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ENERGY
COMMISSION

2010-2011 INVESTMENT PLAN FOR THE ALTERNATIVE AND RENEWABLE FUEL AND VEHICLE TECHNOLOGY PROGRAM

DRAFT STAFF REPORT

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Preface

The increased use of alternative and renewable fuels supports the state's commitment to curb greenhouse gas emissions, reduce petroleum use, improve air quality, and stimulate the sustainable production and use of biofuels within California. Alternative and renewable transportation fuels include electricity, natural gas, biomethane, propane, hydrogen, ethanol, renewable diesel, and biodiesel fuels. State investment is needed to fill the gap and fund the differential cost of these emerging fuels and vehicle technologies.

Assembly Bill (AB) 118 (Núñez, Chapter 750, Statutes of 2007) created the Alternative and Renewable Fuel and Vehicle Technology Program (Program). This statute, amended by Assembly Bill 109 (Núñez, Chapter 313, Statutes of 2008) authorizes the California Energy Commission (Energy Commission) to "develop and deploy innovative technologies that transform California's fuel and vehicle types to help attain the state's climate change policies." The Energy Commission has an annual program budget of approximately $100 million.

The statute also directs the Energy Commission to create an advisory committee to help develop and adopt an investment plan. The statute calls for the investment plan to describe how funding will complement existing public and private investments, including existing state and federal programs. The Energy Commission will use the investment plan as a guide for awarding funds. The statute calls for the investment plan to be updated annually.

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INTRODUCTION

Extraordinary changes have taken place in our economic, political, and energy landscape in the last few years. The California economy, along with the U.S. economy, is still struggling to overcome one of the worst recessions since the Great Depression. California had one of the highest unemployment rates in the nation at 12.5 percent in October 2009, with over 2.2 million California residents unemployed.[1] After months of economic decline, however, indicators are beginning to show signs of gradual improvement. Monthly job losses have diminished, residential and commercial construction has stabilized and state-wide home prices have risen for the last several months. The overall U.S. economy expanded in the third quarter after four quarters of decline however, the recovery is expected to be gradual with slow job growth and a constrained credit market.

Economic uncertainty, volatile energy prices, and capital constraints have had an adverse affect on green transportation technology development and deployment over the past year.[2] Potential investors in alternative and renewable fuel projects are wary of uncertain fuel price forecasts and many who would otherwise be willing to invest are hesitant. Due to lower gasoline prices consumers and businesses are somewhat less motivated to buy alternative or advanced vehicle technology than they were when gasoline prices spiked many months ago.[3] They also have less discretionary income to spend on new vehicles or higher priced alternative vehicles.

Over the long term, however, there are positive trends for green transportation. For example, green transportation employment in California has increased 152 percent since 1995, with the sub-category of alternative fuels jobs increasing 201 percent in that period. [4,5] The recent initial public offering from A123 Systems, a leading supplier of high-power lithium ion batteries is another sign that alternative transportation technology is increasingly attractive to investors.[6] During this critical phase of emerging green transportation technology and deployment, government will continue to play an important role in providing policies that provide long-term market signals and performance standards as well as incentives that encourage private investment in alternative and renewable transportation fuels and technologies.

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[1] California Department of Finance Bulletin, December 2009.

[2] 2010-2011 Investment Plan Biofuels Workshop, September 14-15, 2009.

[3] http://www.reuters.com/article/idUSTRE52M5Q020090323

[4] Green transportation employment primarily falls into motor vehicle and equipment jobs and alternative fuels jobs.

[5] "Many Shades of Green: Diversity and Distribution of California's Green Jobs", Next 10 and Collaborative Economics, October 2009

[6] "Driving Transportation Innovations", Next 10, October 2009

In 2008, California's transportation sector consumed approximately 15 billion gallons of gasoline and greater than 3 billion gallons of diesel fuel.[7] This sector represents approximately 40 percent of the state's greenhouse gas (GHG) emissions, the largest amount from any single sector.[8] Although the 2008-2009 economic downturn has diminished near-term fuel consumption, projections indicate that without GHG emission reduction policies, the combined volume of gasoline and diesel consumption will grow by 2.3 percent over the next 10 years.[9] This is due largely to increasing diesel demand, as gasoline demand is expected to drop by a small amount over the same period.

Beginning in 2003, many key California policies have been adopted to reduce GHG, reduce the state's dependence on petroleum, increase the development and use of alternative and renewable fuels and vehicles, and stimulate in-state sustainable production and use of biofuels.(Table 1) Transforming California's transportation sector to achieve these policy objectives will require the well planned use of state and federal funds to encourage private investment in alternative and renewable fuels and technologies.

It is important to note that reaching the GHG and petroleum reduction goals, will require additional steps beyond alternative and renewable fuels deployment. The Energy Commission's 2050 analysis shows that the state cannot meet transportation's GHG "fair share" by fuel switching and advanced vehicle technologies alone. Aggressive transportation planning such as more efficient land use planning and transportation mode changes are required to reduce vehicle miles traveled.

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[7] "Fuel Taxes Division Statistics and Reports - Board of Equalization" http://www.boe.ca.gov/sptaxprog/spftrpts.htm

[8] California Energy Commission, *2009 Integrated Energy Policy Report*, Final Committee Report, December 2009, CEC-100-2009-003-CTF.

[9] Energy Commission staff.

Table 1: Summary of Key Policy Objectives

Objectives	Goals and Milestones
GHG Reduction[10,11]	Reduce GHG emissions to 1990 levels by 2020 and 80% below 1990 levels by 2050
Petroleum Reduction[12]	Reduce petroleum fuel use to 15% below 2003 levels by 2020
Alternative and Renewable Fuel Use[13]	Increase alternative and renewable fuel use to 11% of on-road and off-road fuel demand by 2012, 13% by 2017, and 26% by 2022
In-State Biofuels Production[14]	Produce in California 20% of biofuels used in state by 2010, 40% by 2020, and 75% by 2050

The Energy Commission is providing incentives to accelerate the development and deployment of clean, efficient, low-carbon alternative fuels and technologies. Assembly Bill (AB) 118, (Núñez, Chapter 750, Statutes of 2007) created the Alternative and Renewable Fuel and Vehicle Technology Program (Program). The statute amended by AB 109 (Núñez, Chapter 313, Statutes of 2008), authorizes the Energy Commission to develop and deploy alternative and renewable fuels and advanced transportation technologies to help attain the state's climate change policies. The Energy Commission has an annual Program budget of approximately $100 million that provides financial support for projects that:

- Develop and improve alternative and renewable low-carbon fuels.
- Reduce California's use and dependency on petroleum transportation fuels, and increase the use of alternative and renewable fuels and advanced vehicle technologies.
- Optimize alternative and renewable fuels for existing and developing engine technologies.
- Produce alternative and renewable low-carbon fuels in California.

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[10] Assembly Bill 32 (Núñez, Chapter 488, Statutes of 2006).

[11] Governor's Executive Order S-3-05.

[12] *Reducing California's Petroleum Dependence*, California Energy Commission and Air Resources Board joint agency report, August 2003, publication #P600-03-005.

[13] *State Alternative Fuels Plan*, Final Adopted Report, CEC-600-2007-011-CMF, December 2007.

[14]Governor's Executive Order S-6-06.

- Decrease, on a full fuel cycle basis, the overall impact and carbon footprint of alternative and renewable fuels and increase sustainability.
- Expand fuel infrastructure, fueling stations, and equipment.
- Improve light-, medium-, and heavy-duty vehicle technologies.
- Retrofit medium- and heavy-duty on-road and non-road vehicle fleets.
- Expand infrastructure connected with existing fleets, public transit, and transportation corridors.
- Establish workforce training programs, conduct public education and promotion, and create alternative and renewable fuel and vehicle technology centers.

The Energy Commission can use grants, loans, loan guarantees, revolving loans, and other appropriate financial measures. Entities including public agencies, private businesses, public-private partnerships, vehicle and technology consortia, workforce training partnerships and collaboratives, fleet owners, consumers, recreational boaters, and academic institutions are eligible for funding.

The statute requires the Energy Commission to prepare an investment plan to determine funding priorities and opportunities and describe how Program funding will be used to complement other public and private investments. The Energy Commission adopted its first investment plan combining funds from fiscal years (FY) 2008-2009 and 2009-2010 at the April 22, 2009, Business Meeting. The statute also requires the Energy Commission must also adopt a new investment plan each year. This investment plan will be the funding guide for FY 2010-2011.

DETERMINING PRIORITIES AND OPPORTUNITIES

To assist in determining the priorities in the first investment plan, the Energy Commission developed a method for examining and achieving the state's ambitious 2020 and 2050 GHG emission targets. This method was based, in part, on the *2050 Vision* developed as part of the *State Alternative Fuels Plan* that was jointly adopted by the Energy Commission and the California Air Resources Board (ARB) in December 2007.[15]

The analysis model used the California Conventional and Alternative Fuel Response Simulator (CALCARS) model to establish a "business as usual" baseline fuel demand projection. The baseline included gasoline, diesel, and hybrid vehicles. From this baseline, the analysis established a plausible scenario for the introduction and use of alternative and renewable fuels and advanced vehicle technologies through the 2050 time period. The scenario incorporated the penetration of natural gas, propane, fuel cell, battery electric, plug-in hybrid, biodiesel, and flex fuel (E-85) vehicles to reduce emissions.

For the *2010-2011 Investment Plan*, the Energy Commission will continue to rely on this core analysis to determine the relative contributions of various fuels and technologies toward achieving the 2050 GHG emission targets. The analysis has been updated to incorporate the Energy Commission's most recently adopted fuel demand forecast, which has expanded its baseline projections to include alternative fuels. In addition to the previously mentioned technologies, the analysis also incorporates a broadened scenario that accounts for the penetration of biodiesel and increased availability of E-85 over time. Finally, updated full fuel-cycle carbon intensity values for alternative and renewable fuels using different feedstocks are used. These updates improve the accuracy and resolution of emerging fuel and technology effects in GHG reduction. A more detailed description of these changes can be found in Appendix A.

Consistent with the low carbon fuel standard (LCFS), the alternative and renewable fuels expected to contribute to petroleum and GHG reduction all result in lower carbon intensity as compared to the gasoline and diesel intensity baselines. These GHG reductions are more than the required LCFS reduction, occur earlier, and are surplus to the 10 percent reduction required by 2020. (See Appendix A for details)

The *2010-2011 Investment Plan* includes information obtained from five stakeholder workshops held in September and October of 2009. The workshops focused on the technologies and markets for electric drive, biofuels, natural gas and propane, hydrogen and electric drive infrastructure. *The 2010-2011 Investment Plan* also takes into account Program funds awarded thus far, American Recovery and Reinvestment Act (ARRA) funds awarded to successful California project applicants, and the effect of the Zero Emission Vehicle regulation modifications, Low Carbon Fuel Standard, Bioenergy Action Plan, Clean Fuels Outlets

[15] *State Alternative Fuels Plan*, Final Adopted Report, CEC-600-2007-011-CMF, December 2007.

regulations, Renewable Fuel Standard, National Greenhouse Gas and Corporate Average Fuel Economy Standards for Vehicles, Renewable Portfolio Standard and Clean Air Action Plan.

Status of Program Funding

Since the adoption of the first investment plan in April 2009, the Energy Commission has committed approximately $20.6 million to:

- Establish statewide workforce training and development programs,
- Convert state-owned hybrid-electric vehicles to plug-in hybrid-electric vehicles,
- Certify hydrogen dispensing equipment for retail hydrogen fueling stations and establish specifications for hydrogen and biodiesel fuels,
- Examine best management practices and sustainability certification programs for imported fuels and fuels produced in California,
- Develop a communications plan that will inform consumers of the availability of alternative and renewable fuels and vehicle choices.

The Energy Commission also is providing approximately $36.2 million as match funding to approximately $93.6 million of ARRA funds to:

- Install thousands of new electric vehicle charging sites,
- Expand the number of natural gas fueling stations,
- Purchase medium- and heavy-duty natural gas and hybrid-electric trucks
- Produce high energy density Lithium-ion batteries with 3 times better energy density for plug-in hybrids and electric vehicles,
- Develop and demonstrate the science and technologies necessary to significantly increase production of algal biofuels.

The details of the ARRA funding commitment are discussed further, however, the strategic decision by the Energy Commission to match federal stimulus funding has resulted in significant uncommitted Program funding from the first investment plan. The Energy Commission, therefore, is releasing a series of focused solicitations for approximately $113 million to:

- Further expand the electric charging, natural gas, E-85, and hydrogen fueling network,
- Purchase propane school buses,
- Construct blending and storage terminals for biodiesel and renewable diesel fuels,
- Construct biomethane production facilities,
- Construct advanced biofuel production facilities,
- Construct battery and vehicle component manufacturing facilities,

- Conduct advanced medium- and heavy-duty hybrid-electric and alternative fuel truck demonstrations,
- Advance the sustainability of California's alternative and renewable fuel market.

These remaining funds are expected to be encumbered during the first and second quarters of calendar year 2010.

The American Recovery and Reinvestment Act of 2009

One of the major developments since the adoption of the first investment plan was the implementation of the ARRA and the resulting billions of dollars of federal stimulus funding that are being distributed nationally for a broad range of economic stimulus activities. To date, over $33 billion of the ARRA funds has been awarded.

President Obama signed the ARRA into law on February 17, 2009, to stimulate the economy, create jobs and address a variety of critical areas of national concern.[16] One of the areas targeted for the economic stimulus was energy.

The initial announcement of federal funding opportunities in March 2009 for alternative and renewable fuels and advanced vehicles immediately preceded the adoption of the first investment plan. To help California entities successfully compete for available federal funds, the Energy Commission issued a solicitation in April 2009 offering $175 million[17] of Program funds from the first investment plan as cost share to those who were submitting proposals to the federal government in response to a transportation-related ARRA funding opportunity announcement.

The Energy Commission reviewed 108 proposals requesting more than $624 million of Program funds and $1.815 billion of ARRA funds. Of the 108 applications, 38 percent were applying to the federal Clean Cities solicitation, 35 percent were for transportation electrification, 12 percent for biorefineries, and 10 percent for battery and component manufacturing—the rest were for Transit Investments for Greenhouse Gas and Energy Production (TIGGER) and Advanced Research Projects Agency-Energy (ARPA-E).

To date, the Energy Commission has committed $36.2 million to California projects that have been awarded approximately $93.6 million in ARRA funds. These projects also include $127.8 million in private funds. Table 2 shows these ARRA funds awarded to date for alternative and renewable transportation projects that are receiving AB 118 match funds and those not receiving AB 118 match funds.

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[16] http://www. energy.gov/recovery

[17] This amount was later reduced to $156 million. $4 million for standards and certification and $15 million for workforce training and development had already been committed for specified entities in the 2008-2010 Alternative Fuels Investment Plan.

Table 2: ARRA Awards in California (in millions)

Program	Federal Funds Available	ARRA Awards with AB 118 Match			ARRA Awards w/o AB 118 Match
		ARRA Awards	AB 118 Match Funds	Private/ Other Match	ARRA Awards
Transportation Electrification	$400	$70.273	$17.556	$83.966	$3[18]
Clean Cities	$300	$19.359	$14.450	$43.510	$6
ARPA-E	$400	$4.000	$1.000	$0.329	$12
Adv Battery Manufacturing	$2,000	$0	$0	$0	$0
Diesel Emission Reduction	$300	$0	$0	$0	$27
Applied RDD&D	$2,500	$0	$0	$0	$14
TIGGER	$100	$0	$0	$0	$18
Integrated Biorefinery	$483	$0	$0	$0	$45
Efficient Class 8 Trucks and Adv Tech for LD Vehicles	$115-$240	$0	$0	$0	*[19]
Algal/Adv Biofuels Consortia	$85	*[20]	$3.000	*[21]	$.4
Totals	$6,683-6,808	$93.632	$36.206	$127.805	$125.4

[18] Funding is an estimate of California's share of multi-state projects.

[19] $187 million was awarded to major heavy duty truck and passenger vehicles companies and at this time it is unknown how many of the vehicles will come to California.

[20] Total award of $44 million nationwide but California portion is not yet available.

[21] California portion not yet available.

As of November 2009 total transportation awards made nationwide were over $2.8 billion. California received none of the $2 billion available for advanced battery manufacturing. Nationwide, excluding California, infrastructure funding was awarded for: 30 biodiesel (B20), 112 E-85, 146 natural gas (of which 133 were Compressed Natural Gas), 253 propane, and 2 hydrogen stations; 1,571 electric charging sites; and 50 truck stop electrification projects. Vehicle purchases funded nationally, excluding California, included 2,647 natural gas, 2,576 electric drive/hybrid electric, and 3,256 propane vehicles.[22] These nationwide awards provide support to the industry that also provides vehicles for California use. In this regard, California ultimately will benefit from more robust vehicle and infrastructure manufacturing industries.

The ARRA awards that were made to California include two liquefied natural gas public access fueling stations, 3,191[23] electric charging sites; 442 medium-duty liquefied natural gas vehicles, and 123 plug-in Class 2-5 hybrid-electric vehicles.

Air Quality Improvement Program

The ARB is responsible for administering the AB 118 Air Quality Improvement Program (AQIP) which provides up to $50 million per year for grants to fund clean vehicles and equipment, air quality research, and workforce training. [24]

Both AQIP and the Energy Commission's Program were established by the same legislation and provide opportunities for complementary funding strategies. For example, unlike the Energy Commission, ARB cannot fund infrastructure for alternative and renewable fuels. The Energy Commission, therefore, is making significant investments in fueling and electric charging stations, and fuel storage facilities. Both agencies can fund vehicle technology development and commercial deployment. The Energy Commission, however, is largely funding the former while ARB is providing incentives for the latter with a focus on electric drive and zero emission vehicles. The Energy Commission is providing deployment incentives, but only for natural gas and propane vehicles.

As part of the FY 2008-2009 State Budget, the Legislature directed that FY 2008-2009 AQIP funds be used for a new ARB Truck Loan Program to assist truckers affected by the ARB regulations adopted in December 2008: the Statewide In-Use Truck and Bus Regulation and the Heavy-Duty Vehicle Greenhouse Gas Emission Reduction Measure. About $35 million is available for this program which supplements ARB's existing grant incentive programs. Loans will be

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[22] Recovery Act Announcements, 2009.

[23] Includes 1,041 public level 2, 1,000 commercial level 2, 1,000 home charging and 50 level 3 charging stations.

[24] http://www.arb.ca.gov/msprog/aqip/aqip.htm and http://www.arb.ca.gov/msprog/aqip/meetings/aqip_workshop_presentation_120809.pdf

available for the purchase of new or used trucks, diesel emission control devices, and U.S. Environmental Protection Agency (EPA) SmartWay technologies. [25]

ARB's Truck Loan Program is designed to leverage state dollars to maximize funding opportunities and to provide credit access to truckers, so they can take early action in upgrading their fleets. The program will be rolled out in the spring of 2010 with loan opportunities for truckers becoming available over the next several months.

For FY 2009-2010 total AQIP funds of $34.6 million are allocated to hybrid truck and bus vouchers ($20.4 million), zero-emission and plug-in hybrid light-duty vehicle rebates ($4.1 million), lawn and garden equipment replacement ($1.6 million), zero-emission agricultural utility terrain vehicle rebates ($1.1 million) and advanced technology demonstrations ($7.3 million). The AQIP 2010-2011 Funding Plan is currently under development and will be available for public review in May 2010 and likely be presented to the Board for adoption in June 2010.

Zero Emission Vehicle Regulation

The Zero Emission Vehicle (ZEV) regulation was adopted in 1990 as part of the ARB's Low Emission Vehicle Program and has been modified several times over the years.[26] It requires large automakers to produce certain percentages of "pure" zero emission and "near-zero" emission vehicles for sale in California. The goal of the ZEV regulation is to meet California's air quality and greenhouse gas reduction goals and has resulted in the introduction of new vehicle technologies in California. As a result of the ZEV regulation, over one million Californians are driving partial zero and advanced technology partial zero emission vehicles (PZEV and AT PZEV).

Automakers may comply using a variety of different types of zero emission vehicles. The ZEV program currently allows for four compliance options: PZEV (partial or "near zero" emission vehicles; advanced gasoline vehicles), AT PZEV (advanced technology PZEV; hybrids, natural gas vehicles), Enhanced AT PZEV (hydrogen ICE and plug-in hybrid electric), and ZEV (pure zero emission vehicles; battery driven and fuel cell vehicles (FCVs)). ARB is currently preparing to seek regulatory changes that would take the PZEV and ATPZEV compliance options out of

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[25] 2009-2010 AQIP Funding Plan page 6 explains how 2008-09 funds were directed to the truck loan program. ARB did not develop a Funding Plan for FY 2008-09 due to time constraints. The Legislature codified financial assistance for truck loans in HSC Section 44274.7. The original funding amount was $42M but based on revenues generated during that fiscal year only $35 M was available.

[26] The Air Resources Board approved changes to the ZEV Program on March 27, 2009 which became effective in early 2009. These new ZEV categories including Type IV ZEV (a ZEV with a 200 mile or more range and fast refueling), type V ZEV (a ZEV with a 300 or more range plus fast refueling), AT PZEV (hydrogen internal combustion engine and plug-in hybrid electric vehicles) and several other changes (see Appendix B).

the ZEV program and instead include them in the Low Emission Vehicle (LEV) and Pavley programs[27] by 2020. LEV regulations and GHG tailpipe standards will thus be adjusted to in effect require the continued production of vehicles that operate at PZEV or ATPZEV emissions levels.

Zero Emission Bus Regulation

The ARB's Zero Emission Bus (ZEB) regulation was adopted in 2000 as part of the Transit Fleet Rule. It affects only large transit agencies with more than 200 buses and includes a 15 percent fleet ZEB purchase requirement. Ten agencies are affected with six in Northern California and four in Southern California. Two compliance paths are offered: the diesel path (2011-2026 timeframe for purchase requirement) and the alternative fuel path (2012-2026 timeframe for purchase requirement) e.g. fuel cell buses (FCB), battery-operated buses etc.

Low Carbon Fuel Standard

Governor Arnold Schwarzenegger established the Low Carbon Fuel Standards (LCFS) by Executive Order in January 2007 and the ARB adopted standards and protocols on April 23, 2009 . The LCFS establishes carbon intensity (grams CO2e/MI) standards that fuel producers and importers must meet each year beginning in 2011. The 10-year LCFS schedule requires a gradual reduction in average carbon intensity for the first several years, beginning January 1, 2011, then steeper reductions, year-to-year over the remaining years, concluding with a 10 percent carbon intensity reduction by 2020. The LCFS will be reviewed periodically to update advances in low carbon fuels, production technologies, and full cycle assessments.

Bioenergy Action Plan

On April 25, 2006, Governor Schwarzenegger issued Executive Order S-06-06 which established targets for the use and production of biofuels and biopower and directed state agencies to work together to advance biomass programs in California. The Bioenergy Interagency Working Group is working to meet the goals of the Bioenenergy Action Plan (BAP)[28] which include maximizing the contribution of bioenergy toward achieving the state's petroleum reduction, climate change, renewable energy and environmental goals. The Executive Order established targets to increase the production and use of bioenergy, including ethanol and biodiesel fuels

[27] AB 1493 (Pavley, Chapter 200, Statutes of 2002), known as the Pavley Bill, requires the ARB to adopt regulations for the reduction of GHG emissions from motor vehicles. More information is available on the ARB's website: http://www.arb.ca.gov/cc/ccms/ccms.htm.

[28] Publication number CEC-600-2006-010, July 2006.

from renewable resources. For biofuels, the state's goal is to produce a minimum of 20 percent of its biofuels within California by 2010, 40 percent by 2020 and 75 percent by 2050. Regarding the use of biomass for electricity, the state's goal is to meet a 20 percent Renewable Portfolio Standard target for renewable generation for 2010 and 2020.

Renewable Fuel Standard

The federal Renewable Fuel Standard (RFS) Program was established under the Energy Policy Act of 2005. The U.S. Congress gave the U.S. EPA the responsibility to coordinate with the U.S. Department of Energy, the U.S. Department of Agriculture, and stakeholders to design and implement the RFS Program. With the passage of the Energy Independence and Security Act of 2007, Congress made several important revisions to the RFS.

As of January 1, 2010, the new RFS-2 increased the total renewable fuel required to be used as transportation fuel from 9 billion gallons in 2008 to 36 billion gallons by 2022. Of the four separate standards, the cellulosic biofuel requirement grows most significantly at 100 million gallons in 2010 to 16 billion gallons in 2022; one billion gallons more than corn based ethanol (15 billion gallons that year).[29]

Parties (refiners, importers, and blenders) have minimum yearly calculated volumetric blending obligations that gradually rise between 2009 and 2022. Not surprisingly, the RFS will increase demand for ethanol and biodiesel. Companies can generate Renewable Identification Number (RIN) credits for excess renewable fuel use which may be purchased or sold for compliance purposes.

