutes	27	$68.8	16	$39.5
Diesel Substitutes	60	$177.1	26	$74.2
Biomethane	62	$191.9	27	$76.8
Renewable Hydrogen	3	$11.9	2	$7.9
Total	**152**	**$449.7**	**71**	**$198.4**

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

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

107 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.

The most recent Clean Transportation Program solicitations for low-carbon fuel production were GFO-18-601 (focused on community- and commercial-scale projects) and GFO-18-602 (focused on demonstration projects.) In January 2019, the notice of proposed awards was released for GFO-18-601. The proposed total award from this solicitation was $19.45 million and went to five community- and commercial-scale low-carbon fuel production plants. This solicitation was significantly oversubscribed, with 18 passing proposals requesting $71.4 million.

Low life-cycle GHG emissions, as well as other sustainability considerations, have long been a primary factor in determining Clean Transportation Program funding for renewable fuel production projects. Table 16 shows a selection of the commercial-scale projects by fuel type that either received or are proposed to receive Clean Transportation Program funding. While the pathway used for these projects may not have the lowest carbon intensity, the technologies used are sufficiently developed to allow for considerable annual production of at least several hundred thousand gallons of fuel per year.

Table 16: GHG Emission Reduction Potential of Commercial-Scale Clean Transportation Program Projects

Fuel Type	Feedstock Descriptions	Average GHG Emission Reduction [108]	# of Projects	Range of Annual Capacity for Individual Projects	Total Annual Capacity Increase
Biomethane	Dairy manure; fats, oils, & grease; food, green, yard, & municipal waste	166%	10	140,000 – 2,870,000 DGE	8.5 Million DGE per Year
Diesel Substitutes	Waste oils* (various)	83%	15	1,928,311 – 20,000,000 DGE	106.4 Million DGE per Year
Gasoline Substitutes	Sugar beets; grain sorghum	47%	4	2,600,000 – 26,000,000 GGE	34.6 Million GGE per Year
Renewable Hydrogen	Renewable electricity & water	100%	1	750,000 GGE	0.7 Million GGE per Year

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

Clean Transportation Program low-carbon fuel production solicitations have also funded precommercial projects. Though these projects do not yet produce as much fuel as commercial-scale projects, precommercial projects focus on transformative technology solutions that have the potential to increase yields, productivity, or cost-effectiveness of low-carbon fuel production. The CEC 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

108 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.

approaches that can subsequently be expanded into wider markets. A sample of Clean Transportation Program precommercial low-carbon fuel production projects is shown in Table 17, including pathways and greenhouse gas emission reduction potential.

For recent Solicitation GFO-18-602, the CEC supported transformative technologies through demonstration-scale projects. These projects include innovative fuel demonstrations and advancements to increase yield, productivity, and cost-effectiveness, as well as an emphasis on sustainability and new feedstock utilization (such as woody biomass). In January 2019, the notice of proposed awards for GFO-18-602 was released, proposing $12 million for five demonstration-scale, low-carbon fuel production plants.

Table 17: Sample of Precommercial Clean Transportation Program Projects

Fuel Type	Pathway Description	Estimated GHG Emission Reduction[109]	# of Projects	Annual Capacity for Individual Projects (DGE)
Biomethane	Anaerobic codigestion of wastewater; manure; or food, beverage, or green waste	89% - 150%	4	57,000 – 328,000
Diesel Substitutes	Esterification or trans-esterification[110] of algae, manure, or food waste	45% - 55%	2	Nominal
Diesel Substitutes	Gasification of green waste or manure	67%	2	Nominal – 365,000
Gasoline Substitutes	Fermentation of cellulosic or agricultural residues*	76% - 85%	6	Nominal

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

The need for production incentives stems largely from extended volatility in the price of petroleum fuels. Alternative fuels are linked in price to those of gasoline, diesel fuel, 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 CEC 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 Clean Transportation Program, when accounting for funding needs from other fuel types and technologies. As such, alternative fuel production incentives are not viable under the Clean Transportation Program.

109 Ibid.

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

Other Sources of Funding

Other state and federal programs also provide support and incentives to low-carbon fuel producers. The California Department of Resources Recycling and Recovery (CalRecycle) Organics Grant Program conducted three grant cycles in 2014, 2017, and 2018, which awarded $32.9 million to nine biomethane-producing projects. For Fiscal Year 2018-2019, slightly more than $25 million is available for waste diversion using greenhouse gas reduction funds.

The California Department of Food and Agriculture awarded $35.2 million in October 2017 for anaerobic digesters at dairies through the Dairy Digester Research and Development Program and awarded $72.4 million for additional dairy digester projects in 2018. For 2019, the California Department of Food and Agriculture anticipates making between $61 million and $75 million available for these activities. The CEC will work with these agencies to ensure future funding awards are complementary rather than duplicative.

For Fiscal Year 2018-2019, the Legislature also allocated $12.5 million in greenhouse gas reduction funds toward a new Low Carbon Fuel Production Program to be administered by the CEC. This funding will be used to support new and expanded production of low-carbon fuels at commercial scale. At its July 15, 2019, CEC business meeting, the CEC adopted guidelines to implement the program. These guidelines included requirements that any award must result in more than 1 million diesel gallons equivalent per year, and any produced fuel must have a carbon intensity lower than 30 grams per megajoule (about 70 percent below gasoline or diesel).[111]

In addition, the LCFS and RFS requirements can support low-carbon fuel producers by creating markets for carbon credits and renewable fuels. The incentives earned through the LCFS provide steady financial support to low-carbon fuel producers, distributors, and blenders in California. In 2018, 88 percent of LCFS credits were granted for biofuels including biomethane, ethanol, biodiesel, and renewable diesel.[112] These credits equate to an incentive of more than $1.1 billion for biofuel producers and retailers, if sold at the average credit price of $154 for 2018.[113] CARB and CEC staff expects that the LCFS will serve as the state's primary source of financial support for low-carbon fuel production and distribution.

Related State Policy

CEC 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,

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111 More information about the Low Carbon Fuel Production Program is available at https://ww2.energy.ca.gov/transportation/lowcarbonfuels/documents/.

112 California Air Resources Board. April 30, 2019. "LCFS Quarterly Data Spreadsheet." Available at http://www.arb.ca.gov/fuels/lcfs/lrtqsummaries.htm.

113 California Air Resources Board. April 10, 2019. "LCFS Monthly Credit Price and Transaction Volumes April 2019 Spreadsheet." Available at https://www.arb.ca.gov/fuels/lcfs/dashboard/creditpriceserieswithoutargusopis.xlsx.

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. SB 1383 set additional goals to reduce statewide disposal of organic waste from 2014 levels by 50 percent by 2020 and 75 percent by 2025. CARB also notes in the *Short-Lived Climate Pollutant Reduction Strategy* that the state must have sufficient organics processing capacity to handle this additional diverted organic waste.[114] Low-carbon fuel production projects that reduce methane emissions, such as biomethane production plants, can help achieve the state's short-lived climate pollutant reduction goals. Given these state goals, the corresponding need for organic waste-processing infrastructure, and guidance provided by CalRecycle,[115] future funding opportunities under this Clean Transportation Program allocation will continue to exclude landfill gas projects from consideration and instead limit biomethane production projects to those that use prelandfill organic waste.

In September 2018, Senate Bill 1440 (Hueso, Chapter 739, Statutes of 2018) was signed into law, requiring the CPUC, in consultation with CARB, to consider adopting specific biomethane procurement target goals. The procurement program must be a cost-effective means of achieving the forecast reduction in emissions and short-lived climate pollutants and adhere to state environmental and energy policies. Moreover, Assembly Bill 3187 (Grayson, Chapter 598, Statutes of 2018) requires the CPUC, by no later than July 1, 2019, to open a proceeding to consider funding biomethane interconnection infrastructure through a gas corporation's utility rates. The CEC will closely follow the progress of the CPUC on these subjects.