National Greenhouse Gas and Corporate Average Fuel Economy (CAFÉ) Standards for Vehicles

On September 15, 2009, the U.S. EPA and the U.S. Department of Transportation's National Highway Safety Administration (NHTSA) proposed an historic National Program that would dramatically reduce GHG emissions and improve fuel economy for passenger cars, light-duty trucks, and medium-duty passenger vehicles, covering model years 2012 through 2016.

The combined U.S. EPA and NHTSA standards require these vehicles to meet an estimated combined average emissions level of 250 grams of carbon dioxide (CO_2) per mile, equivalent to

[29] The RFS includes four separate categories including Biomass Based Diesel, Cellulosic Biofuel, Total Advanced Biofuel and Total Renewable Fuel. RFS eligible corn based ethanol is the difference between Total Renewable Fuel and the sum of the other three categories. Source: EPA Table "RFS2: 4 Separate STDS."

35.5 miles per gallon (MPG) if the automobile industry were to meet this CO_2 level solely[30] through fuel economy improvements. Together, these proposed standards would cut CO_2 emissions by an estimated 950 million metric tons and 1.8 billion barrels of oil over the lifetime of the vehicles sold under the National Program (model years 2012-2016).

Under this proposed National Program, automakers would be able to build a single light-duty national fleet that satisfies all requirements under both the National Program and the standards of California and other states, while ensuring that consumers still have a full range of vehicle choices.[31] Automakers will also be able to earn, trade, and bank credits by producing battery electric vehicles, plug-in hybrid electric vehicles, fuel cell vehicles, and (for a limited number of model years) flex-fuel vehicles.

Renewable Portfolio Standard

California's Renewable Portfolio Standard (RPS) was established by Senate Bill 1078 (Sher, Chapter 516, Statutes of 2002), and amended by Senate Bill 107 (Smitian and Perata, Chapter 464, Statutes of 2006) and Senate Bill 1036 (Perata, Chapter 685, Statutes of 2007). It requires electric corporations to increase procurement from eligible renewable energy resources by at least 1 percent of their retail sales annually, until they reach 20 percent by 2010. The Governor, by signing Executive Order S-14-08 established a more aggressive goal of 33 percent by 2020. This higher goal is a key strategy for meeting the state's greenhouse gas emission reduction targets[32] and has implications for potential greenhouse gas reductions for electric vehicles.

On September 15, 2009, Executive Order S-21-09 ordered that the ARB, under its AB 32 authority, adopt a regulation consistent with the 33 percent renewable energy target by July 31, 2010. ARB shall also work with the PUC, the Energy Commission and the California ISO to encourage the creation and use of renewable energy sources built upon the RPS Program and may increase the target and accelerate and expand the time frame based on a thorough assessment of relevant factors.[33]

Clean Air Action Plan

On November 20, 2006, the Port of Los Angeles and Port of Long Beach both adopted the San Pedro Bay Ports Clean Air Action Plan (CAAP)[34]. The goal of the CAAP is to reduce port-

[30] A/C and tailpipe emissions represent 1%-3.5% of fuel economy standards.

[31] http://www.epa.gov/oms/climate/regulations.htm.

[32] http://www.energy.ca.gov/portfolio/ and http://www.cpuc.ca.gov/PUC/energy/Renewables/index.htm.

[33] http://gov.ca/executive-order/13269.

[34] http://www.portoflosangeles.org/environment/caap.asp.

related air pollution, including particulate matter, nitrogen oxide, and sulfur oxide, by at least 45 percent by 2012. As part of the CAAP, the Ports are implementing a Clean Trucks Program[35] (CTP), which aims to reduce heavy-duty drayage truck-related air pollution by 80 percent by 2012. Part of the CTP requires the scheduled phase-out of trucks that do not meet the 2007 federal emission standards. Beginning January 1, 2010, pre-1994 diesel trucks, and certain non-retrofitted 1994-2003 trucks, will be banned from use in the ports.

Both ports also offer incentives for fleet owners to replace older trucks with newer, cleaner trucks. In particular, the Alternative Fuel Vehicle Funding Program, funded by the ports, the South Coast Air Quality Management District (SCAQMD), and ARB (with Prop 1B funds), offers $50 million to incentivize the purchase of natural gas trucks for use within either of the ports.

FUNDING ALLOCATION

The sections below describe the state of the technologies and markets for each category of alternative and renewable fuels and vehicles: electric drive, hydrogen, ethanol, biodiesel/renewable diesel, natural gas, and propane. Based on the current funding landscape and the status of the alternative and renewable fuels and advanced vehicle technologies and markets, the Energy Commission presents the following observations and funding allocations.

Electric Drive

Electric drive applications include hybrid-electric vehicles (HEV), plug-in hybrid-electric vehicles (PHEV), and battery electric vehicles (BEVs) in light-, medium-, and heavy-duty applications. There were approximately 350,000 light-, medium- and heavy-duty electric drive vehicles registered in California in 2008 for on-road use. The majority of these electric drive vehicles were HEVs.[36] Currently, 10 automakers are producing light-duty HEVs and as many as 110,000 are being added to the market in California each year. DMV data for 2008 shows less than 15,000 of California's electric drive vehicles were BEVs of which approximately 10,000 are low-speed neighborhood electric vehicles (NEVs), a decrease from the more than 23,000 BEVs registered in 2004. PHEVs represent less than 500 of the current electric drive vehicle population. Changes in 2008 to the ZEV program would encourage the production and deployment of PHEVs by allowing a new class of vehicle, Enhanced Advanced Technology Partial ZEVs, to meet up to 90 percent of the ZEV requirement in the near term (2012 to 2014)

[35] http://www.portoflosangeles.org/ctp/idx_ctp.asp.

[36] 2009 IEPR.

and up to 50 percent in the medium-term (2105 to 2017).[37] ARB estimates up to 25,000 PHEVs per year between 2012 and 2014.[38]

Installation of electric charge infrastructure will need to keep pace with the roll-out of electric drive vehicles. As more consumers desire home vehicle recharging, policies to develop both public and private infrastructure sufficient to meet the requirements for widespread use of BEVs and PHEVs will be required. Utilities will have to develop charging strategies and procedures and special rates that meet the needs of vehicle recharging and grid reliability. Infrastructure equipment will need to be standardized, on and off the vehicle.

Widespread use of electric drive technology still requires:

- Commercially available models in all vehicle classes
- Reductions in the cost of vehicle components and vehicle price to be competitive, without subsidies, with conventional vehicles
- Adequate charging infrastructure
- Public familiarity with battery recharging and replacement, and vehicle performance
- Local grid distribution (such as, local transformer) capacity to serve increased load

Light-Duty Vehicles

Given light-duty HEVs' current entries into the market, this section of the investment plan focuses on PHEVs and BEVs, which are integral to California's low-carbon transportation future. Full fuel-cycle emissions of BEVs using today's California electricity grid are 65 percent to 70 percent lower than the emissions of conventional gasoline vehicles.[39] As California shifts to an increasingly renewable electricity generation system, BEVs will account for fewer GHG emissions on a full fuel-cycle basis. Full fuel cycle emissions of PHEVs are estimated to be 50 percent lower than conventional gasoline vehicles, depending on the proportion of miles driven in electric mode, which is a function of installed battery capacity and driver behavior.

The main barrier to penetration of light-duty BEVs and PHEVs is vehicle purchase price, mostly due to battery cost. The current federal tax rebate of $7,500 for BEVs and PHEVs helps to offset their incremental cost over comparable conventional gasoline vehicles as shown in Table 4.

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[37] Zero-Emission Vehicle Standards for 2009 and Subsequent Model Year Passenger Cars, Light-Duty Trucks and Medium Duty Vehicles, Section 1962.1, Title 13, California Code of Regulations.

[38] 2008 Proposed Amendments to the California Zero-Emission Vehicle Program Regulations, Staff Report, California Air Resources Board, February 8, 2008.

[39] The Air Resources Board's January 2009 GREET model results are 96.1 g/MJ for California reformulated gasoline and 124.1 g/MJ for electricity. The 64 percent estimate takes into account the higher efficiency of electric vehicles (approximately a factor of three).

Table 4 Estimated Incremental Vehicle Cost[40]

	HEV	PHEV	BEV
Minimum	$2,182	$8,861	$20,122
Maximum	$5,056	$10,324	$31,342

Advanced battery technology, lighter in weight and with higher energy densities that can provide longer range driving is a challenge being pursued by several California battery manufacturers. Nanotechnology is being applied to develop high energy density lithium-ion batteries.[41] Integration of electric drive components into vehicle designs and platforms may still take several years to perfect.

In a market research survey conducted by the Dohring Company along with studies from the U.C. Davis Institute of Transportation Studies indicate a potential consumer market share of at least 12 percent of California's light-duty vehicle sales. Limitations were the lack of larger passenger vehicle models, restrictions of leasing versus purchasing, and price points that were not similar to a comparable gasoline vehicle. According to the Dohring study, limited range and function were not as much of an obstacle as product unavailability.[42]

PHEVs and BEVs have higher initial purchase prices than conventional vehicles, due to their high operating efficiency. However fuel costs are expected to be less in comparison to most internal combustion vehicles operating on gasoline. The cost of electricity as a fuel is typically 70 percent to 80 percent below the cost of gasoline per mile traveled[43]. In addition, BEVs are allowed high occupancy vehicle (HOV) lane access. However, until battery durability is improved, higher battery replacement costs may offset other savings. Currently, nickel metal hydride batteries last at least 5 years.[44] The United States Advanced Battery Consortium (USABC) has a 15 year goal for batteries in BEVs.[45] In December of 2009, the USABC issued

[40] 2009 IEPR.

[41] 2009 R&D 100 award given to Envia Systems and Argonne National Laboratory for highest energy and cycle life of all lithium-ion battery systems available in the market for electric vehicles.

[42] *The Current and Future Market for Electric Vehicles*, Green Car Institute.

[43] AB 1007.

[44] *Battery electric Vehicles: An Assessment of the Technology and Factors Influencing Market Readiness*, UC Davis/Institute of Transportation Studies for the Public Interest Energy Research Program/California Energy Commission, June 2007.

[45] *Batteries for Plug-In Hybrid electric Vehicles (PHEVs): Goals and the State of Technology circa 2008*, UC Davis/Institute of Transportation Studies, UCD-ITS-RR-08-14, May 2008.

Requests for Proposal Information for four projects related to advanced battery development for HEVs, PHEVs, and BEVs.[46]

For consumers unfamiliar with BEV technology, the location of chargers, implications of limited driving range and battery replacement cost are the primary areas of concern. Consumer education is essential to familiarizing consumers with electric vehicle technology.

According to the DMV, only 14,670 BEVs were in operation in California in 2008. Of those, approximately 10,397 are neighborhood electric vehicles (NEVs) which are limited or low-speed vehicles for off-highway use. Of the non-NEV's, about 42 percent date from 1999 and earlier, and use outdated batteries and battery management systems.

For automakers, the benefits of high efficiency, reduced greenhouse gas and other criteria emissions, and fuel diversity are the primary motivations for pursuing BEV and PHEV technology. In addition, state policy is driving the timing of the industry investments including California's ZEV mandate. The ZEV mandate employs a credit system, with the cleanest vehicles receiving the most credits. Today's ZEV mandate is expected to result in the production of the following number of electric drive vehicles as shown in Table 5:

Table 5: Average Annual Vehicle Sales to Meet ZEV Mandate[47]

	2012 – 2014 (12 % Total Requirement)			2015 – 2017 (14 % Total Requirement)		
	Percent	Vehicles Per Year	Vehicles over period	Percent	Vehicles Per Year	Vehicles over period
ZEV	0.3% – 3%	840 – 8,353	2,500 – 25,000	3% – 6%	8,333-16,660	25,000 – 50,000
Enhanced AT PZEV	0 – 2.7%	Up to 25,000	Up to 75,000	Up to 3%	Up to 28,000	Up to 83,000
AT PZEV	3%	65,000	195,000	2%	51,000	153,000
PZEV	6.00%	420,000	1,260,000	6.00%	420,000	1,260,000

The ZEV mandate only applies to the five largest automakers: Ford, GM, Chrysler, Honda and Toyota. In addition, eight other existing automakers and 15 start-up companies plan to release BEVs and PHEVs during this time frame. Consequently, the total number of vehicles released during this period will likely be higher than shown in Table 5. Higher vehicle production

[46] http://www.greencarcongress.com/2009/12/usabc-issues-requests-for-proposal-information-for-four-energy-storage-projects-for-hybrid-plugin-hy.html.

[47] 2008 Proposed Amendments to the California Zero-Emission Vehicle Program Regulations, Staff Report, California Air Resources Board, February 8, 2008.

numbers should result in economies of scale thus reducing battery costs. As a result, incremental capital costs will be reduced for these vehicles compared to conventional vehicles.[48]

Under the ARRA, Ford received $5.9 billion in loans from the U. S. DOE to help it retool its plants to produce 13 fuel-efficient models, including as many as 10,000 EVs per year beginning in 2011. Nissan received $1.6 billion in loans to retool its Tennessee plant to make EVs. In August 2009, Ford, GM, Chrysler, and others received $2.4 billion in federal grants to encourage the development of HEVs and EVs. The grants include $1.5 billion for battery makers, $500 million for companies developing electric motors and drive components, and $400 million to test a recharging system for electric cars. While these ARRA funds are nationwide, historically California has received over 20 percent of all HEVs and over 40 percent of all BEVs produced or imported nationally. The ZEV mandate may increase the percentage of vehicles that are deployed in California.

The ARB, through its AQIP, is providing $4.1 million in its 2009-2010 Funding Plan as purchase incentives for BEVs and PHEVs with additional funds in the future. Therefore, the Energy Commission is not proposing to provide incentives this investment plan. However, the Energy Commission will consider a reallocation of funds in this investment plan to augment ARB's funds should the need arise.

Light-Duty Vehicle Retrofits

Retrofitting HEVs to PHEVs can achieve GHG and petroleum reductions from a growing population of light-duty vehicles in California. Conversions can familiarize consumers with plug-in technology and begin to create demand for the electric vehicle components and charging infrastructure that will be necessary to support commercial-scale BEV and PHEV deployment. By reducing the engines' need to generate electricity, a converted PHEV can reduce GHG emissions by as much as 30 percent over a conventional HEV on a lifecycle basis. [49] This reduces GHG emissions both by allowing the vehicle to operate less in internal combustion mode and by extending the life of the vehicle.

The ARB requires certification of retrofit vehicles, which means they must meet the same tailpipe standards as required for new vehicles. Performance tests and protocols are under development for a variety of electric drive conversions to ensure that they meet or exceed the base vehicles emissions requirements. Only one company, A123, is currently approved by ARB to retrofit HEVs to PHEVs and only for the second generation Toyota Prius.[50] There were approximately 275,000 registered Prius's in 2008; of these 220,000 are second generation models.

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[48] Energy Commission staff estimates with information from 2008 Proposed Amendments to the California Zero-Emission Vehicle Program Regulations, Staff Report, California Air Resources Board, February 8, 2008.

[49] Low Carbon Fuel Standard.

[50] The ARB is going through rulemaking (effective February 13, 2010) on PHEV test procedures and conversion system certification requirements.

Expected demand for Prius conversions for public and private fleet applications is in the range of 500 to 1,000 vehicles per year. [51] Prius conversions cost an estimated $10,000 per vehicle, less the $1,000 federal tax incentive for these conversions. The Energy Commission will be working closely with the PHEV Research Center to establish a demonstration program and will be evaluating the results of this effort to determine funding recommendations for HEV conversions in the future.

Medium- and Heavy-Duty Vehicles

There are nearly one million medium and heavy duty vehicles registered in California on the road and a half-million registered in other states which are operating in California. [52] Hybrid-electric and hydraulic-hybrid technologies on medium- and heavy-duty vehicles can potentially reduce GHG emissions 60 percent on a full fuel cycle basis compared to convention diesel vehicles. Hybrid electric trucks use the engine to recharge the batteries, which assists the engine and auxiliary functions. Hydraulic-hybrids use a hydraulic pump and motor to offer a power boost to the engine and auxiliary functions. Refuse trucks, drayage trucks, package delivery vans, utility trucks, transit and school buses, and harbor craft are the most practical applications due to their unique duty cycles. Deeper emissions and petroleum reductions can be achieved by combining PHEV technology with alternative and renewable fuel engines.

PHEV bucket trucks incorporate a battery powered electric motor for electric drive, hydraulics, and auxiliary tools without idling the combustion engine. These vehicles spend as much as 60 percent of their running time idling at a job site. With high idle fuel consumption estimates at 1 gal/hour, a PHEV bucket truck can displace an estimated 2000 gal/year in utility mode alone.

Hybrid trucks increase fuel economy and reduce emissions by approximately 60 percent. Presently, fewer than 600 commercial hybrid trucks are on the road today. However, at least 15 companies are developing hybrid-electric technologies and at least four companies are developing hydraulic-hybrid technologies. The primary obstacle facing this industry is the high incremental cost of the trucks, as shown in Table 6.

Table 6: Estimated Incremental Cost for Medium- and Heavy-Duty Electric Drive Vehicles[53]

	HEV	PHEV	BEV
Minimum	$16,000	$35,000	$50,000
Maximum	$24,000	$45,000	$100,000

[51] Staff analysis based on Energy Commission Electric Drive Workshop, and debriefing meetings with applicants after the ARRA solicitations.

[52] DMV data

[53] 2009 IEPR.

Electric drive medium- and heavy-duty trucks, buses, and non-road vehicles can saturate market niches earlier than electric drive passenger vehicles at a much lower level of production (3,000 to 5,000 vehicles per year). With these production volumes, the vehicles battery costs will be reduced significantly. Additionally, with the higher fuel savings of these vehicles they will achieve cost competitiveness with diesel vehicles sooner than in the light-duty market.

The ARB in coordination with the Energy Commission has decided to use their AB 118 funds for the deployment of on-road medium- and heavy-duty diesel HEVs. The Energy Commission's funds will be used to demonstrate advancements in medium- and heavy-duty BEV and PHEV vehicles as well as hybrid and hydraulic truck applications using alternative fueled vehicles. The Energy Commission funded the demonstration of medium-duty PHEV utility vehicles, shuttles, service trucks, and delivery vehicles through ARRA. Under the FY 2008-2010 Investment Plan, Program funds will match ARRA funding to provide a demonstration of 123 medium-duty plug-in hybrid electric vehicles, primarily in central and southern California. The Program will provide $9 million with approximately $26 million from ARRA and $26 million in participant match funds.

In addition to the California projects, ARRA funded almost 2,576 HEVs and 100 BEVs for demonstration in the medium- and heavy-duty vehicle classes nationwide. The funding will evaluate technical feasibility and build customer familiarity through a nationwide demonstration.

The ARB has allocated $29 million for four diesel hybrid and hydraulic hybrid truck deployment projects and for advanced technology demonstrations of diesel alternatives over the FY 2009-2010. Due to a large demand for rebates for these hybrids, the number of applicants may exceed ARB's funding.

Next generation plug-in hybrid and battery electric trucks need continuing proof-of-concept demonstrations to accelerate market introduction. The Energy Commission is providing up to $9.5 million of FY 2008-2010 Program funds in a current solicitation for projects that will advance the technology and develop the commercialization of BEV, HEV, PHEV, and alternative fueled advancements in medium- and heavy-duty vehicles. In addition the Energy Commission is funding a $3 million dollar Center of Excellence which will test and demonstrate advanced technology for class 8 trucks, including BEVs, PHEVs and HEV's. It will also provide education and outreach. The number of demonstrations and their geographic location will be determined when the Center is established based on need and resources.

To provide ongoing demonstrations of advancements, the Energy Commission will allocate $12 million in this investment plan to fund demonstration programs to stimulate the development of pre-commercial advanced technologies. Based on stakeholder information received and the demand shown by ARB and ARRA projects, vehicle demonstrations will aid the industry in providing vehicles that respond to customer needs.

Non-Road Applications

Electricity has the potential to replace diesel fuel in a number of non-road markets including forklifts,[54] truck refrigeration and auxiliary power units, port cold ironing, and truck-stop electrification (TSE).

Electrifying truck engines and non-road applications offers significant criteria pollutant and GHG emission reduction benefits, as well as fuel savings and other efficiency improvements. [55] However, the high upfront capital costs to purchase and install equipment inhibit the widespread adoption of these technologies.

In 2006, California had seven truck stop facilities that featured TSE infrastructure and services. However, California has more than 300 truck stop-sites and 20,000 truck parking spots that are candidates to switch to TSE and use electricity instead of fuel burning auxiliary power units for cabin power. Currently, the Energy Commission has a grant solicitation providing up to $125,000 per TSE project. ARRA funding provided over $22 million for 50 TSE projects outside of California, expanding the network of TSE availability for the more than 76,000 long-haul trucks that travel into and within California. TSE costs about $10,000 per parking stall and truck refrigeration units cost $12,000 to $15,000 per unit. The Energy Commission recommends $2 million for demonstrations on non-road medium- and heavy-duty vehicles in this investment plan.

In addition to TSE the Energy Commission is looking into port cold ironing. These naval ships often idle for several times longer than medium- and heavy-duty trucks just for the electricity produced. In addition, these vessels use high sulfur fuel, have very poor emission control systems and their large engines burn several times more petroleum than even the largest trucks. Plugging these vessels into a stationary power source can significantly reduce their emissions. Retrofitting ships may not be a good investment, however, as they may change routes, and because standards for cold ironing vary according to the ship's origin.

Charging Infrastructure

Installation and upgrades of electric charge infrastructure will need to keep pace with the roll-out of electric drive vehicles. Existing electric charging infrastructure is sufficient to support the current BEV and PHEV populations; however, current infrastructure is inadequate to support the anticipated BEV and PHEV sales expected by 2012. In the city of Los Angeles alone, about 400 chargers will need to be upgraded and 100 new chargers installed.[56] Nissan and the City of San Francisco, on behalf of the Bay Area EV Corridor, will promote the development of a charging network in a nine-county region. For the Bay Area EV Corridor it is estimated that

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[54] The Energy Commission is using both in-door and out-door BEV forklifts within this context. Out-door forklifts are not fully commercial products.

[55] 2009 IEPR.

[56] "L.A. Prepares for More Electric Vehicles", Los Angeles News, Associated Press, December 2, 2009.

approximately 1,000 chargers will be needed by 2011.[57] Nissan has committed to making the Nissan LEAF commercially available in the Bay Area upon its debut in December of 2010.[58]

California has approximately 3,000 public access electric charge points and an additional 1,500 commercial and municipal locations that offer charging service. A charging site (or station) may offer multiple charging points and a charging point consists of a single charge outlet. These public access charge points need to be upgraded to include Society of Automotive Engineers (SAE) J1772 compliant connectors to charge new BEVs and PHEVs. In addition to upgrades, a larger, more strategic network of new electric charging stations will be needed to support the number of BEVs and PHEVs in the next few years. Installation of new charging points will reflect the growth of urban area BEV and PHEV purchases, business and municipal fleet purchases, commuter corridor locations, and charge points for medium-duty and heavy-duty electric trucks and transit buses.

There are three voltage levels for recharging BEVs and PHEVs: level 1 is ordinary household current at 120 volts; level 2 at 240 volts, is used in residences for washers and dryers, although some older houses do not have level 2 wiring; and level 3, at 480 volts, is not found in residences, but is necessary for quick charges. For a BEV with a 100 mile range, recharging at level 1 requires six to eight hours and is essentially an overnight process. Level 2 recharging requires no more than two hours while a level 3 recharge takes about 10 to 15 minutes but does not use the standard SAE J1772 connector.

Installation of residential charging stations needs to be seamless; this includes permitting, installation, and inspection. Likewise, mechanisms and protocols for uniform payment, similar to bank ATM systems, would allow charging at any site, enhancing vehicle commercialization. The Energy Commission will examine these issues more closely as it considers funding for charging infrastructure.

Senate Bill 626 (Kehoe, Chapter 355, statues of 2009) requires the PUC, in consultation with the Energy Commission, the ARB, electrical corporations, and the motor vehicle industry to evaluate and implement policies relating to plug-in hybrid and electric vehicles and adopt rules by 1 January 2011. On August 20, 2009, the California Public Utilities Commission (PUC) filed an Order Instituting Rulemaking. The rulemaking will "consider tariffs, infrastructure and policies needed for California investor-owned electric utilities to ready the electricity system in a consistent, near-term manner for the projected statewide market growth of light-duty electric vehicles throughout California." [59] Comments are invited from all governmental entities with interests related to the rulemaking.

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[57] Bob Hayden, City of San Francisco Department of the Environment, conversation with Jonah Margolis, 1/11/2010.