Summary

Given the near-term petroleum and GHG emission reduction potential of any low-carbon, drop-in gasoline or petroleum replacement, future solicitations under this category may emphasize renewable gasoline, renewable crude oil, and similar products in an attempt to accelerate development. In addition, given the ultimately limited quantities of common feedstocks such as waste vegetable oil and food waste, future solicitations may also emphasize underused and emerging feedstocks such as woody biomass or agricultural residue. Recent drought and other effects of climate change have accelerated a decline in the health of California forests and resulted in increased tree mortality. The potential supply of woody biomass feedstock from dead trees exceeds that of any other source of waste material in the state, and the sustainable harvesting and use of this biomass can avoid carbon emissions from wildfire and decomposition. CEC staff seeks to attract technologies that can economically convert this feedstock into low-carbon biofuels. As a result, on October 24, 2018, the CEC released Solicitation GFO-18-501. This solicitation would provide up to $4 million funding for renewable energy and advanced generation research projects aimed at developing and demonstrating innovative technologies for the conversion of forest waste biomass to renewable gas. Technologies of interest include the systems that convert biomass into intermediate products

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

115 CalRecycle. November 5, 2015. "CalRecycle Comments on the Draft 2016/2017 Investment Plan." Available at https://efiling.energy.ca.gov/GetDocument.aspx?tn=206518.

(for example, synthesis gas) and cleaning and upgrading systems that further refine intermediate products into renewable gas.

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 CEC 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 CEC may also consider alternative funding mechanisms, such as revolving loan or loan guarantee programs, which may be more suitable for large projects and developed industries.

For FY 2019-2020, the CEC allocates $10 million Clean Transportation Program funding for Zero- and Near-Zero Carbon Supply Production. This funding will be used for conversions of waste streams projects or renewable hydrogen production or both. Staff does not intend to carve out any of the $10 million for any specific fuel, but rather have them compete to drive the most innovative projects. Incentives for Low Carbon Fuel Production and Supply are available through multiple state agencies, such the CalRecycle Organics Grant Program and the California Department of Food and Agriculture Dairy Digester Research and Development Program, and by earning LCFS credits.

Summary of Alternative Fuel Production Allocations

Table 18: FY 2019-2020 Funding for Alternative Fuel Production

Zero- and Near Zero-Carbon Fuel Production Relevant Policy Goals: – GHG Reduction – Short-Lived Climate Pollutant Reduction – Petroleum Reduction – In-State Low-Carbon Fuel Production – Low Carbon Fuel Standard	$10 million	$2.5 million decrease relative to FY 2018-2019
Total	**$10 million**	

Source: California Energy Commission

CHAPTER 5:
Related Opportunities

Natural Gas Vehicles and Infrastructure

Natural gas vehicles and fueling infrastructure are commercially mature alternative transportation technologies, and a significant number of these vehicles have already been used 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.[116] California leads the nation in the number of compressed natural gas (CNG) and liquefied natural gas (LNG) fueling stations, with 328 public or private CNG stations and 46 public or private LNG stations.[117]

Under the LCFS, conventional natural gas offers modest GHG reductions of about 14 percent compared to gasoline and diesel.[118] However, the life-cycle GHG emissions of natural gas vehicles can be significantly reduced with the use of biomethane, which has some of the lowest carbon intensity values established by the LCFS. Biomethane from wastewater biogas offers life-cycle GHG emission reductions of as much as 92 percent compared to diesel, while biomethane derived from high-solids anaerobic digestion can reduce life-cycle GHG emissions by upward of 125 percent.[119] Biomethane derived from dairy biogas has the lowest carbon intensity approved under the LCFS; about 255 grams of carbon dioxide equivalent greenhouse gases per megajoule.[120]

In 2015, Cummins Westport Inc. became the first natural gas engine manufacturer to receive emission certifications from both the U.S. EPA and CARB at a level of 0.02 grams NO_X per brake horsepower-hour, which is equal to a 90 percent reduction in NO_X emissions compared to existing emission standards.[121] These engines, referred to as low-NO_X engines, are now available for purchase and have the potential to support the market deployment of near-zero-

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

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

118 Ibid.

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

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

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

emission medium- and heavy-duty natural gas trucks. By using biomethane and low-NO_X engines, natural gas trucks have the potential for low criteria pollutant emissions and low or even negative GHG emissions.

Clean Transportation Program Funding to Date

The Clean Transportation Program has provided significant support for the deployment of natural gas vehicles, as summarized in Table 19.