[58] *Nissan, San Francisco Collaborate to Develop Bay Area EV Charging Network*, www.nissanusa.com/leaf-electric-car/news.jsp, December 7, 2009.

[59] http://docs.cpuc.ca.gov/word_pdf/FINAL_DECISION/106042.pdf.

Another option to accommodate charging needs is the Battery Switch Station (BSS), where a discharged battery pack is replaced with a fully charged battery pack. BSS enables third party battery ownership, ease of battery replacement for servicing, and use in secondary applications. Since most charging will be done at home, work, and in public spaces, BSS deployment is not required on the same scale as the current gasoline infrastructure. High mileage fleets such as taxicabs could use BSS within and between cities. BSS deployment, similar to natural gas station deployment, could initially follow the freeways between major cities before branching out to secondary roads. To expedite, validate and test the battery switch model, any battery switch station will require the funding of switchable battery cars. At this time, staff does not recommend funding battery swap stations due to the lack of vehicle manufacturer support.

A large portion of the current public charging infrastructure will need to be upgraded to handle new BEVs and PHEVs. Funding from the previous Investment Plan used to match federal ARRA dollars were used to support Nissan, GM, Ford, and Chrysler BEV rollouts only in the San Diego and Sacramento areas (through responses to the Energy Commission's solicitation, PON-08-010). Currently, the Energy Commission has a grant solicitation with approximately $3 million available for electric drive infrastructure. The geographical distribution of electric drive infrastructure proposals under this solicitation is not known at this time.

OEM BEV rollouts will include the Bay Area and the greater Los Angeles area. Southern California Edison estimates 1,000 charging station upgrades will be required throughout their service territory by 2011.[60] In addition, several OEMs are testing PHEV models and Toyota's goal is to have a Prius PHEV on sale for retail consumers by 2011.[61] By leveraging program funds with private industry dollars, the Energy Commission expects to meet anticipated needs with a $3 million allocation for charging infrastructure. In combination with other programs, this should ensure the current charging points are adequate to support new vehicles.

Manufacturing

Encouraging manufacturers of BEVs and PHEVs and their components to locate or expand their operations in California has the potential to create several thousand green jobs and substantial benefits to the state's economy. For example, at its peak production before it closed, the New United Motor Manufacturing Inc (NUMMI) plant in Fremont, California employed 4,500 high skilled laborers and up to 35,000 supply chain workers in a joint venture between GM and Toyota.

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[60] "California utility prepares for surge in plug-in electric cars" by Chris Woodyard, USA Today, March 16, 2009.

[61] "Toyota Releases Details on Toyota Prius PHEV" by Jeffrey Ross, December 16, 2009, http://www.autotropolis.com/autotropolis-columns/car-tech/toyota-releases-details-on-toyota-prius-phev.html.

Several California manufacturers make lead-acid and nickel metal hydride batteries and component parts for gasoline vehicle automakers, components for the electronics industry, and stationary power storage systems for military and industrial customers. In addition, several start-up vehicle manufacturers have emerged in California and begun developing prototype and early market electric vehicles. However, high upfront capital costs impede these manufacturers from developing and expanding the plants and assembly lines to make advanced electric vehicle components and produce electric and alternative fuel vehicles for commercial sales.

Although the U.S. Department of Energy awarded nearly $1.7 billion nationwide for vehicle and battery manufacturing incentives, no California firm was selected for federal ARRA economic stimulus funding during 2009. However, the ARRA funds that were awarded nationwide will still have a large impact on the nation's ability to manufacture electric vehicles and components, and will in turn impact California's market for electric drive vehicles.
Under the FY 2008-2010 Program funding, the Energy Commission will award $19 million for a combination of grants for pre-development stages of manufacturing plants and loans to help finance assembly and production plants that make vehicles, batteries, electric propulsion systems and other components in California. The Energy Commission will collaborate with the State Treasurer's Office (STO) to establish loan mechanisms; additionally, STO will facilitate sales tax exemptions for the purchase of equipment to manufacture zero emission vehicles. The $19 million should result in 8 to 12 funding awards.

California utilities estimate that California will represent 25 percent of the national purchases of light-, medium-, and heavy-duty electric vehicles. As a result of the ARRA solicitation process and follow up interviews with stakeholders the CEC recommends manufacturing incentives of $7.5 million to $10 million. This will ensure that California manufacturers are established to fulfill demand from California customers seeking electric drive vehicles. California will benefit economically from the local production of vehicles and components. This funding will likely result in 20,000 to 30,000 electric vehicles sold per year within 5 years. Additionally, by 2014 battery sales will likely reach 100,000 per year within California primarily for medium-duty and heavy-duty auxiliary power units. At these levels it is expected that battery cost will drop by up to 50 percent from current market rates thereby increasing the competitiveness of PHEVs and BEVs compared to conventional vehicles. Repayments from revolving loans could reduce the need for annual allocations, and within five years, the need for manufacturing incentives could be eliminated, reduced or based only on loans and loan guarantees. Conversely, if California incentives are not provided in the near term, customer demand will be met by products manufactured primarily outside of California. [62]

[62] All data in this paragraph was taken from the Energy Commission Electric Drive Workshop, and debriefing meetings with applicants after the ARRA solicitations. All meetings hosted by the Energy Commission staff.

Table 7: Electric Drive Funding Summary

Develop and demonstrate advanced on-road medium- and heavy-duty technology	$12 Million
Develop and demonstrate advanced non-road medium- and heavy-duty technology	$2 Million
Infrastructure and related activities	$3 Million
Manufacturing facilities and equipment	$7.5 Million
Total	$24.5 Million

Hydrogen

Hydrogen fuel cell vehicles (FCVs) are zero-emission vehicles, producing no tailpipe criteria pollutants. Fuel cells generate electricity through an electrochemical process, using hydrogen as the fuel, to power an electric motor which drives the vehicle. When the hydrogen is converted to electricity in a fuel cell, the only by-products are heat and water.

Today, very little hydrogen is produced for use as a vehicle fuel. The vast majority of hydrogen is produced for industrial purposes through the reformation of natural gas. Hydrogen produced from natural gas and used in an FCV can reduce GHG emissions by 56 percent when compared to California's reformed gasoline.[63] The GHG reduction potential for hydrogen in FCVs ranges from 26 to 86 percent, depending largely on the hydrogen production method.[64] The higher values are possible when hydrogen is produced from biomass feedstocks including waste cellulose and biomethane produced from landfill gas.

Hydrogen can also be produced from low-carbon renewable resources, either as feedstocks or process energy, providing even greater greenhouse gas benefits on a full fuel cycle basis. Senate Bill 1505 (Lowenthal, Chapter 877, Statutes of 2006) requires that, on a statewide basis, no less than 33.3 percent of the hydrogen produced for, or dispensed by, fueling stations that receive

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[63] Based on Detailed California Modified GREET Pathway for Compressed Gaseous Hydrogen from North American Natural Gas version 2.1. California Air Resources Board http://www.arb.ca.gov/fuels/lcfs/lcfs.htm. and *Full Fuel Cycle Assessment: Well-to-Wheels Energy Inputs, Emissions, and Water Impacts* Consultant Report. California Energy Commission CEC-600-2007-004-REV.

(Numbers are on Grams/mile basis, i.e., EER values included to represent the full picture). Compressed H2 from on-site grid electrolysis: 26%; Compressed H2 from on-site NG reforming: 56%; Compressed H2 from on-site 70% renewable electrolysis: 63%; Compressed H2 from on-site NG reforming using 33% landfill gas as feedstock: 66%; Compressed H2 from on-site NG reforming using 100% landfill gas as feedstock: 86%. (All values % GHG reduction compared to California reformed gasoline baseline).

[64] Ibid.

state funds be made from eligible renewable energy resources. The ARB is currently developing regulations to clarify elements of the SB 1505 mandate for a possible June 2010 adoption.

Vehicle roll-outs by automakers will help transition the current early demonstration fleets to early commercialization, the timing for which is driven largely by the Zero Emission Vehicle and Zero Emission Bus mandates. During this transition, government and private investments in hydrogen fueling infrastructure will be essential in order to complement the roll-out of light-duty and transit FCVs. These investments will be needed to establish strategically located hydrogen fueling stations.

In order to overcome the high upfront costs of hydrogen fueling infrastructure when serving a small but growing vehicle population, a balance of government incentives and regulatory approaches is unavoidable. It is essential, though, that this is supplemented by strategic, business-oriented placement (market development) and funding of these stations. A focused and disciplined method is needed that includes all available "tools" for leveraging funds. (such as public-private partnerships, joint ventures, "anchor" stations in cluster communities,[65] co-locate fueling with CNG/other alternative fuels etc.) A crucial element of this effective strategy is to combine high-volume fuel use with multiple users to create the best business case and stimulate station owners/operators to co-invest. This also enables the stations ongoing future operation.

The ARB is currently evaluating a number of approaches to provide policy incentives to energy companies who invest in ultra-low carbon fuels including hydrogen. This includes the use of credit multipliers under the LCFS and changes to the Clean Fuels Outlets (CFO) program which requires energy companies to provide infrastructure once a certain number of vehicles have been sold. In December 10, 2009, the ARB directed staff to investigate the potential for these mechanisms and decisions on any proposed changes are expected in late 2010. These regulatory tools have the potential to create a clear business model for private investment in hydrogen infrastructure as vehicle numbers grow.[66]

Lastly, in order to establish hydrogen fuel as a commercial option in the future, a type approval for retail dispensing (and quality) of hydrogen is necessary. California is lacking standards for commercial or retail hydrogen dispensers for fueling vehicles, meaning that hydrogen cannot currently be sold in California on a retail per unit basis. Under an interagency agreement with the Energy Commission, the California Department of Food and Agriculture's (CDFA) Division of Weights and Measurement Standards (DMS) will seek to create a type approval by late 2010.

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[65] Cluster areas are Santa Monica, Torrance, Irvine, Newport Beach, early-adopter areas identified by UC studies and according to the California Fuel Cell Partnership's 2009 Action Plan http://www.cafcp.org/sites/files/Action%20Plan%20FINAL.pdf.

[66] Joan Ogden et al. "Roadmap for Hydrogen and Fuel Cell Vehicles in California: A Transition Strategy through 2017". Institute of Transportation Studies, University of California, Davis. December 21, 2009.

Light-Duty Vehicles

California's Zero Emission Vehicle (ZEV) program is the single most important driver in the introduction and commercialization of light-duty FCVs into the California market. (See Appendix B for a detailed description of the ZEV program). While the volumes are currently low, FCVs are expected to move from the current demonstration stage to early commercial volumes within the next decade. Table 6 shows the range of numbers of vehicles that the ARB estimates could be rolled out under ZEV compliance options and under the LCFS base case scenario.

In early 2009, the California Fuel Cell Partnership (CaFCP) prepared their first-ever Action Plan to deploy FCVs and fueling stations in California. [67] The Plan contained a survey of automakers conducted in late 2008 to determine timing and location of their deployment of FCVs in California. The first line in Table 7 shows the estimated FCV roll-outs according to the 2008 voluntary survey. The CaFCP is currently updating its survey for 2009.

Table 6: FCV and ZEV Roll-Out, Estimated Ranges (ZEV Mandate Requirements)

	2010-11	2012-14	2015-17
"Gold" FCVs (ZEV compliance)	0 to 250	0 to 5,357	0 to 25,000
"Gold" ZEV (Total FCV & BEV)	0	0 to 25,000	0 to 50,000
FCV (LCFS base case scenario)	0 to 1,400	0 to 9,000	0 to 45,000

The second line in Table 7 shows the results of a recent Energy Commission/ARB joint survey of automakers' written FCV rollout commitments. The majority of these vehicles will be rolled out in the Southern California cluster communities (see Appendix C for details on these cluster communities).[68]

[67] California Fuel Cell Partnership, Hydrogen Fuel Cell Vehicle and Station Deployment Plan: A strategy for Meeting the Challenge Ahead, http://www.fuelcellpartnership.org/sites/files/Action%20Plan%20FINAL.pdf.

[68] Cluster areas are Santa Monica, Torrance, Irvine, Newport Beach, early-adopter areas identified by UC studies and according to the California Fuel Cell Partnership's 2009 Action Plan http://www.cafcp.org/sites/files/Action%20Plan%20FINAL.pdf.

Table 7: Estimates of OEM Vehicle Roll-Out Numbers (Cumulative for Each Year)

	2009	2010	2011	2012	2013	2014	2012-14	2015-17
CaFCP December 2008 Survey	193	370	712				4,307	53,907
CEC/ARB November 2009 Survey	93	192	330	495	769	1,839	3,103	47,809

The federal Emergency Economic Stabilization Act (EESA) of 2008 included an extension of the Investment Tax Credit (ITC) for fuel cell technology through 2016. For FCVs that weigh no more than 8,500 pounds, the base credit amount is $8,000 if the vehicle is placed in service on or before December 31, 2009, and $4,000 if the vehicle is placed in service after that date. (It should be noted that neither $ 4,000 nor $8,000 is likely to cover the cost differential to a conventional vehicle).[69] Funding was offered for light-duty vehicles under the federal ARRA program, but none of those projects were approved by DOE. Table 8 provides the FCV roll out by major metropolitan areas.

Table 8: FCV Roll-out by Major Metropolitan Areas[70]

	2009	2010	2011	2012	2013	2014	2015-2017
Los Angeles Area (4 clusters)	52	105	175	257	372	849	18,349
Los Angeles Area (Other)	16	30	57	88	117	382	9,115
San Diego		4	8	8	23	33	1,100
Bay Area	9	20	34	48	91	264	11,145
Sacramento	9	17	25	38	60	117	1,942
Other	7	16	31	56	106	194	6,158
Total	93	192	330	495	769	1,839	47,809

The Energy Commission is not offering any vehicle incentives at this time; however, the ARB has allocated $4.1 million for light-duty vehicle incentives in their AQIP 2009-2010 Funding Plan. Under ARB's funding criteria, a fully-functioning FCV, such as the Honda Clarity FCX,

[69] Current early testing and demonstration FCVs have only theoretical price tags, sometimes in excess of one million dollars per vehicle.

[70] According to CEC/ARB November 2009 Survey.

would be eligible for a $5,000 per vehicle rebate. ARB expects the bulk of this allocation to be used for BEVs (and potentially PHEVs) since most FCVs are not marketed to retail customers yet. At public workshops, ARB staff has indicated its intent to continue this Clean Vehicle Rebate Project (CVRP) as a multi-year program, though no allocations for the 2010-2011 AQIP Funding Plan have been approved.[71]

Heavy-Duty Vehicles

California has pursued the vigorous development and deployment of alternative-fueled and hydrogen fuel cell transit buses through regulations and incentives for more than 10 years. Over this time, many developments and successes have advanced the evolution of hydrogen fuel cell transit bus technologies for the benefit of the state and the nation. Hydrogen fuel cell buses can reduce GHG emissions from 26 percent to 86 percent compared to conventional diesel buses, depending on the method of hydrogen production.[72]

Since 2004, the ARB has helped co-fund fuel cell bus demonstration programs in the bay area and in Southern California. The HyRoad Program, led by AC Transit in Oakland/Emeryville, will roll out 12 hydrogen FC buses in mid 2010. [73] In addition, the ARB co-funded two fuel cell buses with SunLine Transit in Twentynine Palms. The first of 12 bay area buses is expected to be operational by the end of 2009. (Please see the Introduction section of this document for details on the ZEB program.)

In a July 2009 ARB meeting, staff was permitted to delay the ZEB purchase requirement, however, ARB staff has not changed the actual regulation. A two to three year delay is likely. In addition, ARB staff has been directed by the Board to develop cost-differential purchase metrics to re-evaluate and re-institute the schedule for purchase requirement, and to report back to the Board by July 2012. The reasons for the delay of the purchase requirement include the higher than expected cost differential compared to conventional diesel buses and the new alternative fuel technologies, and the reliability, durability and commercial readiness of the transit bus technologies.

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[71] For the 2010-2011 Funding Plan, ARB has indicated that two FCV models may be eligible as ZE Vs under the CVRP if funding is continued. The Honda Clarity and the Mercedes B-Class could be eligible if they are leased to customers in a three-year lease agreement.

[72] Based on Detailed California Modified GREET Pathway for Compressed Gaseous Hydrogen from North American Natural Gas version 2.1. California Air Resources Board http://www.arb.ca.gov/fuels/lcfs/lcfs.htm. and *Full Fuel Cycle Assessment: Well-to-Wheels Energy Inputs, Emissions, and Water Impacts* Consultant Report. California Energy Commission CEC-600-2007-004-REV.

(Numbers are on Grams/mile basis, i.e., EER values included to represent the full picture). Compressed H2 from on-site grid electrolysis: 26%; Compressed H2 from on-site NG reforming: 56%; Compressed H2 from on-site 70% renewable electrolysis: 63%; Compressed H2 from on-site NG reforming using 33% landfill gas as feedstock: 66%; Compressed H2 from on-site NG reforming using 100% landfill gas as feedstock: 86%. (All values % GHG reduction compared to California reformed gasoline baseline).

[73] "AC Transit for the Environment," http://www.actransit.org/environment/hyroad_main.wu.

A company in Southern California (Vision Industries) has proposed hydrogen fuel cell heavy-duty drayage trucks to be deployed for moving goods in and around ports. This fuel cell truck (battery-dominant hybrid) looks promising, but as a prototype, has undergone very limited testing. Additional testing, validation and demonstration are needed to prepare the technology for commercial demonstration or deployment.

In addition, other related "bridging" technologies being developed for hydrogen. For example, blending up to 30 percent hydrogen with natural gas and hydrogen-compressed natural gas (H/CNG) fuels have produced positive emission and operational results in trucks, buses, and vans. Hydrogen-fueled internal combustion engines offer another bridging technology with the potential to reduce greenhouse gas and criteria emissions although the lower efficiency of combustion engines relative to fuel cells reduces their benefits. This may be a viable transition option from existing conventional vehicle technology.

Under ARRA, there is very limited funding available for heavy duty hydrogen vehicle incentive programs. The only project funded under ARRA/DOE was for hydrogen fueling infrastructure (to fuel hydrogen fuel cell buses in Connecticut). However, the Federal Transit Administration did make a significant contribution (12 FCBs) to the AC Transit's HyRoad hydrogen bus program.

The Federal Investment Tax Credit for fuel cell technology provides tax credits of between $10,000 and $40,000 for heavy-duty vehicles, based on the weight of the vehicle. The credit may be claimed for vehicles placed in service after December 31, 2005, and purchased on or before December 31, 2014.

Another funding source comes from the South Coast Air Quality Management District (SCAQMD). It reserves some of its Clean Fuels Program funding (13 percent of $16.6 million) for hydrogen and fuel cells. This is mostly intended for research and development in transit and heavy-duty applications with the goal of air quality improvement. Co-funding demonstration/test fleet projects through the AQMDs is already in progress as explained in the ZEB section above. Additionally, ARB is currently reviewing, monitoring and re-assessing components of the AQIP to potentially fund and support Hydrogen fuel cell buses in future funding plans.

The Energy Commission may consider funding for hydrogen trucks in FY 2010-2011. If allotted, this will come from funds reserved for on-road medium- and heavy-duty electric drive vehicles. (See the electric drive section for more details.)

Non-Road Applications

A recent report for the DOE identified at least two near-term markets for non-road use of hydrogen fuel cells.[74] Forklifts in warehousing and distribution centers and airport ground support equipment (which include certain classes of forklifts). Fuel cell forklifts are considered

[74] *Full Fuel-Cycle Comparison of Forklift Propulsion System*, Argonne National Laboratory, ANL/ESD/08-3, October 2008.

to have near-term market potential because they provide zero emission operation, allow rapid re-fueling, and do not diminish in power during operation. The ability to rapidly refuel is especially attractive for multi-shift applications. Indoor and outdoor air quality concerns are another important reason for preferring battery electric or fuel cell forklifts over combustion engines in the work place. The Department of Defense through the Defense Logistics Agency has a large fuel cell forklift demonstration program underway at distribution depots throughout the country. Argonne National Laboratory has estimated that about 50,000 battery electric forklifts have been sold each year from 2005 to 2007 representing a large market potential for this new technology. It is possible in certain locations that infrastructure to serve forklift applications could also adequately serve vehicle applications. Finding such locations may be a challenge, but would offer opportunities for more effectively funding projects that serve more than one infrastructure purpose.

The Energy Commission does not intend to fund off-road applications in FY 2010-2011, but acknowledges their importance and potential. The ARB AQIP Funding Plan for FY 2009-2010 includes $2 million for non-road applications, for example agricultural and lawn/garden equipment, marine vessels, locomotives, and other off-road equipment.[75] The Energy Commission proposes that the ARB continue to support these activities in the coming fiscal year.

Infrastructure

In its first investment plan, the Energy Commission sought to provide adequate funding (up to $40 million) for the cost-shared establishment of needed hydrogen infrastructure based on the information available from public agencies, public and private organizations and stakeholders. Since that time, many developments have occurred, some that have advanced and some that have hindered these critical and strategic infrastructure establishment efforts.

The Energy Commission sought purposeful collaborations and participation with all involved entities and stakeholders. Some of those include:

- Collaborations with the CaFCP, ARB, the Institute of Transportation Studies (UC Davis), National Fuel Cell Research Center (UC Irvine), and the National Renewable Energy Laboratory (NREL).
- Partnerships with air quality management districts and other public agencies, such as the Clean Air Technology Initiative.[76]
- Development of an interagency agreement with the California Department of Food and Agriculture, Division of Measurement Standards for the establishment of hydrogen fuel

[75] "Proposed AB 118 Air Quality Improvement Program Funding Allocation for Fiscal Year 2009-2010," available at: http://www.arb.ca.gov/msprog/aqip/fundplan/aqip_FY09-10_FP.pdf.

[76] Participants include the U.S. EPA, U.S. DOE, ARB, South Coast Air Quality Management District, and the San Joaquin Valley Air Pollution Control District.

quality standards and the certification 'type approval' for a retail hydrogen dispenser for use at retail stations in California.

- Discussions with industrial gas companies (IGCs) on the strategic development of hydrogen fueling infrastructure to accommodate the planned roll-out of FCVs and FCBs in California.
- Discussions with OEMs and the preparation/administration, with the ARB, of a survey of expected FCV rollouts with specification of timing, location and numbers of vehicles to be deployed over the next several years.

Based on these collaborations, participations and discussions, the Energy Commission has noted that the evolving landscape for hydrogen fueling infrastructure involves several important factors for success.

- Approximately 12 months is required to establish a hydrogen fueling station.[77] This represents a significant decrease from previous estimates, which were up to 24 months, due to improvements in technology and permitting processes.
- Currently all existing stations have 350 bar dispensing pressure, with the exceptions of two stations dispensing at 700 bar (UC Irvine and Burbank). New stations will be expected to offer both 350 and 700 bar fueling options.
- The cost to build a new hydrogen station with a minimum dispensing capacity of 100kg per day ranges from $2 to $3 million.[78] These costs show signs of decreasing, as the industry develops new, innovative production, distribution and retail supply strategies that are more cost-efficient, including larger capacity stations. Refurbishing an existing station may be possible is some cases, but upgrading to a higher dispensing pressure or dispensing capacity may or may not be cost prohibitive.
- In a preliminary assessment of the existing hydrogen fueling station network in or nearby the four designated clusters in southern California, two stations lack sufficient operation and maintenance support to continue operation, and three stations would require capacity expansion/upgrades, and possibly operations and maintenance support, to be useful in the future (see Appendix C).
- A further assessment can determine whether three existing stations outside designated clusters could serve as 'connector' stations if capacity expansion/upgrade for open access was achieved, and whether any of the existing stations not operating now, or scheduled to cease operation, have equipment that could be utilized at other 'connector'

[77] "Hydrogen Fuel Station Building and Permitting," Presentation by Mike Mackey, P.E., General Physics Corporation, hosted by the California Fuel Cell Partnership on October, 2009.

[78] "California Hydrogen Highway Network: CaH_2Net – Summer 2009 Update," California Air Resources Board, http://www.hydrogenhighway.ca.gov/update/summer09.pdf.

station locations. The Energy Commission is now planning such an assessment to take place.

- A focused and strategic effort is needed to include all available "tools" for leveraging funds (such as establishing public-private partnerships, or joint ventures, "anchoring" stations in cluster communities,[79] co-locating fueling with CNG/other alternative fuels, and combining high-volume fuel use with multiple users to create the best business case and to stimulate station owners/operators to co-invest, and producers to invest in renewable hydrogen production).
- There is currently no Federal funding dedicated to the strategic roll-out of hydrogen fueling stations in California. However, funding from AQMDs and other local authorities, as well as private industry partners, could significantly enhance the efforts to establish infrastructure, further easing the deployment of FCVs.
- Public funding alone is an unsustainable strategy in the long term to support the growing development of an extensive hydrogen fueling infrastructure in California as FCV deployments increase toward commercialization. ARB is currently evaluating the potential to use credit multipliers under Low Carbon Fuel Standard (LCFS) and changes to the existing Clean Fuels Outlets regulation for ZEV enabling infrastructure development. These "Complimentary Policies" can hold substantial promise for success in the development of this needed hydrogen infrastructure, if they are approved.[80]

A recent assessment of the hydrogen fueling stations[81] established over the past several years shows that except for one Sacramento station and two in the San Francisco bay area, all others are located in the greater Los Angeles area. Of the original 25 dispensing stations, three are operated by transit agencies, five by automakers, and three by universities. Of all the previously established stations in California, today five are publicly accessible and in useable condition. Of the remaining 20 stations, some may have potential to be adaptable or salvageable if funding can be provided (and if they are in strategically beneficial locations).

The ARB has awarded funding to seven fueling station projects over the past two years. These are expected to come online in 2010 or 2011. Most of these have 100 kg or more capacity (up to

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[79] Cluster areas are Santa Monica, Torrance, Irvine, Newport Beach, early-adopter areas identified by UC studies and according to the California Fuel Cell Partnership's 2009 Action Plan (Available at http://www.cafcp.org/sites/files/Action%20Plan%20FINAL.pdf)

[80] At its December 10, 2009 Board meeting, Members of the Air Resources Board directed ARB staff to investigate the potential for using these mechanisms and to report back to the board in December of 2010. These regulatory tools may offer an attractive and viable compliment to public incentives funding, providing needed balance to the existing vehicle-oriented ZEV mandate. Considering the exponential growth of the vehicle volumes projected in 2015-2017, this three-pronged approach of cost-shared station establishment incentives, station establishment mandates and regulatory credits for "early actions", will provide the best, most balanced chance for mid- term and long-term ZEV mandate success.

[81] CaFCP hydrogen fueling station tracking documentation. August 2009 update.

140 kg) and all of them are equipped with 350 bar and 700 bar dispensing capability. Typically, new stations built today will need to offer a minimum of 50-100kg/day, and are usually equipped with both 350 bar and 700 bar fueling capabilities to allow for fueling newer and older model FCVs.

Initially, the CaFCP's Action Plan called for establishing 50 new fueling stations by 2017, about 8-10 new stations per year in order to avoid a "fueling deficit" for OEM vehicles deployed. This expectation has changed based on the new, lower vehicle rollout commitment numbers from automakers shown in Table 7. Compared to CaFCP's prior (late 2008) survey for vehicle deployment, the data from the CEC/ARB (late 2009) survey has determined that about half the vehicles will be placed into the market over the next three years (see Tables 7 and 8). This effectively slows the introduction of vehicles and delays the predicted "fueling deficit" by about two years.

In the current state of FCV demonstration, one FCV will use an average of one kg/day. Considering this, and the numbers from Table 8, focusing funding for stations in designated southern California clusters (and for other compelling and strategic locations outside those clusters) and for critical transit demonstrations is the most practical course. Honda has shown its support for such an approach by offering to place up to 25 vehicles in a particular urban area cluster to concentrate the placement of fueling stations. [82]

Table C-1 of Appendix C shows a supply and demand analysis that the Energy Commission developed using values from Table 8 and ARB estimates on fueling capacity supply for the seven new stations, five existing stations and those recommended for increased capacity/upgrade. Of these stations, seven are located in or near clusters and five could be considered "connector" station locations for fueling vehicles listed in "Other" locations on the OEM survey (See Table C-1). The results show that required capacity for the vehicle deployments in the greater Los Angeles area could be met with the existing and new fueling stations through 2012. Beginning in 2013, there is a projected "fueling deficit." The Energy Commission notes that deployment of light-duty FCVs are expected in Sacramento, San Diego, and the San Francisco Bay area. In the past, these areas have not been viewed as a high priority for the installation of fueling infrastructure.

To address the projected fueling deficit, the Energy Commission will provide $22 million from the first investment plan in a solicitation to be released this spring to ensure ample hydrogen availability at publicly accessible fuel dispensing locations. The solicitation will also address fueling options for transit properties and other strategic fueling infrastructure opportunities, including off-road applications such as material handling operations. The Energy Commission will invest its funds in a cost-efficient manner that maximizes hydrogen throughput at each station.

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[82] Cluster areas are Santa Monica, Torrance, Irvine, Newport Beach, early-adopter areas identified by UC studies and according to the California Fuel Cell Partnership's 2009 Action Plan http://www.cafcp.org/sites/files/Action%20Plan%20FINAL.pdf.

Specifically, it is estimated that this funding could establish six to eight "retail" stations (either inside or outside designated clusters), support existing stations requiring funds for continuing operations and maintenance, expand capacity/upgrade existing and strategically useful stations, and help establish needed transit demonstration fueling capability. It may be possible to establish up to 1,000 kg/day fueling capacity, more than filling the fueling deficit.

The Energy Commission recognizes, however, that there are still uncertainties associated with the permitting, design, installation, and operation of hydrogen fueling infrastructure. Therefore, the Energy Commission is recommending an additional $14 million in this investment plan for hydrogen fueling infrastructure. The Energy Commission will closely monitor the results from its upcoming hydrogen infrastructure solicitation, and re-evaluate infrastructure needs in an ongoing and focused manner.

The Energy Commission also recognizes that the combination of establishing cost-shared infrastructure (whether through public-private partnership, joint venture or other development agreement), the Clean Fuel Outlets regulation, and the approval of credit multipliers for "early actions" will provide the most balanced and 'likely to succeed' path to the focused, timely and coordinated development of necessary hydrogen fueling infrastructure for the successful commercialization of FCVs.

Table 9: Hydrogen Funding Summary

Fueling Infrastructure	$14 Million
Total	$14 Million

Ethanol

Ethanol is a fully commercial bio-based gasoline blending component currently used in all of California's Reformulated Gasoline (CaRFG). E-85, a mixture of 85 percent ethanol and 15 percent gasoline hydrocarbons,[83] is a high renewables content alternative fuel for flexible fuel vehicles (FFVs). About one billion gallons of ethanol were used to make CaRFG in 2008 while less than one million gallons of ethanol were used to make E-85.

The demand for renewable fuel calculated as ethanol in California must triple between now and 2022 to meet California "fair share" requirements of the federal RFS, and a portion of transportation fuel carbon reduction requirements envisioned under California's Low Carbon Fuel Standard.[84] [85] The RFS requires that new biofuels consist of more than 50 percent advanced biofuels by the year 2022. Ethanol produced in Brazil using sugar cane already meets this definition under the revised RFS proposed regulations. California has an opportunity to create economic and employment benefits by promoting new in-state production of ethanol and a shift from corn to low carbon alternate feedstocks in existing facilities to meet the RFS. Increased in-state biofuels production would also create the opportunity to produce ethanol with a much lower greenhouse impact through improved production efficiencies and the use of feedstocks derived from waste streams and sustainably produced low carbon bioenergy crops. On a full fuel cycle basis, these feedstocks and state-of-the-art best practice biofuel production could result in an ethanol product with 80 percent and higher GHG emissions reductions relative to corn derived ethanol from the Midwest.

California has seven ethanol production plants — five corn-based ethanol plants and two smaller food and beverage waste processing plants.[86] When fully operational, these plants have

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[83] Unlike other states, Energy Commission staff believes that California refiners and blenders use California reformulated gasoline blendstock to make E-85 fuel. CARBOB (California Renewable Blendstock for Oxygenate Blending or "unfinished" California gasoline) is the most readily available source for the 15 percent "gasoline" portion of E-85.

[84] Corn based ethanol is the only immediate renewable fuel available to achieve RFS requirements, though increasingly, cellulosic ethanol could come to dominate California in-state production of ethanol as new facilities come on line over the next 10 years. Staff believes that some advanced biofuels such as biobutanol, and other bio oxygenated and non-oxygenated hydrocarbons ("biogasoline") may come to commercial status within this time period. However, any new type of transportation fuel would first need to undergo a fate and transport assessment and be approved for use in California prior to that type of fuel becoming a viable option for compliance with either the RFS or LCFS regulations.

[85] California Air Resources Board, *Proposed Regulation to Implement the Low Carbon Fuel Standard; Initial Statement of Reasons,* March 5, 2009. ARB staff expects conventional and advanced biofuels to contribute from 60 percent to 89 percent of the total carbon content (intensity) reductions in gasoline by 2020.

[86] California's five conventional corn "dry mill" ethanol plants are located in the San Joaquin Valley, while the two smaller plants are located in southern California. The California Cheese Company ceased operations at its Corona plant and laid off all 700 workers in late 2007. Parallel Products' plant in Rancho Cucamonga continues to process brewery and beverage processing wastes as it has since 1984.

a combined production capacity of about 250 million gallons per year (MGPY), representing about 25 percent of California's current ethanol demand. However, all five of the modern corn-based ethanol plants were idle for most of 2009 due to adverse market conditions. Only one is now in operation. In 2008, 86 percent of California's ethanol needs were met by imports of ethanol from corn-based plants in the Midwest while in-state plants provided 10 percent. Foreign ethanol imported via California ports provided the remaining 4 percent.[87] With the in-state production industry idled for most of 2009, jobs, tax revenue, and local income were lost.[88]

Loss of in-state ethanol production also has an important GHG advantage given an unwavering demand for ethanol blended into CaRFG. California plants produce ethanol that, on a full fuel cycle basis, has about 20 percent fewer GHG emissions than the average corn-based ethanol shipped in by rail from the Midwest.[89] California's small producers currently use natural gas for process energy (rather than the average Midwestern mix of coal and natural gas) and distribute "wet grains" to dairies and cattle feed lots. Newer production facilities (with higher process efficiency) combined with energy savings of not drying distillers grains gives California plants an inherent lower energy use (and carbon footprint) benefit when compared to average size and age Midwest plants.[90]

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[87] Foreign ethanol usually comes to California from Caribbean, Latin and South American nations under reduced or no tariff international agreements as well as from NAFTA partners Mexico and Canada. These agreements do not include Brazil, the world's second largest ethanol producer, however, Caribbean nations can upgrade hydrous Brazilian ethanol (minus the 54 cent per gallon U.S. tariff) for import into the U. S. under a 7 percent quota tied to corn based U.S. ethanol production in the previous calendar year. Other nations are subject to a 54 cent per gallon U.S. import tariff and ad valorem tax.

[88] Staff projects ethanol production in 2009 of 31 million gallons or 13 percent of California's installed capacity. If this projection holds, then just 3.1 percent of California's estimated one billion gallon ethanol demand in 2009 will be provided by California plants.

[89] California Air Resources Board analysis using the California version of the GREET model estimates Midwest corn ethanol full fuel cycle pathway GHG emissions about 25 percent higher than California plants distributing wet distillers grains locally.

[90] California's five dry mil ethanol plants were built in 2005, 2006 and 2008(3). These state of the art plants will have to continue to invest in efficiency upgrades just as the Midwest "baseline" plants have to keep their edge and remain competitive in the marketplace. The LCFS is a regulatory driver to increasingly move California plants to lower carbon feedstocks, advanced process technologies, and biomethane as a replacement for natural gas.

Light-Duty Vehicles

Significant use of renewable fuel in accordance with the aggressive RFS2 timeline can be achieved primarily through the use of high renewable content ethanol mixtures in light duty vehicles[91]. The federal RFS fair share biofuel use requirements for California can be achieved over the next 13 years with significant growth in the number of FFVs, and concurrent growth in the number of retail and fleet outlets and supporting distribution infrastructure and use of E-85. However, it appears that constraints imposed by new car emissions certification requirements will constrain new sales of FFVs in California in the coming years.[92]

To achieve RFS goals, California's existing fleet of 400,000 FFVs will have to increase by at least 2.8 million vehicles (and perhaps more depending on CaRFG demand) by 2022 if consumers owning FFVs use E-85 100 percent of the time. This number doubles to 5.6 million vehicles if consumers use E-85 only 50 percent of the time.[93] California's FFV growth depends on accelerated manufacturing and deployment by multiple automakers to achieve these production volumes for the California market. Currently, Detroit automakers are producing enough FFVs to meet consumer demand nationwide, and are on track to achieve 50 percent of their new car offerings as FFVs in 2012. However, these manufacturers are also beginning to withhold FFVs from the California market due to challenges in meeting California's new car and light truck PZEV emissions certification standards.[94] Each manufacturer must comply with a decreasing fleet average non-methane organic gas (NMOG) emission standard[95] over time

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[91] Use of ethanol and methanol in heavy-duty vehicles is not currently a widespread commercial scale practice in the United States.

[92] For the 2010 model year, Chrysler is withholding two FFV models from the California market and 10 other states who have adopted California Emissions standards. GM's 2010 FFV Impala is available only on request at dealerships. If not specified FFV, dealers will sell the gasoline SULEV version of the Impala to California consumers. Personal communication by Mike McCormack with Coleman Jones of General Motors Corporation.

[93] To encourage full time use of E-85, staff believes that a California Fuel Ethanol Reserve (CFER) will provide a mechanism to encourage competitively priced E-85 (gasoline gallon equivalent pricing or better) and dampen price volatility in the initial years of a low volume E-85 market. This voluntary reserve is modeled on the Energy Commission's successful California Fuel Methanol Reserve created in 1990s to market M-85 to consumers and fleets. Lacking a "Reserve" or other incentive directed to consumers, energy equivalent E-85 pricing (relative to CaRFG) is thought to command only a 50% share of the fuels market assuming the AFV (i.e., FFV) owners are assured (or perceive) that E-85 is conveniently available at retail outlets. See footnote # 73, David L. Greene.

[94] Cullen, Kevin "Fuel Economy & Emissions: Ethanol Blends vs. Gasoline" General Motors Powertrain Engineering ,presented at the DOE Biomass R&D TAC Meeting – September 10, 2007 and Ambrozaitis, Giedrius "Comments of the Alliance of Automobile Manufacturers On the Florida Department of Environmental Protection Proposed Rulemaking to Adopt the California Low Emission Vehicle Program (CA LEV)", August 11, 2008.

that will require all vehicles to achieve the super ultra low emissions (SULEV) tailpipe standard and zero evaporative emissions standards. Other manufacturers are not positioned to adequately fill this future potential gap of FFVs, and all manufacturers must find technical solutions to overcome the PZEV emissions certification hurdle. In order to achieve federal and California air quality standards and reduce toxic air contaminant emissions, a strategy must be developed that includes both technical solutions by the manufacturers and regulatory accommodation in California's emission certification procedures.

Despite the hurdles for FFVs in the California market, no funding is recommended for FY 2010-2011. While FFVs, including additional components, add modestly to the cost of a new vehicle, automakers are currently and have historically priced product line FFVs the same as their gasoline counterpart vehicles.

Fueling Infrastructure

E-85 fuel outlets will need to grow rapidly to accommodate FFV growth and consumer's choice of E-85, presuming FFV emissions certification issues and manufacturer's concerns are resolved within the next one or two years. In order to provide adequate availability of E-85 for consumers and businesses operating FFVs, the 43 existing retail and fleet fueling facilities must be expanded dramatically over 13 years to comply with the RFS renewable fuel use obligations of over 3 billion gallons of ethanol in 2022. A minimum of 900 to 1,800 E-85 dispensers must be strategically located to encourage large-scale E-85 demand by consumers to serve a presumed growing FFV market. [96,97]

E-85 dispensers are sparsely distributed within California. The current 43 dispensers represent only 0.4 percent of 10,400 retail gasoline outlets presumed to be operating today. Los Angeles and San Francisco Bay regions are notably lacking, while Sacramento region boasts the highest number of E-85 dispensers per capita.

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[95] The non-methane organic gas standard is ARB's "hydrocarbon" standard adjusted for ozone reactivity of fuel molecules. For example, oxygen containing molecules (e.g. ethanol, methanol, and butanol) have lower ozone reactivities than most hydrocarbons (e.g., benzene, gasoline components). Thus, "alcohol" cars can emit more "hydrocarbons" under the ARB NMOG standards, yet have the same ozone forming effect as a gasoline car emitting fewer gasoline "hydrocarbon" emissions.

[96] Analysis of dispenser needs for E85 to achieve RFS obligation under gasoline demand scenarios provided by Fossil Fuels Office staff—900 dual hose dispensers placed at retail stations represents about 10 percent coverage; 1,800 dispensers would be 20 percent of all retail gasoline outlets assuming 9,000 operational gasoline retail stations in the 2016 to 2022 time frame. Commission staff has assumed a gradual decline in the number of retail outlets from 10,500 presumed to be operating in 2009.

[97] Testimony from biofuel infrastructure industry panel at the September 14-15 2009 Investment Plan workshop, California Energy Commission.

The federal government, as part of the EISA (2007), allows an investment tax credit of up to 50 percent for alternative fuels infrastructure applicable to E-85 installations, up to $50,000. [98] Funding offerings are not expected from the ARB's AQIP or from regional air districts.

The Energy Commission estimates that up to $100,000 is sufficient Program funding to leverage a new E-85 dispenser and associated new underground equipment including fuel tank, given an estimated total cost of $250,000 per underground installation. New above ground installations are less costly, thus up to $50,000 is seen as an appropriate level of state funding. An allocation of $8.5 million will provide 85 additional underground dispenser installations assuming a cost-shared level of $150,000 by Program applicants. Since 43 E-85 dispensers are established and operating in California, and 55 more will be added through federal funds and/or FY 2008-2010 Program funding, FY 2010-2011 Program funding will contribute to the total of 183 dispensers statewide or about the first 10 percent of the 1800 dispensers needed to achieve the upper bound of the "adequate consumer availability" goal.[99] A funding allocation of $ 8.5 million for E-85 dispensers therefore provides a reasonable balance between one-time ARRA funding and immediate needs to increase E-85 fuel availability to at least 400,000 FFVs operated by consumers and fleets in California. At least four business models are being employed in California to meet perceived latent demand for E-85.[100]

Fuel Production

The federal Renewable Fuel Standard of the federal Energy Independence and Security Act of 2007 (EISA)[101,102] will drive renewable fuel production and use in California through 2022.

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[98] Staff has assumed that AB 118 FY 2008-2010 cost-sharing funds ($4 million) will supplant DOE ARRA funds in the event that Pearson Fuels declines federal funds or otherwise fails to execute an agreement to spend ARRA funding.

[99] Consumers are not concerned about alternative fuel being available when 10 to 20 percent of all gasoline retail outlets have an alternative fuel dispenser. Source: David L. Greene, "Survey Evidence on the Importance of Fuel Availability to Choice of Alternative Fuels and Vehicles," *Energy Studies Review*, vol. 8, no. 3, pp. 215–231, 1998. To achieve the 1800 dispenser installation goal (20 percent) by the end of the AB 118 Program, about 270 E-85 dispensers would need to be installed each year. To achieve the lower goal of 900 stations (10 percent), 121 stations per year would be required. Thus, future year AB 118 funding for E-85 dispensers needs to be in the range of $ 12.1 million to $ 27 million per year to achieve these 10 to 20 percent E-85 fuel availability goals during the remaining term of the AB 118 Program This estimate assumes $100,000 cost share in AB 118 funds per dispenser location (i.e. underground).

[100] In California, Propel, Pearson Fuels, Nella Oil Company, DMC Green Inc. among others have developed most of the existing E-85 stations. Details of the business approach are available on company websites.

[101] Staff estimates of future transportation fuels supply and demand forecasts include ethanol, E-85, and biodiesel use obligations under EISA; roughly equal volumes of ethanol blend E-10 and E-85 would be needed to meet the 2022 volume targets; WebEx Western States Coordination Meeting presentation, October 29, 2009, Fossil Fuels Office, Fuels and Transportation Division, California Energy Commission.

[102] The Renewable Fuel Standard Program was authorized under the Energy Policy Act of 2005 and amended in the Energy Independence and Security Act (EISA) of 2007. Among other requirements of the

California's fair share of the Total Renewable Fuel use obligation under RFS2 requires growth in ethanol demand of about 2 billion gallons by 2022. The assumption is that ethanol will be the predominant, but not the sole biofuel used to displace gasoline and lower its carbon content. When combined with the current volume of 1 billion gallons that is blended into CaRFG today, total demand for ethanol in 2022 will be 3.0 billion to 3.2 billion gallons per year. To comply with this requirement, California will need to add about 164 million gallons of new ethanol supply each year to satisfy the demand for gasoline and, increasingly, E-85 blending.

Between 2010 and 2012, CaRFG will shift from a 6 percent (E-6) to a 10 percent (E-10) ethanol-in-gasoline blend. The blending limit for ethanol under the Clean Air Act is 10 percent. This equates to about 1.5 billion gallons of ethanol annually. Further increases to higher blending levels (for example, E-15) are impeded by this so called "blending wall" in federal statute.[103] Therefore, the use of E-85 is the only practical way to meet RFS requirements by 2022.[104] If this scenario becomes reality, then consumer use of E-85 must grow to about 12 percent of California's gasoline demand to meet the state's RFS2 fair share requirement.

A mix of in-state produced ethanol, Midwest ethanol, and foreign-sourced ethanol will be required. California is uniquely positioned, however, to use vast in-state cellulosic and other low carbon feedstocks, and produce at least 80 percent of its fair share of RFS2 new ethanol from feedstocks other than corn. California has significant waste streams from the agricultural, municipal, and forest sectors that are available for use as feedstocks for advanced biofuels with low carbon content.[105] This contributes to achieving the RFS requirement of more than 50 percent of these new types of "low carbon" biofuels by 2022. Bioenergy crops such as energy cane and sweet sorghum can be grown on marginal soils to produce very low carbon ethanol

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RFS Program, the former "RFS1" and latter "RFS2"require mandatory biofuels use. "RFS2" fuel use obligations are much more aggressive than those of "RFS1," culminating at 36 billion gallons nationwide in 2022.

[103] The Clean Air Act Amendments of 1990 established a limit of 3.7 weight percent oxygen in gasoline as the upper limit of oxygen content. This limit corresponds to 10 percent by volume (not weight) ethanol blending in gasoline. Other oxygen containing blending components such as methanol, butanol or MTBE have different corresponding volumetric blending levels corresponding to the 3.7 weight percent limitation (e.g., butanol is 16 percent by volume).

[104] The federal Environmental Protection Agency, Department of Energy, oil and automotive manufacturers (Coordinating Research Council) and other affected industries are evaluating issues surrounding the use of ethanol blends greater than 10 percent. In addition, U.S. ethanol industry interests have petitioned EPA under Section 211 (f) of the Clean Air Act waiver process to allow an increase to 15 percent ethanol blending in gasoline.

[105] The California Biomass Collaborative projected for 2010 biomass potential of 86 million BDT/yr gross and 36 million BDT/yr technically recoverable biomass in California. Source: www.Biomass.ucdavis.edu/reports.html "An Assessment of Biomass Resources in California, 2007", Draft Report, PIER Collaborative Report, March 2008. Using an average CBC value of 82 gals of ethanol derivable from each BDT of a mix of biomass wastes and residues yields a technical potential in 2010 of 2.9 billion gallons of ethanol. CBC source "California Biofuel Goals and Production Potential", 2007.

(with 75 percent and higher reductions from the petroleum baseline) using some conventional, developing and demonstration phase future commercial conversion technologies.

California's LCFS identifies a major role for biofuels and will be another important factor that will increase the demand for low-carbon biofuels, particularly biofuels with very low full fuel cycle carbon emissions.[106] The LCFS requires transportation fuel providers (obligated parties) that make, buy, sell, distribute, or trade transportation fuels to decrease the carbon content of CaRFG and California diesel 10 percent by 2020. The LCFS differs from the RFS regarding biofuels in that it has no prescriptive production pathway, feedstock or renewable fuel use volumetric requirements. Obligated parties under the LCFS can use other transportation fuels including hydrogen, electricity, and natural gas and other means to meet carbon reduction requirements.[107] Several compliance scenarios in the LCFS illustrate different mixes of alternative fuels to meet the 2020 10-percent GHG reduction target. In one LCFS scenario, ARB staff estimates that 18 cellulosic biorefineries, 6 corn ethanol biorefineries, and 6 new biodiesel refineries could be needed by 2020 to meet the increased demand for low carbon content biofuels.[108]

Like all modern ethanol plants, California plants are candidates for efficiency upgrades and conversion to low carbon feedstocks using available California biomass wastes and sustainably produced bioenergy crops. For example, if biogas were substituted for natural gas in California's ethanol plants, ethanol carbon content would be on the order of 50 percent lower than conventional Midwest ethanol. One such project is underway at Calgren Renewable Fuels Pixley ethanol plant.[109]

At the Energy Commission's 2010-2011 Investment Plan Biofuels workshop, several project developers described strategies to produce very low carbon intensity biofuels (80 percent to 90 percent and greater reductions from CaRFG baseline) at competitive prices in California.