Table 19: Clean Transportation Program Funding for Natural Gas Vehicle Deployment as of March 1, 2019

Funding Agreement or Solicitation	Vehicle Type	# of Vehicles	Clean Transportation Program Funding (in Millions)
Federal Cost-Sharing Projects (ARV-09-001 and ARV-09-002)	Heavy-duty trucks	334	$14.4
Buydown Incentives (PON-10-604, PON-11-603, and PON-13-610)	Up to 8,500 GVW	362	$0.9
	8,501-16,000 GVW	437	$4.9
	16,001-26,000 GVW	136	$2.1
	26,001-33,000 GVW	53	$1.5
	33,001 GVW and up	746	$20.2
Natural Gas Vehicle Incentive Project*	Up to 8,500 GVW	0	$0.0**
	8,501-16,000 GVW	64	$0.4
	16,001-26,000 GVW	64	$0.7
	26,001-33,000 GVW	17	$0.3
	33,001 GVW and up	694	$17.4
California Air District Natural Gas Vehicles (GFO-17-605)	TBD	220	$16.0
School Bus Replacement Projects (GFO-17-607)	School Buses	25	$4.0
Total		**3,152+**	**$82.8**

Source: California Energy Commission. *Total budget for NGVIP agreement is $23.7 million, including administrative costs. **$4,000.

Beginning in 2015, the CEC provided Clean Transportation Program incentives for the purchase of natural gas vehicles through the Natural Gas Vehicle Incentive Project (NGVIP), which is administered by the Institute of Transportation Studies at the University of California, Irvine. Similar to prior solicitations, the NGVIP provides incentives on a first-come, first-served basis at varying levels, depending on the gross vehicle weight. Unlike previous incentive programs, however, the NGVIP provides the incentives directly to vehicle purchasers. Of the $21.8 million available for incentives, about $18.3 million of incentive funds were paid by September 12, 2018, with the remaining $3.5 million reserved.

In May 2018, the CEC awarded $8 million each to the San Joaquin Valley Unified Air Pollution Control District and the South Coast Air Quality Management District to support existing

incentive programs for natural gas vehicles. CEC staff expects these incentives will support the purchase of at least 220 natural gas vehicles.

Additional Clean Transportation Program funds for natural gas vehicle deployment were made available under Solicitation GFO-17-607, which targeted the oldest diesel school buses operating in districts with disadvantaged communities and high participation in free or reduced-price lunches. While most of the available funding was for electric buses under the California Clean Energy Jobs Program, school districts were given the option to certify whether an electric school bus would be unable to meet their needs. These districts were subsequently awarded a limited amount of remaining Clean Transportation Program funding for natural gas vehicle deployment that could go toward natural gas school buses.

To date, the Clean Transportation Program has provided more than $24 million toward the installation or upgrade of about 70 natural gas fueling stations. Of this, about $11.8 million (49 percent) will go toward 32 stations in disadvantaged communities. The most recent solicitation for natural gas fueling infrastructure projects, GFO-16-602, made $3.5 million available to public K-12 school districts in California. This solicitation was undersubscribed, as the CEC received four applications, and only three were eligible and awarded a total of $1.5 million. Remaining natural gas fueling infrastructure funds from the Clean Transportation Program were recently used to support the natural gas school buses funded under GFO-17-607.

Other Sources of Funding

CARB funds low-NO_X natural gas vehicles through its Low Carbon Transportation Investments. During the first Advisory Committee meeting for the Clean Transportation Program Investment Plan Update held November 8, 2018, CARB representatives reiterated that there is considerable funding available through the HVIP. The approved *FY 2018-2019 Funding Plan for Clean Transportation Incentives* includes low-NO_X natural gas vehicles as well as zero-emission and hybrid vehicles as an eligible powertrain under the Clean Truck and Bus Voucher project, for which CARB staff proposes allocating $125 million. As of March 1, 2019, the project has paid vouchers for more than 700 low-NOx vehicles, with more than 900 additional incentives going through the application and redemption process.[122]

CARB is developing a low-NO_X engine standard for medium- and heavy-duty vehicles with an effective date of 2023.[123] More information about this possible new standard, as well as a CARB board hearing, is expected in 2019. The new standard, if adopted, may result in an increase in demand and a self-sustaining market for low-NO_X natural gas vehicles and other powertrains capable of achieving the emission standard.

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122 California HVIP Program Numbers, available at https://www.californiahvip.org/tools-results/#program-numbers.