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[106] The LCFS uses the metric of "carbon intensity" to quantify measurement of and establish numerical requirements of grams carbon dioxide equivalent per Mega-Joule of energy content of all fuels on a lower heating value (LHV) basis (i.e., gCO2-eq/MJ), In-state based California ethanol produced at corn dry mills distributing wet distillers grains to feed lots has a carbon intensity value of 80.7 CO2-eq/MJ while a corresponding Midwest corn based ethanol based on 20 percent coal/NG process heat with drying of the distillers grains has a carbon intensity of 99.4 gCO2-eq/MJ, about a 20 percent carbon reduction advantage when produced in California.

[107] "*The federal RFS would deliver only about 30% of the GHG benefits of the proposed regulation, and does little to incent fuels such as natural gas, electricity or hydrogen. California's LCFS is designed to complement the federal RFS2.*" Excerpt from Executive Summary, Page ES-5, Proposed Regulation to Implement the Low Carbon Fuel Standard, Volume I, Staff Report: Initial Statement of Reasons, California Air Resource Board, March 5, 2009.

[108] California Air Resources Board, *Proposed Regulation to Implement the Low Carbon Fuel Standard: Initial Statement of Reasons*, March 5, 2009.

[109] Testimony of Dolores Santos, AB 118 2010-2011 Investment Plan Biofuels Workshop, September 14 - 15, 2009, California Energy Commission, Sacramento, California.

These strategies include 1) fractionation of feedstocks into multiple value added products including ethanol, renewable diesel, green electricity, and other co-products, 2) development of specialty bioenergy feedstocks such as energy cane and sweet sorghum that can be grown on marginal, non-food crop soils, and 3) capital investments to increase biorefinery production outputs to meet shifting and new market demands, similar to the production strategy used by petroleum refiners.[110]

Lack of capital and debt financing is impeding biofuel plant development and upgrades at some existing plants. If capital and debt financing were readily available, California's existing plants and planned plants now on hold could move forward to initiate use of California's biomass wastes and other alternate low carbon, feedstocks, such as sweet sorghum, citrus wastes, sugar cane, and sugar beets. Many in-state developers of advanced biofuels projects are positioned to provide technology specifically designed to use agricultural, forest, and municipal waste streams.

California's in-state biomass waste stream feedstocks are substantial. According to the California Biomass Collaborative, the annual, technically recoverable feedstocks include 8 million bone dry tons (BDT) of agricultural residues, 9 million BDT of municipal solid waste, and 14 million BDT of woody biomass from forest fuels management and other timber production waste streams.[111]

To meet the in-state production milestone for 2010 as identified in California's Bioenergy Action Plan (BAP), the state needs to restart its largely idle and corn based in-state production capacity of 240 MGPY. This modern infrastructure will serve as the basis for California's shift to cellulosic and other low carbon feedstocks. To achieve the BAP production goals in 2020, 20 plants with average production capacity of 47.5 MGPY would need to be built. Forty plants half that size may more fairly represent the size of emerging cellulosic and other low carbon ethanol production plants. Thus, a mix of 20 to 40 plants ranging from 24 to 47.5 MGPY capacity is possible. The market capital required to build the first two or three plants will be at least $250 million, since advanced biofuel and cellulosic ethanol production technology are unproven at commercial scale. However, capital costs will decrease as the new plants come on line. The Energy Commission estimates capital costs to be $7 to $10 per installed gallon in 2010 and 2011, $5 to $8 per installed gallon in 2012 and 2013, and $3 to $6 per installed gallon up to 2020.

The DOE has released solicitations totaling $570.5 million in funding through the ARRA across two biofuel technology categories: Integrated Biorefinery Production and Algal/Advanced Biofuels Consortia. No DOE awards were made for California based biorefinery facilities under the former, and awards have yet to be announced under the latter. In addition to these project

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[110] Testimonies of David Rubenstein of California Ethanol and Power, Brian Pellens of Great Valley Energy, and Bob Walker of Swan Biomass, AB 118 2010-2011 Investment Plan Workshop, September 14 - 15, 2009, California Energy Commission, Sacramento California.

[111] *An Assessment of Biomass Resources in California, 2007,* PIER Collaborative Report from the California Biomass Collaborative, March 2008, California Energy Commission Contract No. 500-01-016.

funds, the federal government also offers a 10 cent per gallon (first 15 million gallons) production incentive for small ethanol producers. Based on an estimate of 31 million gallons of anhydrous ethanol produced in 2009, California's producer will be eligible for $2.0million in incentives. Blenders will be eligible for an additional $14 million in federal incentives when making CaRFG or E-85.

The Energy Commission is also releasing solicitations for new projects totaling $23 million under the FY 2008-2010 Investment Plan funding cycle. The Biofuel Production Incentive solicitation is intended to help the idled California corn-based biorefineries re-start production. This solicitation could range from $6 million to $10 million, and will include provisions compelling in-state biorefineries to begin the transition to lower carbon feedstocks and increasingly more efficient process technologies (such as cellulosic conversion). The Biofuel Production Plant solicitation will range from $9 million to $13 million. It is intended to provide feasibility and pre-development funding for the multitude of potential advanced biorefinery production projects that have been described in the FY 2010-2011 Investment Plan workshops or discussed with Energy Commission staff.

With new plant construction stalled due to the financial crisis and weak markets, development funding is essential to restart advanced feedstock ethanol production projects and prove the technical and economic feasibility of emerging feedstocks and processes for biofuels. For this reason, the Energy Commission allocates $10 million to fund project feasibility, feedstock, and pre-plant development activities for performance-based new and retrofitted advanced ethanol production technologies that will achieve lower carbon ethanol. Given a broad range of potential funding needs for each project, this amount could fund 10 to 20 projects.

Table 12: Ethanol Funding Summary

Expansion of E-85 dispensers and retail outlets	$8.5 Million
Project feasibility, feedstock and pre-plant development activities for new and retrofit advanced ethanol production technologies	$10 Million
Total	$18.5 Million

Biomass-Based Diesels (Biodiesel/Renewable Diesel)

Biomass-based diesel is a broad term that includes biodiesel and renewable diesel, as well as specific feedstock- and process-based diesels such as algae-based diesel, biomass-Fischer-Tropsch diesel, and diesel from thermal depolymerization of industrial and food processing waste. Of these fuels, only biodiesel is commercially available in California and the United States today.

Biodiesel refers to a non-petroleum-based diesel made from vegetable oils or animal fats using a process called transesterification. This process is a simple, low-cost process that blends bio oils and a catalyst to make a biodiesel fuel, which is often blended with conventional petroleum-based diesel. In 2008, California used 50 million gallons of biodiesel.[112] Today, California has the potential to expand its biodiesel use to 200 million gallons within the industry-accepted blend of 5 percent biodiesel and 95 percent conventional diesel (also known as "B5") with minimal risk.

Renewable diesel also can be made from similar feedstocks as biodiesel, but is processed in a refining facility, where the feedstocks are transformed into a diesel fuel through hydrocracking and hydrogenation. The refinery-based process produces a renewable diesel fuel that is chemically identical to diesel fuel, requiring no modifications for infrastructure or diesel engines.

Biomass Fischer-Tropsch diesel can be made from agriculture waste, green waste, or forest residue; and through a gasification process the biomass is converted into diesel and naphtha. The final diesel product has superior fuel qualities and can be used in any blend level with conventional diesel fuel and infrastructure.

Bio-chemical process for fuel production is being researched by several companies (for example, Amrys, Solazime, Jiangsu Yuehong Chemical Co., Ltd.) Bio-chemical processes vary considerably and the final fuel product specifications are as varied as the processes and are in the beginning stages of development. Energy Commission staff will continue to monitor this promising technology.

Algae-derived diesel is a pre-commercial, research-phase process that involves growing algae in ponds or in containers that either react with sunlight and CO2 or is fed sugar to reproduce and create oils for later separation and use in any biomass-based diesel process. Algae is an especially attractive fuel source for diesel, as the process results in a fuel with up to an estimated 80 percent reduction in GHG emissions compared to petroleum-based diesel.[113] Additionally, algae-derived diesel may have a significant potential to replace conventional

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[112] *Renewable Fuels: Standards, Supply and Demand Projections, & Infrastructure*, Gordon Schremp, California Energy Commission presentation, October 29, 2009

[113] "The Addition of Algae and Jatropha Biodiesel to GHGenius," (S&T)^2 Consultants Inc., September 30, 2009.

fuels, due to its ability to "produce up to 30 times more oil per unit of growth area than land plants."[114]

Depending on the feedstock, biomass-based diesel fuels reduce GHG emissions 12 percent to 88 percent compared to conventional diesel fuel.[115] Additionally, the 50 million gallons of biodiesel used in California in 2008 had the estimated emissions reductions (with the exception of NOx which increases) shown in Table 13 below:[116]

Table 13: 2008 Emission Reductions from California Biodiesel Compared to Conventional Diesel

	Particulate Matter	Hydrocarbons	Carbon Monoxide	NOx	SO2
Percent Reductions	47%	67%	48%	-10%	100%
Emission Reductions (lbs)	252,000	282,000	2,780,000	-775,000	221,000

To maximize GHG emission reductions and biodiesel/renewable fuel production in California, several milestone achievements will be required. California will need strategic deployment of blending and storage terminals to increase the availability of biodiesel/renewable diesel to customers. Additional progress will be needed to produce fuels from renewable feedstocks and purpose-grown crops, including waste sources and algae, and to demonstrate the market viability of these sources. In addition, automakers and engine manufacturers will need to show widespread acceptance of higher biodiesel/renewable diesel blend concentrations for use in all diesel vehicles.

California has several compelling reasons to increase in-state production and use of biomass-based diesels:

- Significant emission reduction: lower carbon intensity
- Along with biomethane, biomass-based diesel represents one of the most effective alternative fuels for reducing GHG emissions. It also provides a significant petroleum diesel gallon displacement, thereby diminishing California's dependence on petroleum.

[114] NREL, Aquatic Species Project Report FY 1989-90, January 1992, pg. 3.

[115] Air Resources Board LCFS analysis, December 14, 2009.

[116] Using the Biodiesel.org Emission Calculator Tool, http://www.biodiesel.org/tools/calculator/default.aspx

- In-state biodiesel production plants are needed to ensure California's "fair share" biofuel use of 60 million gallons per year by 2022 as specified in the RFS of the EISA.[117]
- The LCFS identifies a major role for biofuels, such as biomass-based diesel, in achieving the 10 percent carbon intensity reduction target. Biofuels are projected to contribute 60 percent to 89 percent of the carbon intensity reductions.[118] Up to 30 new biorefineries could be needed in California to meet the carbon intensity reduction requirements.[119]
- California has biomass waste streams from agricultural, municipal, and forest sectors available for the production of biofuels with low carbon intensity. Bioenergy specialty crops such as algae, jatropha, and canola can be grown on marginal land to produce biofuels using conventional conversion technologies.
- To meet the 2010 in-state production goal in California's BAP, the state needs to restart its largely idle in-state production capacity of 68 MGPY. In-state production increases California jobs and economic benefits and reduces greenhouse gas emissions by minimizing imported fuel transport costs and impacts. California needs to add 115 million gallons of new capacity to meet the 2020 BAP goal.

Biodiesel/Renewable Diesel Fuel Use and Vehicles

In 2008, 1.1 million on-road diesel vehicles were registered in California, consuming 2.8 billion gallons of diesel. Off-road diesel demand adds an additional one billion gallons. Heavy-duty and off-road vehicle applications use over 92 percent of all diesel fuels, and therefore represent the key market for biomass-based diesel fuels. [120] However, these applications are very price sensitive and biodiesel's higher fuel prices, which can be 20 cents to 40 cents higher per gallon of B20 blend, depending on the price of regular diesel, represent a barrier to adoption.

Biodiesel has unique fuel properties that require a unique ASTM D-6751, fuel specification. Biodiesel has special handling, storage, and use requirements. This fuel poses challenges with vehicles and engine durability; fuel plugging, variably fuel quality, and cold weather

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[117] Staff estimates of future transportation fuels supply and demand forecasts for biodiesel use obligations under EISA used in the Transportation Energy Forecast for the 2009 IEPR.

[118] California Air Resources Board, *Proposed Regulation to Implement the Low Carbon Fuel Standard: Initial Statement of Reasons*, March 5, 2009.

[119] Staff finds 1.4 billion gallons of soybean biofuel is needed at 68 g GHG/MJ by 2020.Assuming 50 million gallons per plant, 28 plants would be needed. Conversely, 8 yellow grease plants would be needed; however, there is not enough yellow grease in California to fuel 8 plants.

[120] Emerging Fuels and Technologies Office, Total Fuel Use Analysis of DMV population and fuel demand. G. Yowell.

properties. No vehicle modifications are required to use biodiesel except for preventative maintenance to replace fuel filters prior to and after a few loads of B20 fuel.

Renewable diesel has less variable fuel properties than biodiesel, and complies with ASTM D975 (petroleum diesel fuel) or ASTM D396 (home heating oil).[121] These characteristics are favored by engine manufacturers. Based on current ASTM specifications, renewable diesel fuels are not anticipated to require any vehicle modifications or preventative maintenance.

Since 1992, most diesel fleets, obligated to meet federal alternative fuel use requirements, use B20 as their lowest-cost compliance option.[122] Most major medium- and heavy-duty diesel engine vehicle manufacturers accept blends of up to B20 in their vehicles, which are also accepted as an alternative compliance option for the federal alternative fuel vehicle purchase requirements.[123] Federal fleets required to use an alternative fuel in medium- and heavy-duty vehicles provided sufficient market opportunity for some manufacturers to build B20 compatible vehicles in limited models. These medium- and heavy-duty engines were not subject to the aggressive emission reduction required of light-duty vehicles since the 2004 model year. The 2010 heavy-duty diesel engine standards will pose a similar stringency as the 2004 light-duty standard.

All light-duty diesel cars and pickup trucks can use B5 blends without voiding manufacturers' warranties. However, new light-duty diesel vehicles are susceptible to biodiesel's engine-oil-dilution, and have critical emission control needs. As a result, vehicle manufacturers are currently not recommending higher blends for use in new light-duty vehicles; however, some are conducting research that may enable future B20 acceptance. Since renewable diesel blends of up to 90 percent meet conventional diesel standards, light-duty diesel vehicle manufacturers are not likely to be as concerned with higher blends of renewable diesel as they are with higher blends of biodiesel.[124]

In November 2008, ASTM International adopted new biodiesel standards for B5, B20 and B100 blends to address the fuel quality problems identified in the recent past. The Energy Commission is funding additional work to develop and perform test methods for the development of national standards for biodiesel blends greater than 20 percent by volume.[125] Compliance with the recently established ASTM B5 standard would provide the opportunity to triple biodiesel use.

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[121] http://www.biodiesel.org/pdf_files/fuelfactsheets/Co-Processing%20One%20Pager.pdf.

[122] The Energy Policy Act of 1992, EPAct 1992 regulations require that federal and state and alternative fuel provider fleets build an inventory of alternative fuel vehicles.

[123] National Biodiesel Board, OEM statement, http://www.biodiesel.org/resources/oems/default.shtm.

[124] Renewable diesel engine testing finds that blends up to nearly 90 percent have the ability to meet ASTM 975 Standards, Preliminary Results from Neste and Conoco Phillips Testing, 2003-2007.

[125] This task is $523,000 out of $4 million agreement with Department of Food and Agriculture.

In 2008, 1.6 million gallons of biodiesel was sold at 39 retail stations. Of these 1.6 million gallons, one million gallons were sold as part of B20 blends, and 250,000 gallons were sold as B99 blends.[126] The majority of fuel was used by non-retail facilities such as commercial fleets, governmental entities, private card locks and rental companies, most of which relied on B20 blends.

Funding for vehicle demonstrations is not recommended for biodiesel vehicles. The producers of some new biomass-based diesel fuels are requesting vehicle demonstration funds. These demonstrations will allow for pre-commercial identification and correction of any deleterious engine effects that might otherwise dissuade light-duty vehicle manufacturers. While the Energy Commission will continue to monitor this opportunity, it is not currently allocating any Program funds for this purpose.

Fuel Production

California has 11 biodiesel plants with a combined annual production capacity of 87 million gallons. Due to biodiesel's inability to compete with petroleum-based diesel prices, these plants will likely produce less than 25 million gallons in 2009. Six plants, representing one-third of the state's biodiesel production capacity, are idle due to their price disparity.[127] The LCFS requires 20 percent of diesel as biodiesel. The Biomass Action Plan requires a minimum of 20 percent of biofuels to be produced within California by 2010 and 40 percent by 2020. With an estimated diesel demand of 5.25 billion gallons by 2020, a minimum of 200 million gallons of biomass-based diesel and other biofuels are needed, requiring an in-state plant expansion of up to 115 million gallon.[128]

Biodiesel plants use recycled cooking oil (yellow grease) as their lowest-cost and lowest GHG feedstock, and use more expensive, and typically higher, GHG feedstock such as soybean, palm, and a variety of plant and animal oils. In order to reach higher production volumes of lower carbon biodiesel, "second generation" feed sources and plants are necessary such as biomass-based cellulose, waste, and algae. Second generation plants will need assistance as they move into pilot and pre-commercial scale plant sizes. Both first and second generation fuel production expansion is needed to reach the 2020 goals. Building biofuel plants is one of the most effective and fastest ways to reach the goals of the Bioenergy Action Plan, and directly supports California's economy.

Seven ARRA match funding requests totaling $19.5 million were received by the Energy Commission for new plants, though none have been awarded funds at this time. On November 12, 2009, DOE and USDA announced $24 million in funding in Biomass Research and Development grants to produce biofuels. Of these funds, $1.6 million was awarded to a California firm. The ARB's AQIP has not awarded funds in this area, nor have any of

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[126] Source: California Energy Commission, Petroleum Industry Information Reporting Act (PIIRA) data.

[127] Docket comments by the California Biodiesel Alliance, February 16, 2009.

[128] 5.25 million gallons x 20% for LCFS x 20% for BAP.

California's regional air quality management districts. The Energy Commission allocated $13 million for biofuel production plants with FY 2008-2010 funds, and estimates an approximate cost of $.71 per new gallon of capacity.

A federal $1.00 per gallon incentive for biodiesel production began in 2002 and expired on December 31, 2009. Given that the ARB's LCFS program will not significantly impact the market demand for biodiesel for another two years, fuel producers will have little motivation to invest in ensuring these plants' continued operation in the short-term without the federal production incentive.[129] With the incentive's expiration, state funding is critical to fill this gap, otherwise most biodiesel plants will close. State funding is a critical short term strategy to provide transitional support to instate biodiesel plants until the LCFS takes effect. The LCFS should provide a 10 cent to 75 cent per gallon market price premium for biofuels providing 40 percent to 90 percent GHG reduction in a $20-$60/MT GHG market, respectively.

For FY 2010-2011, the Energy Commission is proposing $5 million dollars for biomass-based diesel production. This level of funding would support either new plant capacity of 7 million gallons, or provide incentives to sustain existing plants' production of up to 25 million gallons.[130]

Fuel Terminal Storage and Blending

The continued growth of biomass-based diesel produced and used in California is critically dependent on the establishment of bulk storage and terminal blending facilities for bio-oils. California imports approximately 62 percent of its transportation fuels from domestic and foreign source and this trend continues to grow for petroleum and biofuels alike.[131] Renewable diesel will require bulk terminals to receive and store the large volumes of bio-oils required to competitively produce renewable diesel. Terminal blending facilities may be needed, in areas not served by a refinery, to common carrier pipeline and storage terminal. ARB's LCFS carbon intensity and sustainability requirements will ensure that future imported renewable fuels are sustainably grown and provide lower carbon intensity.

Nearly all bulk receiving terminals are sited with access to marine ports, railroads, and pipelines sufficient to move the fuel volumes into the 4 billion gallon per year diesel market. Adding biofuel capacity and modifying existing bulk terminals to accept biofuels are critical to biofuels' expanded future use.

Terminal blending racks are used to store bulk volumes of unblended fuels and dispense blended fuels for trucks to deliver to retail, fleets, and farm customers. California terminal racks

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[129] As of the end of December 2009, it appears that the U.S. Senate intends to address the extension of the incentive early in 2010.

[130] Assuming a 20-cent incentive per gallon.

[131] Schremp, Gordon, Aniss Bahreinian, Malachi Weng-Gutierrez. *Transportation Energy Forecasts and Analyses for the 2009 Integrated Energy Policy Report,* Draft Staff Report. California Energy Commission CEC-600-2009-012-SD.

are not modified to accept biodiesel fuels. Biodiesel terminal rack modifications can lead to a significant expansion of biofuel volumes due to the ease, lower-cost and time to load the fuels compared to today's method. In California, biodiesel fuels typically experience after-plant transport costs of 15 cents to 50 cents per gallon, compared to 9 to 12 cents for gasoline and diesel fuel. [132] These higher transportation costs should be eliminated with the establishment of appropriate rack terminal modifications to accept the biofuel.

Currently, financial institutions are not funding biofuel infrastructure projects, and industry has not provided funding to comply with California third-party certification expenses. Funds from non-Program government sources, such as the ARRA, ARB, or local air quality districts, have not been made available for biodiesel infrastructure investments. The Energy Commission's Program funds alone are not sufficient to finance a large part of the bulk terminal modifications. However, Program funds used as a grant or loan guarantee may be able to leverage funds from other financial institutions to minimize the risk for companies to make improvements in advance of economic necessity.

Given the current economy and with the LCFS still under development, infrastructure may be viewed as a risky investment in today's market. Once the LCFS is established, industry will have a better idea of how to comply with the LCFS and whether Biodiesel/Renewable diesel is the preferred path of compliance. Energy Commission funding shares the risk with the industry to build the infrastructure required to achieve state mandated goals. For FY 2008-2010, the Energy Commission allocated $4 million for blending and storage terminal projects; however, no federal funds were awarded to support this area in 2009.

California has over 100 rack-terminals requiring modifications to dispense biomass-based diesel. Renewable diesel that is not comingled with petroleum diesel in community pipeline and community storage sites will require separate and dedicated storage and blending facilities. Modification costs are estimated to be $500,000 to $2.0 million per site. Making these modifications would reduce retail prices of biomass-based diesels and increase biodiesel throughput. An allocation of $5 million dollars could fund one quarter of the terminal modifications at 20 percent of the total conversion cost, assuming $1 million/terminal total conversion cost. In attempting to promote the dispersion of biodiesel into the market, infrastructure investments are expected to yield the greatest results.

For FY 2010-2011, the Energy Commission allocates $5 million in Program funding, including possible loan and loan guarantee mechanisms to increase bulk terminal and storage facility capacity at strategically located Northern and Southern California sites. (Table 14). At the retail level, existing diesel fueling stations can already dispense up to 5 percent biomass-based diesel blends; therefore, Program incentives are needed to modify retail stations to accept biomass-based diesels up to 20 percent.

[132] Tellurium's comments made at the Energy Commission Workshop November 2009.

Table 14: Biodiesel/Renewable Diesel (Biomass-Based Diesel) Funding Summary

Production Plants Using Waste Feedstocks	$5 million
Bulk Terminal Storage and Blending Facilities	$5 million
Total	$10 million

Natural Gas

Natural gas (methane) in compressed or liquefied form (CNG or LNG) has been used as motor fuel in California for more than 20 years. It is used in a broad range of transportation applications, from personal light-duty vehicles to freight movers. California's use of natural gas in the transportation sector is forecast to increase by 150 to 180 percent by 2030 from the 2007 demand of 150.1 million therms, increasing the need for additional fueling infrastructure.[133] California has over 400 CNG and LNG stations, more than 30 percent of which provide public access.

In 2008, there were almost 35,000 natural gas vehicles (NGVs) registered in California. Approximately 28 percent of the vehicles were medium- and heavy-duty vehicles, mostly CNG-powered buses. Medium- and heavy-duty NGVs can also replace diesel vehicles in port drayage, refuse hauling, transit, delivery vehicles, and more. NGVs, along with hybrid diesel trucks, are an important recommended strategy to achieve black carbon, NOx, and GHG reductions.[134] With regulatory requirements to reduce diesel pollution in communities next to ports and rail yards fully in effect by December 31, 2012, natural gas may be the only viable alternative fuel option in the near- to mid-term.

Natural gas is competitively priced with gasoline, typically retailing 5 percent to 20 percent lower than gasoline, which also reflects any associated infrastructure costs.[135] Natural gas typically retails for 3 percent more to 26 percent less on a diesel-energy-equivalent bias. (However, the current average lower fuel economy of NGV's may offset CNG's fuel price advantage.)[136] Vehicles operating on conventional CNG reduce petroleum fuel use by 99 percent, and reduce GHG emissions by 29 percent relative to gasoline and by 21 percent

[133] 2009 IEPR.

[134] Advanced Technology to Meet California's Climate Goals: Opportunities, Barriers & Policy Solutions, California ETAAC Advanced Technology Sub-Group, December 14, 2009.

[135] Energy Commission Staff Analysis of statewide, retail fuel prices. CNG has 10 percent-to-20 percent lower prices per gasoline gallon equivalent, last-year average and 10-year average respectively. (A five percent fuel economy loss is applied to the CNG price.)

[136] Energy Commission Staff Analysis of statewide, retail fuel prices. CNG has -3 percent-to-23 percent lower prices per diesel gallon equivalent, last-year average and 10-year average respectively.

relative to diesel on a full fuel cycle basis (although some criteria pollutants can be higher than their new diesel vehicle counterparts).[137]

While natural gas is generally regarded as a non-renewable alternative fuel, CNG and LNG can also be derived from biomethane gas. Biomethane is produced through anaerobic digestion of organic matter and is chemically and structurally identical to natural gas. The use of biomethane in CNG and LNG vehicles has a tremendous GHG benefit, reducing emissions by 70 percent to 88 percent.[138] More than 70 landfills, 23 wastewater treatment facilities, and more than 12 dairies in California are now capturing biomethane emissions and using them for electricity generation, heating, or alternative fuel production. [139,140,141] Biomethane from California waste streams may be able to produce 120 billion cubic feet of gas or 60 bcf of pure biomethane, comparable to 0.44 billion diesel gallon equivalent.[142] The capture of fugitive biomethane from landfills and dairy waste not only displaces petroleum, but also prevents its release into the atmosphere.[143,144]

Light-Duty Vehicles

Approximately 25,200 light-duty NGVs are on the road in California, accounting for about 12 percent of natural gas use in the transportation sector.[145] The Energy Commission estimates that an additional 6,100 light-duty OEM and retrofitted NGVs will be deployed during the FY 2009-2010 period, and 2,450 during the FY 2010-2011 period.[146] Conventional vehicles retrofitted

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[137] Staff Comparison of 2007 and 2009 MY heavy-duty engine ARB Executive Orders.

[138] The Air Resources Board's January 2009 GREET model analysis estimates biomethane feedstocks dispensed in a LNG/CNG fueling station and used in a natural gas passenger vehicle would result in greenhouse gas emissions of 11.3 to 28.5 g/MJ or approximately a 70 to 88 percent reduction compared to California gasoline. Biomethane used in medium- and heavy-duty vehicles would result in similar reductions compared to diesel.

[139] [139]US EPA Landfill Methane Outreach Program, http://www.epa.gov/lmop/index.htm.

[140] "Opportunities for and Benefits of Combined Heat and Power and Wastewater Treatment Facilities," Eastern Research Group Inc., Energy and Environmental Analysis Inc., April 2007

[141] Personal Communication, Allen Dusault of Sustainable Conservation, December 16, 2009

[142] Biomethane Summit, Westport Innovations Presentation, June 23, 2009

[143] California Air Resources Board (ARB), Detailed California-Modified GREET Pathway for Compressed Natural Gas (CNG) from Landfill Gas, available at http://www.arb.ca.gov/fuels/lcfs/lcfs.htm

[144] "An Overview of Landfill Gas Energy in the United States - Presentation," U.S. Environmental Protection Agency (US-EPA) Landfill Methane Outreach Program (LMOP) June 2009

[145] Energy Commission staff estimate based on Department of Motor Vehicles data for 2008. (G. Yowell)

[146] CALCARS

into NGVs account for only 10 percent to 15 percent of the overall light-duty NGV population.[147]

Honda is the only OEM that retails a light-duty passenger vehicle in the U.S. However, 20 other manufacturers worldwide also make light-duty NGVs. General Motors has nine models available for markets outside the U.S., but, along with other manufacturers, the company is taking a wait-and-see position while evaluating U.S. incentives and infrastructure. [148]

All light-duty NGV engines are basically converted gasoline engines. (Even the engines in OEM NGVs are based on previously existing gasoline engine families that have been redesigned or simply modified for natural gas operation.) California regulations prohibit the after-market conversion of emission-controlled vehicles with retrofit systems to operate on an alternative fuel, such as natural gas, unless the retrofit systems have been evaluated and certified by the ARB. Two firms (Baytech and BAF) have ARB certification to produce kits for converting light-duty conventional vehicles to light-duty NGVs.[149,150] Baytech offers various General Motors (GM) light- and medium-duty vehicles on an aftermarket basis (including pickups, vans, and cutaways). BAF offers natural gas Ford Crown Victoria (used for taxis), as well as E-350 passenger/cargo vans and F-150/250/350 pickup trucks. A third firm, NaturalDrive Partners, is currently seeking certification from ARB for its retrofits.[151] California-based IMPCO sells approximately 13,000 natural gas and propane conversion kits per month to the world market, but none in California, primarily because of the expense required to comply with current ARB certification.[152,153] Table 15 shows the costs of these conversions.

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[147] Estimate by Clean Energy December 1, 2009

[148] www.cngvc.org/pdf/CNGVC_factsheet_KeyPath.pdf, 12/23/2009

[149] Presentation by South Coast Air Quality Management District (AQMD) on September 3, 2009. Titled "Clean Fuels Program Advisory Group." http://www.aqmd.gov/TAO/ConferencesWorkshops/Retreats/9-2009_LoriBerard.pdf

[150] ARB no longer certifies conversion equipment, but they do certify converted vehicles and engines.

[151] Ibid

[152] Presentation by Tim Standke, IMPCO at the "Natural Gas and Propane Workshop" on September 18, 2009.

[153] Mike Eaves, CA NGV Coalition, presentation to the Energy Commission, March 23, 2007.

Table 15: Natural Gas Conversion Costs by Vehicle Model[154]

Vehicle Type	Conversion Cost
Ford Crown Victoria/Lincoln Town Car/Mercury Marquis with 13 gasoline gallon equivalent (GGE)	$13,500
Sierra/Silverado 1500/2500HD pick-up truck with 20 GGE	$15,500
F150/250/350 pick-up truck with 30 GGE	$18,500

Nationwide, the ARRA includes multiple elements to advance alternative fuel and vehicle technologies. Ford received $5.9 billion in loans from the U.S. DOE to help it retool its plants to produce 13 fuel-efficient models. Other auto manufacturers received similar ARRA loans and grants. Although the primary focus of the manufacturers appears to be hybrid and electric vehicles, NGVs may be added to the mix. The Clean Cities program, as part of the ARRA, was one aspect of a great amount of federal activity in 2009 promoting NGVs. [155] It is possible that ARRA funds, in conjunction with other options being considered by Congress, will reverse Ford's and GM's decision in 2004 to halt production of NGVs in North America and spur the development of NGVs by the OEMs.[156] Worldwide, 20 manufacturers including GM and Ford provide NGVs with a cumulative total of 9.8 million vehicles on the road in September of 2008.[157]

Although California received no ARRA funds in the light-duty natural gas sector, the funding of light-duty NGVs elsewhere in the nation will encourage the development of additional NGV models by OEMs. Since the California NGV market generally depends on the same OEMs as the rest of the nation, California's NGV market stands to benefit from a more robust nationwide market.

Federal tax credits are available for the Honda Civic GX, which is the only light-duty NGV currently produced by a major OEM in the U.S. market. The difference in price between the

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[154] "Frequently Asked Questions About Converting Vehicles to Operate on Natural Gas" By Stephe Yborra, Director of Communications & Marketing, NGV America; Document Created March 10, 2009 http://www.ngvc.org/pdfs/FAQs_Converting_to_NGVs.pdf.

[155]Other federal activities in 2009 included: Formation of Congressional Natural Gas Caucus; Tax Extenders Act of 2009 (H.R. 4213) extending the natural gas fuel tax credit by one year; a $5 million budget appropriation for DOE for NGV RD&D; the Natural Gas Vehicle Research, Development, Demonstration, and Deployment Act of 2009 (H.R. 1622) for $30 million annually for 5 years.

[156] *Natural Gas Vehicles, 2009 Year in Review*, Natural Gas Vehicles for America, Washington, D.C., http://www.ngvamerica.org/pdfs/2009NGVYearinReview.Final.121809.pdf.

[157] Pike Research October 19, 2009. http://www.pikeresearch.com/newsroom/17-million-natural-gas-vehicles-will-be-on-the-road-by-2015.

Honda Civic GX ($25,340) and a gasoline equivalent Honda Civic DX ($15,655) is $9,685. [158] A $4,000 federal tax credit is available for vehicles capable of using only CNG or LNG that partially offsets this incremental cost.

The natural gas conversion of a light-duty vehicle is given a federal tax credit of up to 80 percent of the cost gap, up to a maximum credit of $4,000.[159] Using the Ford Crown Victoria model as an example, the net cost of a converted light-duty NGV would equal the original vehicle cost ($18,000) plus the cost of the conversion ($13,500) minus the tax credit ($4,000), or approximately $27,500.

Federal grants and loans to encourage and expand the markets for light-duty NGVs will commence in early 2010. The result of this large influx of funds to the vehicle manufacturers will not be available until 2011 to 2013 (based on the federal three-year agreement term). Therefore, the Energy Commission is not proposing to provide incentives in this investment plan.

Medium- and Heavy-Duty Vehicles

Medium- and heavy-duty NGVs are an important element of the NG fleet consuming 88 percent of the natural gas used by NGVs. In 2008, 9,674 medium- and heavy-duty NGVs represented one percent of these vehicle classes operating in California. Transit and school buses represent 74 percent of the natural gas population (7,144) and refuse trucks represent 10 percent (1,000) of the population. Sixteen years after NGVs' first introduction into bus fleets, they make up 10 percent of these fleets. Eight years after NGVs' introduction into refuse truck fleets, NGVs make up seven percent of these fleets. NGV sales peaked in 2000 and 2002 and have been declining since, particularly in bus fleets.[160] Transit and school buses were the first vehicle types to make extensive use of alternative fuels and diesel particulate filters. With the 2010 emission standards to be in effect soon, zero- or near-zero emission technologies are the next step for this vehicle category and will serve as one rationale for future funding.

Kenworth and Westport both produce natural gas trucks, and several other foreign and domestic trucks are being produced or considered for production. Heavy-duty NGV costs are roughly $70,000-$80,000 higher than for a Class 8 heavy-duty conventional vehicle.

The purchase of Class 8 drayage trucks is the single greatest factor affecting the demand for medium- and heavy-duty NGVs in California for the next few years. About 500 heavy-duty Class 8 trucks use LNG for port applications within the state. Penetration is greatest in Southern California, where local air district and port policies have incentivized more activity.[161] The

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[158] Manufacturer's Suggested Retail Price 2009

[159] "Fact Sheet: Federal Incentive for Natural Gas Vehicles" By NGV America, March 16, 2009 http://www.ngvamerica.org/pdfs/FederalVehicleTaxCredit.pdf

[160] DMV vehicle registration data.

[161] Pete Price, Price Consulting, email, November 16, 2009, 3:49 PM.

Clean Air Action Plan (CAAP) adopted by the ports of Los Angeles and Long Beach is a major driver for these large purchases. The Port of Long Beach will be purchasing 7,800 LNG vehicles and is committed to 50 percent of new trucks being LNG. The Port of Los Angeles has 300 LNG trucks, with plans to add 2,200 more. These purchases will hopefully encourage at least three to four companies who are producing natural gas engines abroad to enter the domestic market with existing or new engines for heavy-duty applications.

A review of the projects requested in conjunction with the ARRA funding provides an insight into the areas in California where natural gas technology is used. NGV proposals fell into three somewhat inchoate regional categories: Southern California,[162] the Bay Area,[163] and Central California.[164] The Southern California region had the largest number of proposals. Two projects, both in Southern California, received funding. In conjunction with ARRA funding, the Energy Commission is funding a project to deploy 180 LNG drayage trucks for the Ports of Los Angeles and Long Beach. The San Bernardino Association of Governments will also receive funds for 262 heavy-duty LNG trucks. These projects will receive a combined $11.5 million of Program funds, along with $17 million of ARRA funds.

Nationwide, ARRA funds were awarded for at least 325 medium- and heavy-duty NGVs.[165] Since these manufacturers would also provide vehicles for a California market, the ARRA funding may strengthen the vehicle offerings for California. Funding for medium- and heavy-duty NGVs has not been made available as part of the ARB's AQIP. The most likely future markets for medium- and heavy-duty NGVs are short and medium-haul applications, pick-up and delivery, and general freight.[166] Clean Energy, a natural gas supplier, foresees applications for the entire range of medium- to heavy-duty trucks.

In the previous Investment Plan, financial incentives were provided for the purchase of medium- and heavy-duty NGVs. These incentives were used to match the ARRA projects described above for the Port of Los Angeles, Port of Long Beach, and San Bernardino. Incentives were not provided for vehicles needed to address air quality issues in the San Joaquin basin, Bay Area or for additional projects identified in the Southern California port areas.

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[162] Southern California region comprises the entire greater Los Angeles area up to Santa Barbara and south to San Diego and the Mexican border.

[163] The Bay-Area starts at San Francisco and includes the peninsula and south to Salinas. Eastward the Bay-Area region extends to Vacaville. The central coast region can be included with either the Bay-Area or southern California.

[164] The central California area, starts at the Oregon border and comprises most of the San Joaquin Valley down to Lancaster including Fresno, Sacramento and Bakersfield.

[165] An additional 2,322 natural gas vehicles were identified for funding, but not identified as to vehicle class.

[166] Westport; Cummins.

For FY 2010-2011, the Energy Commission will allocate $12 million for medium- and heavy-duty NGVs for differential costs after all incentives are accounted for.

Infrastructure

The natural gas fueling infrastructure consists of seven types of fueling facilities:

- CNG home refueling appliances
- Small-capacity CNG stations
- Medium-capacity CNG stations
- Large-capacity CNG stations
- Large-capacity LNG stations
- CNG dispensers added to existing gasoline stations
- Combined CNG and LNG station

The number of natural gas stations in California increased from approximately 375 in January 2007 to approximately 400 in September 2009.[167] Thirty percent of these stations are publicly accessible, and 30 dispense LNG. Small-, medium-, and large-capacity CNG stations (compressors and dispensers) can be added to existing gasoline stations, or built as "stand-alone" CNG stations. The former is the cheaper option, since existing land, concrete infrastructure, and canopy can be used. For example, the Galileo Nanobox is a self-contained system that can be added to fuel islands anywhere.[168] It is also possible for a single station to dispense both CNG and LNG, and in fact LNG can be gasified to CNG with conventional pumps with less energy than it takes to compress pipeline gas to CNG.[169]

CNG stations can be divided into two groups: time fill and fast fill. Time fill stations are cheaper to construct, but require several hours to fill a vehicle. Fast fill stations can refill a vehicle in minutes, but the costs associated with these stations are considerably higher. Fast fill dispensers are the only practical dispensers for use in public access natural gas stations. Table 16 presents Energy Commission estimates of current natural gas infrastructure costs.

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[167] Telephone conversation with Mike Eaves on October 23, 2009.

[168] Presentation by Michael Eaves, Clean Energy "Natural Gas Fueling Infrastructure" at the "Natural Gas and Propane Workshop" on September 18, 2009.

[169] 2008-2009 Investment Plan.

Table 16: Natural Gas Infrastructure Costs

Infrastructure Type	Estimated Costs
Small CNG Station with fast fill[170]	$400,000
Medium CNG Station with fast fill[171]	$600,000
Large CNG Station with fast fill[172]	$1.7 million
Large LNG Station[173]	$1.7 million
Combined CNG (with fast fill) & LNG Station	$2 million

A review of the California projects submitted in response to the Energy Commission's first solicitation, in conjunction with the ARRA funding, shows where natural gas technology is in use in California. The Southern California region had the largest number of proposals over half of which were for the construction of natural gas fueling infrastructure.[174] The Energy Commission funded $2.4 million for five public access LNG stations, leveraging $2.4 million in ARRA funds. The Energy Commission has also issued a grant solicitation with $5.6 million available for CNG and LNG fueling stations. ARB's AQIP program does not fund natural gas infrastructure, while SCQAMD in the last fiscal year allocated $2 million for natural gas infrastructure.

Nationwide, ARRA funded 133 CNG stations and 13 LNG stations. These additional stations add to, but do not substantially impact, infrastructure along vehicle corridors that would extend the range of NGVs.

For FY 2010-2011, the Energy Commission allocates $2 million for the upgrading of existing publicly accessible fueling stations. There are over 200 natural gas fueling stations in California, representing significant investments of both public and private funds.[175] The life expectancy of the tanks and equipment varies depending on the materials used and the quality of the gas. The cost of upgrading equipment can be prohibitive, particularly for schools and local governments encouraged to convert their fleets to NGVs. State funding will relieve these public agencies of this financial burden and maximize the use of existing infrastructure.

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[170] Defined as a capacity of less than or equal to 500 standard cubic feet per minute (scfm).

[171] Defined as a capacity of 100 to 2,000 scfm.

[172] Defined as a capacity greater than 2,000 scfm.

[173] Defined as a capacity greater than 15,000 gallons of LNG.

[174] Southern California region comprises the entire greater Los Angeles area, up to the City Santa Barbara and south to San Diego and the Mexican border.

[175] http://www.afdc.energy.gov/afdc/fuels/natural_gas_locations.html, November 23, 2009.

Biomethane

When organic matter is treated with heat and bacteria over time, a biogas is produced. Once created, biogas can be converted to biomethane by removing impurities such as carbon dioxide, hydrogen sulfide, and water.

Biomethane can be used as an energy source in transportation, power generation, and combined heat and power application, including:

- Direct use as a fuel and heat source for boilers or industrial heat
- Injection into utility-operated natural gas pipeline systems for use by residential commercial and industrial customers, and for use in powering combined cycle natural gas electricity generating stations
- Blended or enhanced with hydrogen, further extending its GHG benefits, or used as a feedstock in hydrogen production
- Refined into gasoline, diesel via gas-to-liquid technologies, or
- Compressed into CNG, or liquefied into LNG for use in transportation applications.

The technologies needed for the production of biomethane as a transportation fuel are "off the shelf" technologies that are generally well developed, commercialized, and carry a "zero technology risk."[176] Biomethane is fully compatible with California's existing natural gas infrastructure and can be used by all vehicles equipped to operate on natural gas.

Biomethane in California will most likely be sourced from dairies, landfills, waste water treatment facilities, agricultural residues, and woody biomass from forest fuels management activities[177]. This is important because biomethane derived from waste stream feedstocks has the lowest carbon intensity value of any commercially viable alternative transportation fuel. CNG and LNG derived from dairy waste and landfill gas can have anywhere from a 70 percent to 88 percent GHG emission reduction from the petroleum diesel baseline.[178] Capturing biomethane from these sources is a particularly important GHG reduction strategy, as methane is 21 times more potent than carbon dioxide as a GHG.

The technical feasibility of deriving both CNG and LNG from landfill gas has already been commercially demonstrated. Currently more than 70 landfills in California are using captured methane emissions as an energy source, and at least two of those are producing biomethane to be used as a transportation fuel. At the Frank R. Bowerman Landfill in Orange County,

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[176] Investment Plan Staff Workshop on Biofuels, CalStart, September 15, 2009.

[177] Should California's existing waste streams be committed entirely to biomethane production, they could provide roughly 24 billion cubic feet of additional biogas potential annually Source: "An Assessment of Biomass Resources in California, 2007": California Biomass Collaborative, PIER Collaborative Report, Contract No 500 01 016, January 2008.

[178] Carbon Intensity value for C/LNG derived from dairy or landfill waste can range anywhere from 11.3 to 28.5 grams of CO2 equivalent / MJ. Source: Air Resources Board Low Carbon Fuel Standard Website.

Prometheus has a plant that will produce 40,000 gallons of LNG, from waste biogas, by late 2009 or early 2010.[179] In Livermore, the Altamont Landfill is currently the world's largest landfill gas to LNG project in the world and is producing 13,000 gallons of LNG daily to be used in Waste Managements' Refuse Trucks.[180] Other landfills working to capture biomethane include Kiefer Landfill, Puente Hills Landfill, and Altamont Landfill.

Dairies could utilize biomethane for off-road agricultural vehicles such as tractors, combines, and threshers, as well as on-road vehicles including pickup trucks and milk trucks. A current working example of onsite biomethane use is at the Hilarides Dairy located in Lindsey, California. The Hilarides Dairy originally collected biogas for onsite electricity generation, but has since expanded to become the first dairy in the United States to power milk trucks with manure derived biomethane. These milk trucks are Peterbuilt trucks that have been converted to CNG and drive a 300 mile round trip route from Lindsey to Hillmar, California.[181]

Biomethane can also be used as a process fuel in the production of other alternative fuels such as ethanol. For example, California ethanol production facilities could substitute the use of fossil natural gas with renewable biomethane in its production process to significantly reduce carbon emissions by as much as 66 percent when compared to California ethanol production using natural gas.[182]

Biomass from forest thinning operations, with proper environmental safeguards, represents a potential biomethane feedstock. Forest biomass residues in California are estimated to be about 14.2 million bone dry tons (BDT) per year.[183] The development of new and improved technologies for biogas production from forest biomass is accelerating.

Biomethane will be entering the natural gas market, and due to the current low price of natural gas, it will be difficult for biomethane to compete on a production cost basis.[184]

The biomethane industry is hampered by capital constraints, and a number of California biomethane projects are now stalled. These projects are having difficulties securing financing due to the uncertainty of how the economics of a biomethane industry will play out in California.

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[179] http://www.prometheus-energy.com/whatwedo/landfillgas.php.

[180] Biomethane Summit, Linde Presentation, June 23, 2009.

[181] Biomethane Summit, Sustainable Conservation Presentation, June 23, 2009.

[182] Presentation by Calgren at Energy Commission's AB 118 Investment Plan Workshop for Biofuels, September 14-15, 2009.

[183] "An Assessment of Biomass resources in California, 2007,": California Biomass Collaborative, PIER Collaborative Report, Contract No, 500 01 016, January 2008.

[184] Last year the average retail diesel price was $2.58 per gallon, and natural gas was $1.81 per diesel gallon equivalent. Source: Energy Commission Staff Analysis of statewide, retail fuel prices.

Gas quality testing and certification is an expensive process with no certainty over who should pay for it – biogas developers, natural gas utilities, or other third parties. In order for biomethane from new feedstocks such as agricultural residues and food waste to be able to enter the natural gas pipeline, extensive gas quality testing must be performed. This testing can be very costly and the natural gas utilities have currently exhausted their gas testing funds allotted for this purpose.[185]

Biogas is the lowest carbon intensity alternative fuel readily available in California. Although the production potential for biomethane is significant, few biomethane or biogas projects are operational in California. The most common feedstock in use is landfill gas, although at least one dairy and one agricultural waste facility exist in the state. The landfill gas projects are likely to have a capacity of roughly four to seven million gallons of liquefied natural gas per year and estimated capital costs in the area of $12 to $20 million. The few agricultural waste projects vary substantially in both capital cost and feedstock, making numeric estimates difficult.

At least 10 California projects, soliciting over $46 million of Program funds, were proposed under the Energy Commission's ARRA cost sharing solicitation to either produce biomethane as a transportation fuel (either as CNG or LNG) or produce biomethane as a process fuel, but none have been funded (by ARRA or the CEC) to date. Consequently, Program funds have not been awarded to biomethane projects. In addition, ARB is not making biomethane investments during their first round of AQIP funding.

Biomethane production was initially allocated $10 million in the FY 2008-2010 Investment Plan. That amount was later increased to $21.5 million through an ongoing solicitation in response to the strong project proposals presented by energy developers at the 2010-2011 Investment Plan workshop. To date, no specific projects have received Program funding.

Biomethane has the potential to tap the state's large forest woody biomass waste streams that will be generated as forest fuels management projects are implemented.

In order to establish biomethane for transportation as an industry in California, grants and incentives must offset high capital costs. As a relatively new industry in the midst of a recession, California will have to ensure supportive government policies and additional financial incentives. In light of $46 million in project proposal requests and the $21.5 million in the recent solicitation, funding is still a substantial need. Consequently, the Energy Commission is allocating $10 million for FY 2010-2011 to help establish a biomethane industry in California. The allocation will focus on projects that use a variety of waste feedstocks, including but not limited to dairy, landfill, wastewater, agricultural and forest residues, as well as a variety of process technologies. Potential areas for funding include:

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[185] Initial research for new biomass feedstocks will cost between $340,000 and $500,000 as a one-time expense and then each individual project will require ongoing gas sampling which is estimated at $20,000 per month. These numbers are subject to increase with more complex feedstocks. Brennan, Ken. "Re: PG&E Gas Quality Testing Cost Estimate." Private communication to Leslie Baroody. November 18, 2009.