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

Summary

For FY 2019-2020, the CEC is not allocating Clean Transportation Program funding for natural gas vehicle incentives or infrastructure projects. Significant incentives for natural gas vehicles are available through the CARB Clean Truck and Bus Voucher Project and various California air district programs. Additional Clean Transportation Program incentives for these vehicles would be redundant with these other funding sources. In addition, the CEC is committed to prioritizing zero-emission vehicles and infrastructure in FY 2019-2020.

Manufacturing

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

In May 2018, the CEC hosted a discussion roundtable focused on zero-emission infrastructure manufacturing. The discussion centered on actions that California state and local government could take to expand or recruit California-based manufacturing into the ZEV infrastructure supply chain. Subsequently, in August 2018, the CEC hosted a public technology merit review workshop to highlight lessons learned from previous Clean Transportation Program funding awards. The workshop also explored challenges and opportunities faced by ZEV manufacturers, ZEV infrastructure manufacturers, and ZEV supply chain component manufacturers in California.[124]

Funding support is critical at all stages of product, manufacturing, and business development to successfully bring emerging technologies to market. The CEC, through the Clean Transportation Program, has provided significant support to expand the in-state manufacturing capacity of zero-emission vehicles and components. California leads the nation in venture capital funding for clean transportation technologies, with 87 percent of these investments nationwide being made in California in 2016.[125] Grant funding from the Clean Transportation Program and the CARB Low Carbon Transportation Investments continues to support demonstration and deployment of alternative fuel vehicles, technologies, and infrastructure.

Despite the financial and technical support available to advanced transportation technology manufacturers, early stage companies often struggle to transition from producing demonstration products to achieving full commercialization. This challenge is often because of

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124 California Energy Commission public technology merit review workshop in August 2018. More information on these workshops is available at https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=15-MISC-04.

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

low volume sales and a lack of available capital to support growth from the private and public sectors, commonly referred to as the commercialization "Valley of Death."[126] At this stage, companies have demonstrated the technical validity and viability of their products but now must prove that the manufacturing process is economical and viable. Doing this requires significant capital, which traditional investors and financiers may be unwilling to provide because of the high-risk nature of early commercial technologies. Additional sources of funding, such as Clean Transportation Program grants, can help reduce this risk and encourage lenders and investors to invest as well.

The CEC has invested more than $43 million in 21 in-state manufacturing projects that support the goals of the Clean Transportation Program. These investments often encourage the siting or expansion of manufacturing plants in California, creating jobs, and supporting the in-state production of zero- and near-zero-emission vehicles and vehicle components.

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

Another example of Clean Transportation Program manufacturing project funding support is 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 35- and 40-foot variants and has a nominal range of up to 350 miles. The manufacturing line is located at Proterra's production factory in the City of Industry (Los Angeles County).

A third example of manufacturing supported success is Efficient Drivetrains, Inc. (EDI), a Clean Transportation Program awardee, which designs and produces hybrid and all-electric powertrains and systems for medium- and heavy-duty vehicles. The award allowed EDI to accelerate and expand its manufacturing operations in Milpitas (Santa Clara County). EDI has developed intellectual property (IP), demonstrated technologies, and expanded its workforce in California. In July 2018, Cummins, Inc. (Cummins), a global power leader with a broad portfolio of transportation solutions, announced the acquisition of EDI. Cummins' Chairman and CEO Tom Linebarger said, "This acquisition will combine EDI's talented workforce and electrification capabilities with Cummins' expertise in developing and manufacturing technologies that power the world."[127] This acquisition represents one path in which portfolio

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

127 Business Wire. July 2, 2018. "Cummins Announces Acquisition of Electric and Hybrid Powertrain Provider". More information available at: https://www.businesswire.com/news/home/20180702005572/en/Cummins-Announces-Acquisition-Electric-Hybrid-Powertrain-Provider

companies can immediately scale and grow global market share as a result of Clean Transportation Program investments.

The most recent solicitation manufacturing, GFO-18-605, was released in December 2018 and well received. The solicitation provided $9.9 million and was an offer to fund projects that support the manufacture of ZEV and ZEV infrastructure technologies. Funding awards were organized into two categories: A) Complete ZEV or ZEV Components or both and B) Electric Vehicle Supply Equipment or Refueling Station Equipment or both. Category A received more than $11 million requested proposals with $4.9 million in total funding recommended, with more than $10 million in committed match funds. Category B received nearly $9 million in requested proposals with nearly $6 million in total of funding recommended, with nearly $7 million in committed match.