- Projects that wholly or partially produce biomethane for direct use as a transportation fuel.
- Projects that use biomethane as a process fuel in the production of another low carbon alternative fuel, such as ethanol facilities using biogas as a replacement for natural gas in the ethanol production process.
- Projects that use biomethane as a feedstock for the production of another low carbon alternative fuel, such as gas to liquid technologies.
- Biomethane feedstock and project feasibility studies for future biomethane capital projects in California. This could include feasibility studies of modifications to existing biogas facilities.
- Gas quality testing for new feedstocks.

Table 17: Natural Gas Funding Summary

Medium- and Heavy-Duty Port Trucks, School Buses and Other Vehicles	$12 Million
Upgrades to Natural Gas Fueling Stations	$2 Million
New Construction or Expansion of Biomethane Production, Feasibility Studies, and Quality Testing	$10 Million
Total	$24 Million

Propane

In the early 1980s, propane was the leading alternative fuel in California—more than 200,000 propane vehicles operated in the state. Despite its availability, less costly infrastructure, and price competitiveness, propane fuel use and vehicle availability declined. Nevertheless, propane continues to be an attractive motor fuel for medium-duty vehicle fleets and will likely grow as more applications become available over the coming years.[186]

Propane offers significant and immediate petroleum use reductions and moderate GHG emission reductions. Propane can be produced as a byproduct of either natural gas processing or petroleum refining. Propane produced as a part of natural gas processing can reduce GHG emissions by 9 percent to 19 percent compared to gasoline—slightly better than petroleum-derived propane. In the future, propane could be produced from renewable resources.

[186] Survey information provided by CleanFuel USA and Western Propane Gas association

Renewable propane may provide much greater benefits, with emission reductions reaching up to 90 percent.[187]

According to the Western Propane Gas Association, California consumed approximately 491 million gasoline equivalent gallons of odorized propane in 2008. Fifty-five to 63 million gasoline equivalent gallons of this consumption was used specifically for on- and off-road vehicles.

Propane is attractive in terms of pricing compared to both diesel and petroleum. If federal excise tax credits for propane use continue to be available in the future, propane will be a viable option for fleets. According to the U.S. Department of Energy, the average cost for propane is $2.69 per gallon, or $3.40 per gasoline equivalent gallon. [188] The federal government also offers a fuel use tax credit of $.50 per gallon-gallon equivalent, which acts as an incentive to propane users to offset the energy loss with the use of propane in vehicles.

Additionally, case studies conducted in Canada and Texas shows significant savings for propane vehicle fuel and maintenance costs. As a result, fleets have become increasingly interested in using propane fueled vehicles.[189]While the propane market will likely grow nationwide in the next few years with the increased availability of engine options and vehicles, this growth will not impact California's market without the appropriate certification from the U.S. EPA and ARB.

While fleet owners are interested in propane because of its emission and cost benefits, there are no funding opportunities available now for vehicle purchases with the exception of the federal school bus incentives. However, with program funding for incremental vehicle cost and the introduction of more ARB-certified vehicle options, propane can be a near-term, viable alternative fuel option for business owners.

Light-Duty Vehicles

The Roush F-150 and F-250 trucks are the only two light-duty propane vehicle certified by the U.S. EPA and ARB. Roush will be seeking certification in the coming months for propane, E-150, 250, and 350 cutaway vans, which have attracted interest from several fleet owners.[190]

The incremental cost for purchasing a light-duty propane vehicle ranges from $4,000 to $12,000 with an average price of $5,000. Roush anticipates that a $3,000 per vehicle incentive is needed to generate sales and stimulate the growth of the light-duty propane market.[191]

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[187] CA-GREET analysis conducted by staff.

[188] As of July 2009, according to U.S. DOE ERRE Price report. Does not include excise tax credit.

[189]http://www.propanefacts.ca/Studies/canadian/reports/fullreport/201/1362/; http://www.propane.tx.gov/commercial/index.php.

[190] Curtis Donaldson, CleanFuelUSA, personal conversation, September 18, 2009.

[191] Todd Maow, Roush, e-mail, September 8, 2009.

With the emergence of new propane vehicles in 2010, interest in using light-duty vehicles as part of delivery, airport, and utility fleets is increasing. Given the new models, current propane fuel pricing, and reasonable buy-down costs for these vehicles, funding availability will help ensure the purchase of an alternative fueled vehicle over a gasoline or diesel vehicle.

Other states across the nation already widely use propane in their public fleets, which demonstrates the market readiness of propane vehicles. Recently Texas was awarded $25.5 million for propane vehicle and infrastructure development. Of the 882 vehicles being deployed, 645 of these vehicles will be light-duty vehicles for use by public school and business fleets. Market readiness for these vehicles will allow them to serve as an early action in reducing GHG emissions in the transportation sector. It is recommended that funding be used to support the expanded use of light-duty propane vehicles.

Medium-Duty Vehicles/Retrofits

Most propane vehicles are retrofits. Propane is viewed as an economical retrofit option for delivery trucks, shuttle buses, and school buses. Sales of the Bluebird school bus continue to increase. Propane is especially beneficial to rural communities and school districts that may not otherwise have access to an alternative fuel.

Only three companies offer propane retrofits for gasoline engines today: Baytech, Bi-Phase Technologies, and Clean Fuel USA. All of the retrofits offered by these companies are for medium-duty General Motors engines (6.0 and 8.1L models). These kits can be used in various applications, but are primarily used for business fleets such as utility trucks, delivery trucks, and airport fleets.

The incremental costs for these systems depend on the application for which the system is being used. The price ranges and federal incentives are listed in Table 18. Systems in the $7,500 price range are typically for applications that include trucks, while the incremental costs for shuttle and school buses are around $20,000. Typically, these incremental costs can be quickly recovered through fuel savings and maintenance costs as shown in case studies conducted by the Texas Railroad Commission. The case studies show that several school districts in Texas have realized savings of up to $400,000 per year when they have converted their school bus fleet to propane. Not only are the fuel savings significant, but the cost of maintaining a propane school bus is less than that of its diesel counterpart, which also contributes to the savings associated with operating propane school buses.[192]

[192] http://www.propane.tx.gov/commercial/index.php.

Table 18: Medium-Duty Propane Vehicle Cost Summary

Incremental Vehicle Cost	$7,500-$20,000
Federal Incentives	• 50% of cost to replace school bus meeting 2010 U.S. EPA emission standards • 25% of cost to replace school bus meeting 2007 U.S. EPA emission standards

In 2009, GM halted production of the 8.1L engine. Only a limited number of these engines are currently available for sale. However, CleanFuel USA anticipates that a successor to this engine will be available in the third quarter of 2010.[193] Additionally, Cummins Engine Co. offers a propane-fueled version of its standard 5.9L engine, known as the B-LPG Plus.

The medium-duty market accounts for a majority of California's propane vehicle usage because of the variety of available applications. However, with the lack of funding incentives, businesses are hesitant to make the large upfront investment to convert their fleets to propane. Consequently, program funding for the incremental vehicle cost is essential to the overall success of propane in the transportation fuel market. The investment is expected to stimulate additional engine development and increased vehicle offerings and fuel usage while leveraging private investment in the base cost of the vehicles and infrastructure upfits.

Heavy-Duty and Non-Road Vehicles

Currently no heavy duty propane vehicles or engines have been certified for use in the U.S. A large engine (HD 7.6 L) for heavy-duty vehicles is currently being developed by CleanFuel USA and will likely be certified by the U.S. EPA and ARB by the third quarter of 2010 or early 2011.[194] Consequently, propane is not likely to enter into the heavy-duty market until 2011. The cost of this engine has not yet been determined.

Propane is already successfully used in off-road applications such as forklifts. Several thousand forklifts in California run on propane. According to the Propane Education Research Council, the cost of a propane forklift is usually between $16,000 and $24,000,[195] which is comparable to a gasoline-powered forklift and nearly $10,000 cheaper than a diesel forklift, while offering additional advantages over a diesel run forklift. For example, propane forklifts require less maintenance and are able to run for several thousand hours before they need significant service. Additionally, propane forklifts have lower emissions than gasoline or diesel forklifts so they are more suitable for use in environments with limited air circulation. Very little additional

[193] Curtis Donaldson, CleanFuel USA, September 9, 2009.

[194] Curtis Donaldson, CleanFuel USA, e-mail, October 9, 2009.

[195] PERC: http://www.propanecouncil.org/enginetemplate.aspx?id=6358.

infrastructure is needed to support propane forklifts; propane suppliers can maintain on-site storage tanks for fleets or operate cylinder exchange programs. While propane forklifts may provide fewer emission benefits than hybrid or all-electric forklifts, they will continue to be successful in this off-road market, especially in rural communities, because of their practicality and cost-competitiveness with conventional forklifts.

Funding will not be considered for heavy-duty or non-road vehicles until heavy-duty propane vehicles are certified for use in California.

Fuel Production

Approximately 60 percent of propane used in California is produced in California refineries, depending on seasonal demand. California is typically a net exporter in the summer, and depending on the weather, can be a net importer in the winter. Imported propane typically comes from Texas, the Midwest, and Canada.

While not yet commercially available, renewable propane could be a good alternative fuel option in the future. Studies are being conducted on the generation of renewable propane at Mississippi State University and Massachusetts Institute of Technology. Brazil is also doing extensive research on renewable propane and its potential to serve as a viable fuel option for vehicles.

Renewable propane can be derived from algae, row crops and wood[196]. Both high-pressure and catalytic cracking have been used as processes for extracting renewable propane from various feedstocks. The derivation of renewable propane requires little additional energy and results in a product that contains the same energy content as propane derived from petroleum.

The Propane and Education Research Council (PERC) is supporting work specifically for the continued development and expansion of renewable propane. According to Greg Kerr, the director of research and development for PERC, PERC is currently reviewing a report it commissioned from the Gas Technology Institute to study the technical and economic feasibility of different technologies and methods to generate renewable propane. For 2010, PERC has allocated at least $600,000 for the further study and development of bio-propane. If the Energy Commission was to have R&D funds available for the continued study of the feasibility of renewable propane, PERC would do its best to leverage its funds with the state funds. Energy Commission staff will continue to monitor the progress of renewable propane, and considers it a promising alternative fuel option in future years.

Infrastructure

Propane retail infrastructure is already widely available and can easily be expanded as demand for propane as a transportation fuel increases. Approximately 189 propane fueling stations are already in place in California, according to the U.S. DOE's alternative fuel and advanced vehicle data center. California has the second largest number of accessible propane fueling stations in

[196] 2009 IEPR, page 162.

the nation, which can already support an expanded vehicle market with funding for light- and medium-duty vehicles.[197]

Infrastructure for propane vehicle fueling could expand quickly, as existing propane dispensing stations can be used for vehicle fueling through the addition of fuel capacity, a tank pump, and metering equipment. With the addition of this equipment, virtually any propane tank/ station in California can be retrofitted to meet a propane vehicle's needs. This will facilitate the increasing demand for propane as a transportation fuel in the years ahead.

The Energy Commission will not provide funding for propane fueling infrastructure in this investment plan, since sufficient federal incentives are in place to support the infrastructure needs in California. Funding for infrastructure may be considered in the future, as the propane market grows.

The Energy Commission will allocate $3 million for light- and medium-duty propane vehicles for the FY 2010-2011 Investment Plan. This funding will be used to fund the conversions of between 130 and 200 vehicles to propane, as well as for the buy-down costs of purchasing new vehicles. This funding will create opportunities for fleets to transition quickly and efficiently to alternative fuel use. Propane is readily available and affordable, and provides both immediate GHG emission benefits and energy independence because all propane used in California is domestically produced. Many fleet owners already consider transitioning to propane as a viable option for their fleets. With the additional incentives provided through this Program, more public and private fleets will make the transition, especially with more vehicle options becoming available in late 2010. Additionally, if renewable propane becomes commercially available, it will provide emission benefits comparable to some of the most effective GHG emission reduction fuels. Providing funding for propane vehicles will ensure that California does not inadvertently preclude the potential market for renewable propane in the future.

Table 19: Propane Funding Summary

Light- and Medium-Duty Vehicles	$3 Million
Total	$3 Million

Innovative Technologies and Advanced Fuels

In the previous sections, the Energy Commission has identified high-priority investments related to specific fuels and vehicles as well as analytical and outreach strategies. The legislative statute establishing this program also provides the Energy Commission with authority to make public investments in opportunities not specifically identified in this investment plan,

[197] http://www.afdc.energy.gov/afdc/fuels/stations_counts.html.

including: projects that optimize alternative and renewable fuels for existing and developing engine technologies; control systems and vehicle/fuel integration systems; advanced internal combustion engines that result in at least 40 percent efficiency improvements; lightweight materials; energy storage; battery recycling and reuse; engine and fuel optimization, electronic and electrified components, idle management technology, and aerodynamic retrofits that decrease fuel consumption.

The Energy Commission is interested in developing a program to co-fund discrete projects that accelerate the development and commercialization of technologies and systems that might include strategies to:

- Improve the efficiency of petroleum- and nonpetroleum-fuel engines to increase fuel savings and greenhouse emission improvements above the current levels (20 percent – 30 percent) in electric hybrid and hydraulic hybrid vehicles.
- Improve the design of key vehicle components including high pressure fuel tank designs, compressors, electronic controllers, motors, fuel cells, batteries, and other components to increase vehicle performance and efficiency.
- Improve the design of key alternative fuel infrastructure components including above and below ground fuel storage, dispensers and safety systems.
- Improve vehicles operations through improved controls and on-board diagnostics.
- Integrate smart grid electricity systems with electric vehicle recharging.
- Develop performance tests, instrumentation, drive cycle protocols, accelerated durability testing, and other technology applications to lower cost and shorten time required to comply with engine, fuel and vehicle certifications.
- Develop alternative materials and production processes for advanced vehicle battery manufacturing and stimulate business practices that encourage the use of vehicle battery and other storage technology in secondary markets and recycle/re-use opportunities.
- Develop high-productivity biomass feedstocks, such as algae and perennial grasses, that can offer significant greenhouse gas benefits and be used to produce "renewable crude oils" or gasoline and diesel fuel substitutes.
- Lightweight materials that have application across multiple vehicles platforms.

Projects could include feasibility studies, market research, early market demonstrations, competitions, performance and certification tests, incubator programs, x-prize awards, research consortiums such as "Centers of Excellence", recruitment of financial investors or a combination of such activities.

The Energy Commission is seeking additional information regarding these possible strategies before proposing a specific dollar allocation. For example, with the federal fuel economy standards under development, what role should the Energy Commission play to improve vehicle efficiency? Also, what level of public investment should the Energy Commission make in algae and other low-carbon feedstocks given the substantial federal and private investments?

Market and Program Development

Additional categories for funding are specifically mentioned in statute and are important to the success of the Program. These categories are workforce development and training, sustainability studies, outreach and marketing, and program analytical and technical support.

Workforce Development and Training

On September 26, 2008, Governor Schwarzenegger signed AB 3018 (Núñez, Chapter 312, Statutes of 2008), establishing the California Green Collar Jobs Council (Council), to develop a comprehensive approach to address California's emerging workforce needs specifically with its budding "green" economy. This Council is a collaborative effort among environmental, workforce development and educational state agencies, and California's local workforce development community, including private employers, labor unions and financial institutions. The Council is an opportunity for state agencies and other stakeholders in the workforce development community to collaborate across traditional organizational restraints and address barriers associated with workforce development as well as program expansion to meet industry needs.

In keeping with this spirit, the Energy Commission, the California Employment Development Department (CEDD), the Employment Training Panel, and the California Workforce Investment Board, in collaboration with the Council, are leading a partnership of state agencies, educational institutions, local workforce investment boards, community and labor organizations and employers to deliver 21st century training programs for workers with all levels of experience. This collaborative effort, known as the Clean Energy Workforce Training Program (CEWTP) combines funding from the American Recovery and Reinvestment Act (ARRA) for the State Energy Program (SEP), Program funding, Workforce Investment Act Governor's Discretionary funds, and private and local funds to create what is believed to be the nation's largest green job workforce development program.

The CEWTP offers California opportunities to develop workforce training programs leading to long-term employment in a new, emerging, low-carbon fuels market. These programs provide education and training for people who are preparing to leave school to join the workforce, want to enter or re-enter the workforce, or just advance in their current career paths. They must be cognizant of and responsive to the needs of an industry undergoing significant change and strive to form commitments and partnerships between the environmental community, labor unions, private sector industries, workforce development programs, primary and secondary education systems, and government.

Current Workforce Training Programs

In its first investment plan, the Energy Commission allocated $15 million in funding for work force training and development. These funds are being used to support the broader CEWTP initiative. Specifically, the Energy Commission has entered into the following Interagency

Agreements (IAs) to access existing programs and expertise necessary to develop a sustainable workforce:

- Employment Development Department (EDD) Interagency Agreement

  The Energy Commission provided $4.5 million to expand and develop local workforce development and training services that focus on job skills needed for alternative and renewable fuel and vehicle technologies. In addition to service delivery, EDD will also provide workforce needs assessments and reports through their Labor Market Information Division and Regional coordination through the California Workforce Investment Boards Industry Cluster Development efforts. EDD's extensive workforce development and training system is well positioned to assess, coordinate, and deliver the services required to meet clean transportation workforce needs. By partnering with the EDD, the Energy Commission takes advantage of their extensive workforce training delivery network to meet the training needs of employers at the local level and their labor market data resources to develop a clear picture of clean transportation workforce needs.

- California Community Colleges Chancellor's Office (CCCCO) Interagency Agreement

  The California community college system offers an accessible and affordable means of education and training. In addition, community colleges are capable of rolling out training modules quickly and can offer short-term courses and certificate programs. Approved in June of 2009, this $4.5 million IA delivers industry needs assessments and high level advanced transportation industry studies through the CCCCO's Centers of Excellence. Training module development and delivery is provided through CCCCO's Advanced Transportation Technologies and Energy Program (ATTE) directly to students at the community colleges.

- Employment Training Panel (ETP) Interagency Agreement

  Established in December 2009, this $6 million IA delivers workforce training services specific to California's emerging green transportation industry and meets Program workforce training objectives. This program differs from the EDD IA and the CCCCO IA in that training services are provided in conjunction and concurrent with employer training efforts. The ETP IA supports essential, industry-driven skills upgrade training for California Green transportation employers, workforce, and workforce development organizations.

These workforce training programs have only recently been initiated and over the next year will yield performance data and workforce needs assessments. This information will assist in the formulation of future workforce development and training funding recommendations. In the meantime, staff will research opportunities to support programs designed to address the needs of disenfranchised young adults as well as programs developed in conjunction with colleges and universities for continuing education. A few examples of promising programs to be evaluated are highlighted below. Future Workforce Development Funding Opportunities

- One target population not addressed by the previous workforce training effort is at the high school level and specifically targets non-college-bound students interested in pursuing green careers and transportation technologies. Funding training programs that prepare students for careers in alternative fuels and advanced vehicle technologies can lead youth to pursue careers in these green industries. A few entities that have demonstrated successful and enduring programs are offered by the California Regional Occupation Centers and Programs and the California Department of Education's Partnership Academy program. Staff recommends evaluating this area for future potential funding
- In addition, numerous California universities and colleges have developed certificated and advanced transportation and environmental sustainability degree programs. For example, the Universities of California at Berkeley and Los Angeles have developed the Institute of Transportation Studies and are considered the world's leading centers for transportation research, education and scholarship. The University of Southern California's School of Policy, Planning and Development offers a summit on ensuring the growth of California's transportation workforce with the intention of developing workers for today's challenges and tomorrow's jobs.

Staff recommends evaluating these and other areas for future potential funding.

By partnering and leveraging resources with education and training professionals, the Energy Commission provides much needed funding for the education and training of people who are unemployed, want to enter or re-enter the workforce, or just advance in their current career paths. By being cognizant of and responsive to the needs of an industry undergoing significant change, the Energy Commission is leading the country in economic recovery.

Standards and Certification

It is essential that California uphold and improve upon its existing environmental standards as new alternative and renewable fuels and advanced vehicle technologies are demonstrated and deployed. These new fuels and advanced vehicle technologies will require that standards and certifications be researched and adopted for the fuels and vehicles themselves, equipment, engines, fuel storage, and fleet and retail dispensing systems. Once these standards and certifications are established, methods and protocols will be determined for responsible state and local agencies to use as they assure compliance and enforcement, while assuring straightforward, reasonable, and timely certification and approval processes. Examples of such needed support include the current Program funding of $4 million for the California Department of Food and Agriculture, Division of Measurement Standards (DMS) for "type-approved" retail fuel dispensers for hydrogen and fuel quality standards for hydrogen and biodiesel blends.

The mission of DMS is to assure consumer confidence in conventional and alternative fuels for retail and commercial fuel dispensing. Typically, DMS is the lead agency (with ARB) for the development of fuel quality standards and commercial fuel measurement standards. Presently there is no approved commercial or retail hydrogen dispenser for fueling vehicles. Consequently, hydrogen cannot be sold in California on a retail per unit basis. A similar situation existed nearly 15 years ago for natural gas fueling dispensers. DMS must establish and enforce testing procedures and quality standards for commercial measurement of hydrogen for vehicle and other refueling applications. In addition, DMS has adopted California regulations which limit contaminates in hydrogen known to be harmful to fuel cells, but these quality standards for gaseous hydrogen have not yet been developed by a national standards development organization, such as American Society for Testing and Materials (ASTM) or Society of Automotive Engineers (SAE). Additionally, biodiesel fuel concentrations greater than 20 percent are not legal for sale in California unless authorized under DMS's Developmental Engine Fuel Variance Program. Biodiesel blends and pure biodiesel may be sold under controlled conditions in a fleet environment.

Under an Interagency Agreement with the Energy Commission, DMS will work with consensus organizations to develop national standards for hydrogen fuel, sampling procedures, testing protocols, and commercial/retail dispensers. DMS will conduct research to support the development of standards that will allow biodiesel blends greater than 20 percent to be available for sale in California in a retail setting. The work will be conducted over three years, commencing in 2010. Additional funding will be required in 2013 to complete the hydrogen standards (currently estimated to be a five-year endeavor).

In 2008, the California State Water Resources Control Board (SWRCB) enacted a policy requiring independent third-party certification. The SWRCB certifies that the fuel stored is not contaminated or out of compliance with the established ASTM fuel specification (the alternative fuel is as labeled B5, B20, or E-85 and the fuels, or fuels with additives, meet established standards for aquatic toxicity). In addition, the SWRCB mission is to reduce the risk of an unauthorized release of fuel to the environment by ensuring that the fuels stored are the same fuels tested by UL for material compatibility (the fuels stored meet ASTM specification) and that the underground storage tank does not exhibit indications of material incompatibility (corrosion and products of elastomer degradation). Permitting of USTs for storage of biodiesel fuel in concentrations greater than 5 percent have been stymied due to a lack of UL-certified USTs. Recently, an emergency regulation was enacted to provide a 36 month variance allowing up to B20 use in California until certification is obtained. [198] During this variance period it is incumbent on the industry to immediately engage in the funding and certification of the UST's.

Due to biodiesel fuel's complexities and the lack of established testing protocols certification progress has been slow. State funding is needed to help industry further develop, negotiate and secure protocols for approval of biodiesel and biodiesel blends infrastructure (i.e. tanks, piping, dispensers, etc.) with the various state, federal, and industry users, and to execute the testing

[198] http://www.waterboards.ca.gov/ust/regulatory/biodiesel_regs.shtml.

needed to secure the approvals for the California Market. To the greatest extent possible, the testing will be done on a generic basis and made available to all interested California parties for their use. Individual companies will need to do their own testing after the protocols are established.

Most retail diesel fuel dispensers and underground storage tanks (USTs) use materials that are certified to be compatible with biodiesel. In addition, terminals and storage facilities require certification for biomass based diesel fuels. However, the USTs have not received the required independent testing organizations certification of the complete system.

Depending on industry efforts to identify protocols and testing required by various regulatory agencies and individual companies, staff will assess funding needs for biomass-based diesel fuel infrastructure third-party certification for underground storage tanks, in future investment plans.

Sustainability Studies

The Energy Commission is the first major government energy agency in the country to make transportation energy project funding decisions based on specific sustainability goals and evaluation criteria. The Energy Commission is required to "establish sustainability goals to ensure that alternative and renewable fuel and vehicle projects, on a full fuel-cycle assessment basis, will not adversely impact natural resources, especially state and federal lands." In response to this statutory directive, the Energy Commission developed the following sustainability goals to identify and promote transportation-related GHG reduction projects that are exemplary in sustainability and environmental performance, and that can serve as national and international models:

- The first sustainability goal is the ***substantial reduction of [life-cycle] GHG emissions*** associated with California's transportation system to help meet California's 2020 and 2050 targets as defined in Health and Safety Code Section 38550 and the Governor's Executive Order S-03-05.
- The second sustainability goal is to ***protect the environment, including all natural resources***, from the effects of alternative and renewable fuel development and ***promote the superior environmental performance*** of alternative and renewable fuels, infrastructure and vehicle technologies.
- The third sustainability goal is to ***enhance market and public acceptance of sustainably produced alternative and renewable fuels*** by developing, promoting, and creating incentives for the production of such fuels in accordance with ***certified sustainable production practices and standards*** as established by government agencies, academic institutions, and nongovernmental organizations.