Summary

For FY 2019-2020, the CEC is not allocating Clean Transportation Program funding for manufacturing because of the emphasis on zero-emission vehicle infrastructure deployment. Manufacturing funding will be paused, however, and reassessed as an area for possible future funding.

Workforce Development

The CEC has also provided significant investments for the training and development of California's alternative fuel workforce through the Clean Transportation Program. Workforce efforts funded by the Clean Transportation Program have grown in size and scope with expanded programs from partner agencies, as well as efforts from new partner agencies. Demand for workforce training and development in alternative transportation remains robust across many technology types, and CEC staff is continuing to engage new organizations and industry partners through the Clean Transportation Program to train, develop, and support a qualified alternative transportation workforce. The CEC will continue to collaborate with other state agencies on how best to implement Clean Transportation Program funding, as well as align with recommended guidelines and best practices.

Beginning in 2009, the CEC partnered with the Employment Development Department, Employment Training Panel, and the California Community Colleges Chancellor's Office (CCCCO) with the intent of providing for and better understanding the state's alternative transportation workforce needs. In addition to growing work within those agencies, the CEC contracted with the Advanced Transportation and Logistics Initiative (ATL Initiative; formerly the Advanced Transportation and Technology Energy Centers), an initiative of CCCCO. The ATL Initiative is hosted by California community college districts that serve the alternative transportation needs for community colleges across the state. The first ATL Initiative agreement, hosted by the San Diego Community College District, awarded multiple California community colleges with funds to purchase specialty equipment required for essential hands-on training and advanced technical training for instructors and trainers to stay at the forefront of ever-evolving technologies. Table 20 provides a list of community colleges funded under this agreement. The second ATL Initiative agreement, with the Cerritos Community College District, focuses on developing a high school clean transportation career pilot program for underserved communities.

Table 20: Community Colleges Funded Under the ATL Initiative by the Clean Transportation Program

Region	Community College
Northern California	American River College (Sacramento)
	Chabot College (Hayward)
	City College of San Francisco (San Francisco)
	Foothill De Anza Community College District (Los Altos Hills)
Central California	Bakersfield College (Bakersfield)
	Hartnell College (Salinas)
Southern California	Cerritos College (Norwalk)
	College of the Desert (Palm Desert)
	Copper Mountain College (Joshua Tree)
	Cypress College (Cypress)
	Los Angeles Trade Technical College (Los Angeles)
	Rio Hondo College (Whittier)
	Saddleback College (Mission Viejo)
	San Diego Miramar College (San Diego)
	Victor Valley College (Victorville)

Source: California Energy Commission

The CCCCO, in partnership with the California Workforce Development Board, and in coordination with Mission College, developed the Energy Transit Apprenticeship Program. The apprenticeship program was funded by the Clean Transportation Program and resulted in institutionalizing the new California Division of Apprenticeship Standards (DAS) for the Santa Clara Valley Transportation Authority, with Mission College as the lead educational agency. The project established the DAS registered apprenticeships for coach operator and service mechanic. The project also supported the enrollment of well over 200 apprentices and established the Mission College Department of Transportation Studies, creating 29 transit career courses and two certificates. Additional outcomes from this project include ongoing coordination with SamTrans, AC Transit, Golden Gate Transit, Fresno Transit Authority, and the City of Stockton. The apprenticeship program will also be a transferable model that will be available across California's multiple local Workforce Development Boards. This transit training apprenticeship model is designed to meet the growing demand for transit workers with alternative fuel and vehicle expertise. These efforts benefit greatly from leveraged funding through the Governor's Office to the colleges for a strong workforce initiative.

In October 2018, CEC staff participated in the Los Angeles Economic Development Corporation meeting to discuss alternative fuel workforce needs. The meeting brought together industry, community colleges, government, and other related stakeholders and was structured in

multiple panel discussions. The panel discussions resulted in a better understanding of the needs and challenges facing employers in the Los Angeles area. The meeting also provided an opportunity for government and community colleges to provide an overview of available resources.

Summary

Based on expectations of needed funds in FY 2019-2020, the CEC allocates $2.5 million for workforce training projects. The CEC will continue to work with partner agencies to determine how Clean Transportation Program funding can best be invested to maximize the benefits of this funding. Workforce training investments will also prioritize disadvantaged and low–income communities and their residents.

Technical Assistance in Equity and Outreach

At its April 8, 2015, business meeting, the CEC approved a resolution to optimize opportunities for economically disadvantaged and underserved communities to participate in CEC programs, including the Clean Transportation Program. Subsequently, SB 350 required the CPUC and CEC to establish the Disadvantaged Communities Advisory Group (DACAG) to advise on programs proposed to achieve clean energy and pollution reduction. In its comment letter to the CEC on June 28, 2019, the DACAG included a recommendation to "Prioritize and Invest in Proper Community Outreach and Engagement." In its letter, the DACAG encourages investment into outreach to disadvantaged communities in partnership with local community-based organizations.[128] This outreach is particularly true for smaller, tribal, or rural communities or a combination that may not have the resources to compete for funding opportunities. Improving such outreach has the potential to create more equitable opportunities to participate in the Clean Transportation Program's Advisory Committee, the identification of funding priorities (such as the program's Investment Plan Update), the development of funding solicitation criteria, and the funding application and award-making process.

Other stakeholders similarly voiced support for investing in community outreach. In the August 5, 2019, Advisory Committee meeting for the Clean Transportation Program, some participants raised the prospect of "capacity-building" funding that would improve the ability of smaller, underrepresented communities to participate in the funding processes of the program. Others raised the example of the Transformative Climate Communities program under the state's Strategic Growth Council, in which community-based organizations were directly responsible for developing funding opportunities. Stakeholders also referenced an approach used by the CEC's Electric Program Investment Charge (EPIC) program, incorporating community partnerships into the scoring criteria of solicitations.[129]

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128 SB 350 Disadvantaged Communities Advisory Group, "SB 350 Disadvantaged Communities Advisory Group Comments on 2019-2020 Investment Plan Update," June 28, 2019. Submitted to Docket 18-ALT-01, TN# 228878. Available at: https://efiling.energy.ca.gov/GetDocument.aspx?tn=228878&DocumentContentId=60238

129 More information from the August 5, 2019, Advisory Committee meeting is available at https://ww2.energy.ca.gov/altfuels/2018-ALT-01/documents/.

The CEC is committed to identifying and developing funding opportunities that improve its ability to specifically include and benefit disadvantaged communities via the Clean Transportation Program.

Summary of Related Opportunities Allocations

Table 21: FY 2019-2020 Funding for Related Opportunities

Natural Gas Vehicles and Infrastructure	-	No change relative to FY 2018-2019
Manufacturing	-	$6 million decrease relative to FY 2018-2019*
Workforce Development Relevant Policy Goals: – GHG Reduction – Petroleum Reduction – Air Quality – Equitable Economic Development	$ 2.5 Million	
Total	**$2.5 Million**	

Source: California Energy Commission. *For FY 2018-2019, the funding for Manufacturing and Workforce Development were combined into one allocation of $8.5 million.

CHAPTER 6:
Summary of Funding Allocations

Funding allocations for FY 2019-2020 are summarized in Table 22. In the event that a different amount of funding is available, the allocations in this document may be revised or amended after final adoption. For details on each allocation, please see the relevant section of the preceding chapters.

Table 22: Summary of Funding Allocations for FY 2019-2020

Category	Funded Activity	2019-2020
Zero-Emission Vehicles and Infrastructure	Light-Duty Electric Vehicle Charging Infrastructure	$32.7 million
	Medium- and Heavy-Duty Zero-Emission Vehicles and Infrastructure	$30 million
	Hydrogen Refueling Infrastructure	$20 million
Alternative Fuel Production	Zero- and Near Zero-Carbon Fuel Production	$10 million
Related Opportunities	Workforce Development	$2.5 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 1 pound of water by 1 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 the related global warming potential. The carbon dioxide equivalent for a gas is derived by multiplying the mass of the gas by the associated global warming potential.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

NATIONAL AMBIENT AIR QUALITY STANDARDS – A set of standards established by the U.S. EPA for six criteria air pollutants, measured by the amount of each pollutant for a specified period.

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

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

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

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

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

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

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

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

APPENDIX A:
LIST OF ACRONYMS

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

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