Biofuels, (referred to as renewable fuels under the federal RFS) are projected to play a critical role in meeting the GHG reduction goals for the state's transportation sector, and the production and use of biofuels must grow substantially to meet RFS fuel use requirements. California currently consumes about one billion gallons of ethanol a year and fifty million

gallons of biodiesel fuel. The demand for renewable fuel calculated as ethanol in California must triple between now and 2022 to meet California "fair share" requirements of the federal RFS. Ethanol represents the majority of transportation fuel carbon reduction requirements envisioned for California gasoline under California's Low Carbon Fuel Standard. Ethanol use is projected to increase to over 3 billion gallons per year by 2022, while biodiesel use is projected to increase to over 200 million gallons per year. The Energy Commission recognizes that the transition to large volumes of alternative and renewable fuels needed to help meet the state's GHG reduction goals from the transportation sector must be managed properly to avoid environmentally and socially destructive production practices.

In response to concerns about the potential for land use change associated with the development of biofuels and bioenergy crops, the Air Resources Board's LCFS program regulations require indirect land use change (iLUC) greenhouse gas emissions to be added to the direct emissions calculated for fuel pathways involving bioenergy crops for feedstocks. Commodity-scale crops that can also be used for food or animal forage, such as corn and soy beans, are most likely trigger land use changes as their production increases. [199] The Energy Commission includes the iLUC estimates into the fuel pathway greenhouse gas emissions estimates used during evaluation of AB 118 funding proposals.

The Energy Commission also strongly supports the development of an environmentally sustainable in-state bioenergy industry so that California can benefit economically from in-state biofuels production. Staff also identified and developed feedstocks and production technologies for use in California that fully integrate elements that will lead to the long-term development of low carbon, sustainably produced biofuels.

For internationally-produced biofuel feedstocks, staff continues to assess the major international initiatives and sustainable certification programs that are in development. The Energy Commission is working with the ARB and other stakeholders to decide how to evaluate international certification programs to determine if they will meet California's goals and standards for sustainable production. The Energy Commission recently joined the Roundtable on Sustainable Biofuels.

In the first investment plan, the Energy Commission recommended that $4 million be used for sustainability research. Two million dollars from this allocation will be spent on forest biomass sustainability research to implement the sustainability work plan developed by the Energy Commission for the Interagency Agency Forestry Working Group[200] in order to develop

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[199] The concept of land use change is that as commodity crops used for food are instead used for energy production, such as with corn, an unmet market demand for the food crop will develop, and eventually a farmer somewhere in the world will clear virgin forest or grassland and convert it to crop land, which will in turn result in the release of CO2 and other greenhouse gas emissions from the removed vegetation and soils. The ARB has developed land use change emissions estimates for corn ethanol and soy biodiesel.

[200] The Interagency Forestry Working Group was convened by the California Natural Resources Agency and California Environmental Protection Agency to develop consistent metrics for forest carbon

consistent definitions and standards for sustainable woody biomass from California's 40 million acres of private and public land forests. Substantial technical and scientific field work will be needed to establish sustainability definitions and standards for the emerging woody biomass fuels industry. The remaining $2 million was shifted to technical projects. For FY 2010-2011, the Energy Commission is allocating $2.5 million for sustainability research and technical support in the categories described below. Sustainability research funding is not available through any other California regulatory programs such as AQIP or the federal ARRA program.

The Energy Commission is planning to: 1) develop more precise tools to measure sustainability attributes and characteristics of projects proposed for funding, 2) create sustainability indicators for biofuel feedstocks and biorefineries, including historic land uses, soil quality, water use and waste water discharge, and biodiversity and sensitive ecosystems, 3) identify best management practices for bioenergy crops, and 4) analyze the effectiveness of current sustainability regulations, goals and evaluation criteria, and to investigate existing sustainability frameworks for regulatory and non-regulatory programs.

Next, sustainability assessments need to be expanded from the project level to the regional level in order to develop a more comprehensive understanding of how increased bioenergy crop production in California could be integrated into existing cropping mixes without adversely affecting food crop or animal feed production, agricultural water use, or wastewater discharges These studies could include the assessment of the environmental performance of current crops and regional assessments of energy crop expansion (such as, Imperial Valley sugarcane, San Joaquin Valley sugarbeets and sweet sorghum, Sacramento Valley sweet sorghum). Similar regional studies for bioenergy crops such as algae and perennial grasses may also be needed as the commercial viability of these crops and their associated process technologies mature. Specific studies are also needed on water use, waste water discharge, land use, and fertilizer and pesticide inputs.

To ensure that water use reduction measures and best management practices are used in the production of biofuels, investigative studies are also needed that quantify water use for different types of biofuel production processes and for bioenergy crops. Examining water best management practices and emerging technologies that reduce water use and waste discharge could also be beneficial.

Finally, California will likely be dependent on imported biofuel feedstocks and finished products to help meet GHG goals for the transportation sector. Investigating international environmental issues will be critical to ensure that all fuels used in California are sustainably produced. Conducting in-country field assessments of industry practices for the harvest and production of South East Asia oil palm, cane ethanol and oil palm in Brazil and greater South America, and African oil palm are recommended to meet this goal. It is also important to field test international sustainability programs and perform third party audits of international biofuels and feedstocks subject to sustainability certification programs along with examining

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accounting and sustainability definitions and standards for the energy and climate change programs at the California Air Resources Board and California Energy Commission.

habitat conservation and restoration efforts for areas affected by plantation development. Performing assessments of sustainability standards, protocols and the efficacy of using sustainability certification programs in the United States and internationally could be very helpful in determining which sustainability certification programs are most relevant to California's regulations and transportation needs.

Program Marketing and Public Education and Outreach

In 2009, the Energy Commission initiated a communication plan during the first year of the program. This plan sets the stage for the 2010-2011 development of a comprehensive message and media campaign that will reach targeted audiences in the most effective and efficient manner as projects are rolled out.

So far, the most effective method of public marketing and outreach for the Program has been in reaching members of industry that are likely to seek funding assistance. Workshops held by the Energy Commission during the development of the Investment Plan, as well as those describing guidelines for various funding opportunities, have been generally well-attended. Additionally, there has been no shortage of requests for funding from the Energy Commission among stakeholders.

Prior to the planning, development or construction of any projects funded by the Energy Commission, many stakeholders must navigate complex local and state permitting processes. Occasionally, the processes of local governments are protracted by active citizens that may be suspicious of the installation or expansion of any projects in their vicinity. To expedite these processes, the Energy Commission must also coordinate with local governmental agencies to provide current industry, regulatory and sustainability information that will assist with the public discourse.

Much of the challenge in implementing a program such as the Alternative and Renewable Fuel and Vehicle Technology Program lies in increasing awareness of the program's existence among the varied public and private entities that can benefit from funding opportunities derived from the legislation and assist us in reaching program goals. This broad-audience challenge can be lessened by the development of an awareness campaign that is crafted to focus marketing and outreach efforts on those entities identified in the program's Investment Plan. The Energy Commission will further enhance this targeted campaign by leveraging contract services with utilization of the expertise and resources available within the Energy Commission. The 2010 outreach and marketing effort will consist of a coordinated internal effort primarily focused on outreach and contracted services focused on marketing and media.

Outreach Plan

In collaboration with the Energy Commission's internal Media and Public Communications Office (MPCO) and the Air Resources Board Communications Office, marketing materials such as fact sheets, brochures and press kits will be developed. These outreach materials will offer simple, straightforward information about the program and highlight the funding priorities identified in the Investment Plan. The MPCO will also coordinate press releases and events highlighting funding opportunities and reporting on projects as they develop in the field.

A program-specific website will be developed to promote involvement in program funding opportunities and to increase participation in funded projects. The website will also provide linkage to agencies with parallel missions, such as ARB's Drive Clean Campaign and the Bureau of Automotive Repair's Drive Healthy information site and other government agencies offering information about complementary programs or events.

In addition, the Energy Commission will continue participation in high profile, regional alternative fuel auto shows and expositions that leverage opportunities to inform interested entities and stakeholders of the program's existence and funding opportunities.

Marketing and Media

A targeted multi-media campaign is required to reach the businesses, fleet managers, universities, and environmental organizations targeted in the investment plan. A public awareness and marketing firm will be secured to develop audience specific print, radio, television, and cable ads and to negotiate media buys that maximize exposures to the program's targeted audience. The Energy Commission estimates that $2.5 million will be necessary to meet this desired level of media and marketing.

The Energy Commission received requests for almost $30 million in education and outreach related activities funding in conjunction with ARRA solicitations. Two proposals received $550,000 in funding. To support what appears to be an underserved program area, the Energy Commission allocates a total of $2.5 million to this area.

Technical Assistance and Environmental/Market/Technology Analysis

The Energy Commission will need continuous updates of the status of vehicle technology and fuels, market analyses, financing trends and other factors that impact the introduction and growth of alternative and renewable fuels in California to monitor the progress of funding decisions and develop future, annual investment plans. Ongoing refinement of analytical methodologies, such as full fuel cycle analysis models, will be needed to evaluate the potential greenhouse gas emission and other environmental impacts of new fuel and vehicle technology options. The Energy Commission has allocated $6 million to fund this technical assistance and analytical work, which is likely to include the following:

- **Technical Assistance for Full Fuel Cycle Analysis with Life Cycle Associates –**
- On-going technical support is needed to establish the life-cycle scale greenhouse gas emissions for new and emerging alternative fuel pathways that have not yet been

analyzed in the Low Carbon Fuel Standard program or through the Energy Commission's existing contract with Life Cycle Associates. The AB 118 program will need additional technical and training support with the California-GREET model as it is expanded and updated to include new climate changing gases, new fuel pathways and sustainability parameters such as water.

- **Spatially and Temporally Resolved Energy and Environmental Tool) (STREET)** represents University of California Irvine's modeling approach for identifying, analyzing and understanding the interplay between GHG, criteria pollutant emissions, water usage and energy intensity generated from displacing existing transportation fuels and technologies. The Advanced Power and Energy Program (APEP) group under Professor Scott Samuelsen at UC Irvine has developed this integrated model, software and simulation to predict environmental and resource usage impacts of current and proposed transportation scenarios. Current and past funding sources for the APEP include DOE, Toyota, Air Products, Honda, Nissan, Air Resources Board and the Energy Commission. Energy Commission is interested in the hydrogen infrastructure capabilities of this model and is proposing to fund this work to expand into other alternative fuels and their infrastructure aspects. $750,000 for three years ($250K per year) is proposed for this work to enable Energy Commission to make decisions on Program funding allocations for alternative fuel infrastructure. For example, the model will produce vehicle rollout scenarios to aid in deciding sustainable locations of fueling stations.
- **Technical assistance in the development of future Investment Plans** -- In order to ensure the most effective use of Program funding, the Energy Commission will also need technical assistance in developing research and market-transformation recommendations for future investment plans. Future funding allocations will require reliable assessments of current fuel and vehicle markets. These market assessments will then be compared against preferred market scenarios defined by policy objectives. Subsequent analyses of the gap between present markets and preferred scenarios will identify the barriers to the development and deployment of clean and efficient low-carbon technologies. This will also identify possible funding opportunities to overcome these market barriers and provide guidance on the preferred methodology for determining funding allocations.
- **NREL's Center for Transportation Technologies and Systems** -- A possible agreement to provide technical support services for the Program, in particular, market assessments of advanced vehicle fuels and technologies, fuels research, criteria and GHG emissions characterization and improvement, biofuels production and use, hydrogen vehicle technology evaluation and infrastructure needs, and the ongoing work the laboratory is presently engaged in regarding scenario planning to achieve climate change, petroleum reduction and air quality goals in the state.

Table 20: Market and Program Development Funding Summary

Sustainability Studies	$2.5 Million
Program Marketing and Public Education and Outreach	$2.5 Million
Technical Assistance and Environmental / Market / Technology Analyses	$6 Million
Total	$11 Million

2010-2011 INVESTMENT PLAN FUNDING ALLOCATION

The allocations in the Investment Plan are based on an analysis of the potential GHG reductions, the relative contributions of each fuel and vehicle category to meeting the 2020 and 2050 GHG targets, the level of public and private funding, feedback from stakeholders, an analysis of proposals received, and the potential economic impact on the California economy of each funding category.

This Investment Plan will seek to leverage existing federal, state and local funding as well as stakeholder investments to accelerate the introduction and use of these fuels and technologies. The Energy Commission will focus on and leverage those technologies that show the most promise and market potential while balancing the need to have a robust portfolio approach to technology development. This approach will mitigate investment risk and emphasize investments that provide immediate lower carbon and GHG and petroleum reduction benefits.

Once the funding allocation is approved the investments and dollar amounts will be itemized under each category in the Table below.

Table 21: Funding Allocation Summary for FY 2010-2011

	Project/Activity	Funding Allocation for FY (2010-2011)
Electric Drive	Develop and demonstrate advanced on-road medium- and heavy-duty technology	$12 Million
	Develop and demonstrate advanced non-road medium- and heavy-duty technology	$2 Million
	Infrastructure and related activities	$3 Million
	Manufacturing facilities and equipment	$7.5 Million
	Subtotal	**$24.5 Million**
Hydrogen	Fueling Infrastructure	$14 Million
	Subtotal	**$14 Million**
Ethanol	Expansion of E-85 dispensers and retail outlets	$8.5 Million
	Project feasibility, feedstock and pre-plant development activities for new and retrofit advanced ethanol production technologies	$10 Million
	Subtotal	**$18.5 Million**
Biomass-Based Diesel	Production plants using waste feedstocks	$5 Million
	Bulk terminal storage and blending facilities	$5 Million
	Subtotal	**$10 Million**
Natural Gas	Medium- and heavy-duty port trucks, school buses and other vehicles	$12 Million
	Upgrades to natural gas fueling stations	$2 Million
	New construction or expansion of biomethane production, feasibility studies, and quality testing	$10 Million
	Subtotal	**$24 Million**
Propane	Light- and medium-duty vehicles	$3 Million
	Subtotal	**$3 Million**
Innovative Technologies and Advanced Fuels	Innovative Technologies and Advanced Fuels	$3 Million
	Subtotal	$3 **Million**
Market and Program Development	Sustainability studies	$2.5 Million
	Program marketing and public education and outreach	$2.5 Million
	Technical assistance and environmental/market/ technology analyses	$6 Million
	Subtotal	**$11 Million**
	Grand Total	**$108 Million**

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APPENDIX A: 2050 Vision Light-Duty Vehicle GHG Emission Reduction

Relative Greenhouse Gas Reductions

Light-Duty Vehicles

This analysis evaluates one potential scenario where the light-duty vehicle segment[201] can reduce GHG emissions in a partially successful attempt to meet "fair share" reduction targets for 2020 and 2050. The transportation sector's "fair share" emission reduction target is not established by statute, but is the calculated emission reduction target for the transportation sector (or in this case for light-duty vehicles) based on the sector's contribution to the state's total GHG emissions. In other words, since the transportation sector is responsible for 38 percent of statewide GHG emissions, its "fair share" emission reduction is 38 percent of the total reduction needed to meet 2020 and 2050 policy goals.

The objective was to work backward from the *2050 Vision* to depict the alternative and renewable fuel and vehicle pathways that may be needed to meet the GHG emissions reduction statutory requirement of AB 32 and to be consistent with the trajectory needed to meet the 2050 target as well. Chapter 6 of the *State Alternative Fuels Plan* describes this vision.[202] The major attributes of this *2050 Vision* are that:

- Most vehicles in 2050 would achieve a fleet-average of 60 miles per gallon; electric-drive vehicles would achieve a fleet-average of 80 miles per gasoline gallon equivalent.
- The 2050 fuel mix would consist of electricity and hydrogen (40 percent), biofuels (30 percent) and petroleum fuels (30 percent).
- The carbon intensity for alternative fuels used in the vehicle populations in 2050 would be reduced by 50 percent relative to 2010 alternative fuels. Gasoline fuel would also be reduced by 50 percent carbon intensity relative to 2010. In addition, gasoline would be reduced from use in 99% of all light duty vehicles to only 10 percent of all vehicles. The 50 percent carbon intensity reduction is consistent with the reduction methods used in the *State Alternative Fuels Plan.*
- The carbon intensity of ethanol is reduced by 80 percent in 2050 relative to today's value. This change in carbon intensity is based on updated feedstock data.

Figure 1 shows the contribution of each of these fuel and vehicle categories toward meeting the total light-duty GHG emissions reduction target through 2050.

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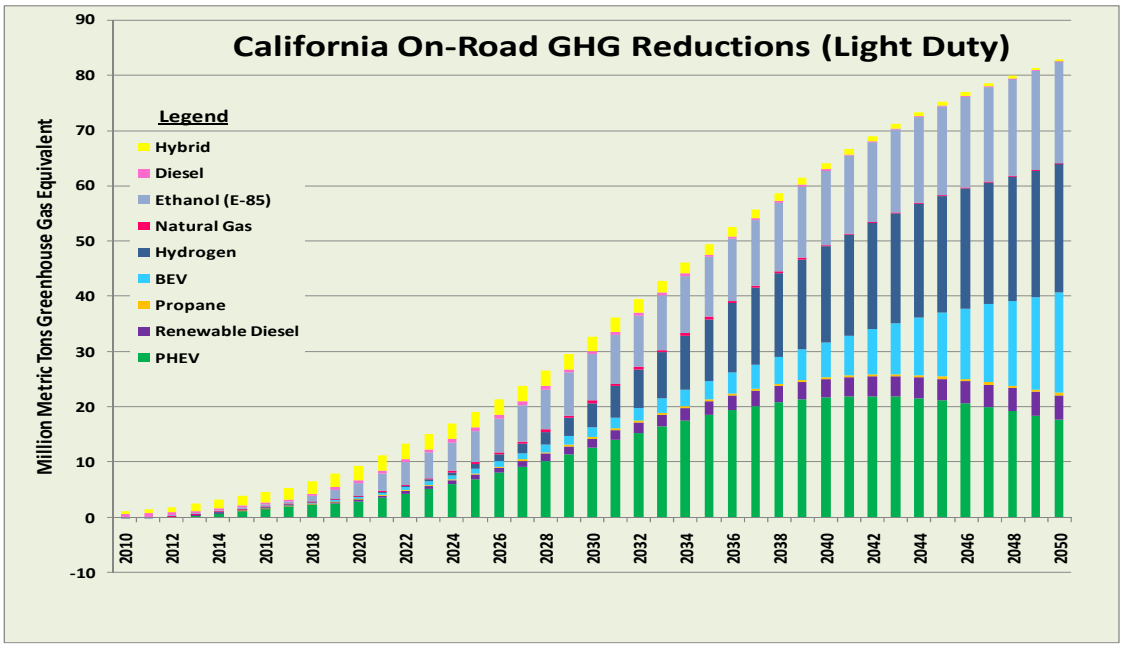
[201] The full Light-Duty Vehicle Analysis is in Appendix A.

[202] *State Alternative Fuels Plan*, Final Adopted Report CEC-600-2007-011-CMF, December 2007.

Figure A-1. 2050 Vision Light-Duty Vehicle GHG Emission Reduction[203]



Conclusions for Light-Duty Vehicles

Drawing upon Figure 1, staff calculated the percentage contribution of each fuel/vehicle type to total light-duty GHG emission reductions. These percentages, shown in Table 1 below, were developed by adding GHG reductions for each category in 2020 and in 2050 and dividing the individual totals for each category by the total GHG reductions. The, Tire Efficiency Program, and VMT reductions were not included to produce the final results below. The VMT reduction and the Tire Efficiency Program would lower the resultant emissions. However, incorporating these programs into this analysis makes it more difficult to evaluate. VMT was kept as a constant.[204]

Differences between assumptions used by this Investment Plan analysis and analysis by the ARB are:

- ARB assumes the 2050 goal will be reached using primarily one alternative fuel. The Energy Commission assumes that multiple fuels will contribute to the goal.

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[203] Reductions are from all alternative fueled vehicles. Numbers are based on a scenario of vehicle penetrations above the 2009 CALCARS baseline. Fuel Categories from the previous investment plan have been broken down into their individual fuels to avoid confusion about actual carbon intensities of these fuels. Super Ultra Low has been broken down into hydrogen, BEV and PHEV. Ultra Low is now Ethanol and Low carbon is now CNG and Propane. Fuel economy improvements have been broken down and added to their respective fuels.

[204] The methodology for estimating VMT is being reviewed by Energy Commission staff.

- The Energy Commission analysis assumes that both hydrogen vehicles and battery electric vehicles will succeed in approximately equal numbers by 2050.
- The Energy Commission analysis uses a larger number of fuel flexible vehicles in the future.

The results of the analysis lead to the following percentages for each of the categories evaluated.

Table A-1: Light-Duty Alternative Fuel GHG Emissions Reductions (2020 & 2050)

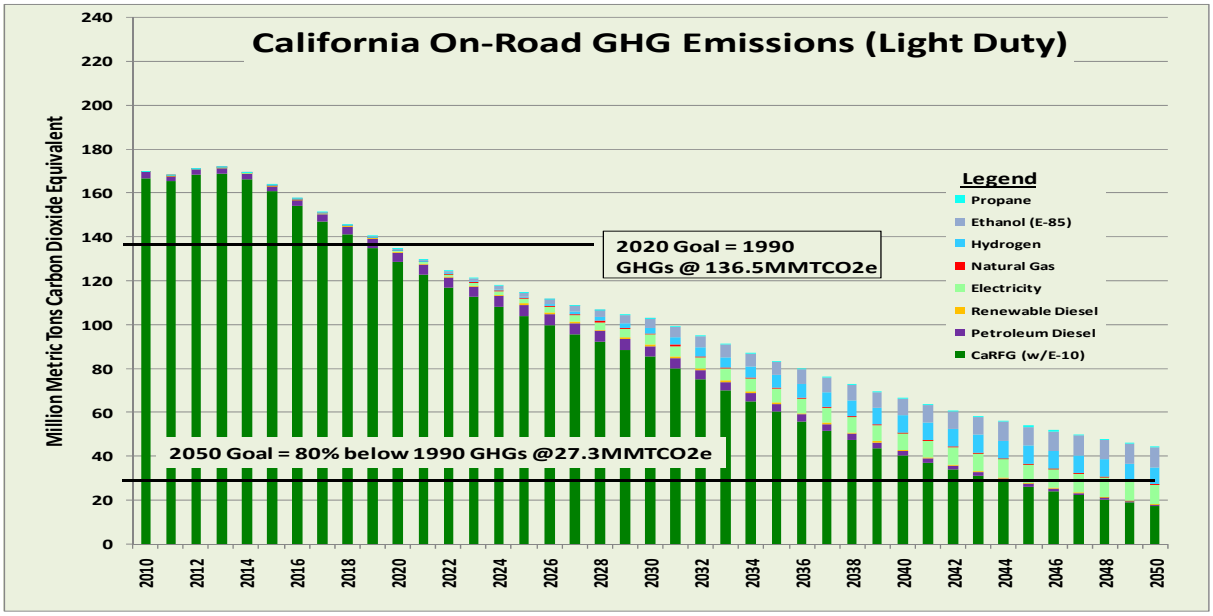
Category	2020 GHG Emission Reduction ($MMTCO_2e$)[205]	2020 Percent GHG Emission Reduction	2050 GHG Emission Reduction ($MMTCO_2e$)	2050 Percent GHG Emission Reduction
Hybrid	2.57	28%	0.40	0.48%
Diesel	0.54	6%	0.07	0.09%
Biomass-Based Diesel	0.35	3.8%	4.36	5.3%
Propane	0.08	0.9%	0.46	0.6%
Ethanol (FFV)	2.17	23.3%	18.35	22.1%
BEV	0.35	3.7%	18.15	21.9%
PHEV	2.98	32.0%	17.77	21.4%
CNG	0.16	1.7%	0.10	0.1%
FCV	0.10	1.1%	23.26	28.1%
Total	9.30	100.0%	82.92	100.0%

Source: California Energy Commission

Using these estimates, Figure 2 shows the effectiveness of this scenario in meeting the fair share 2020 and 2050 GHG reduction targets for the light-duty vehicle sector. As the figure shows, the emission reductions achieved by these measures nearly meet the 2020 goal, but are not adequate to reach the 2050 goal. Figure 3 shows the vehicle sales trends that would generate the emissions shown in Figure 2.

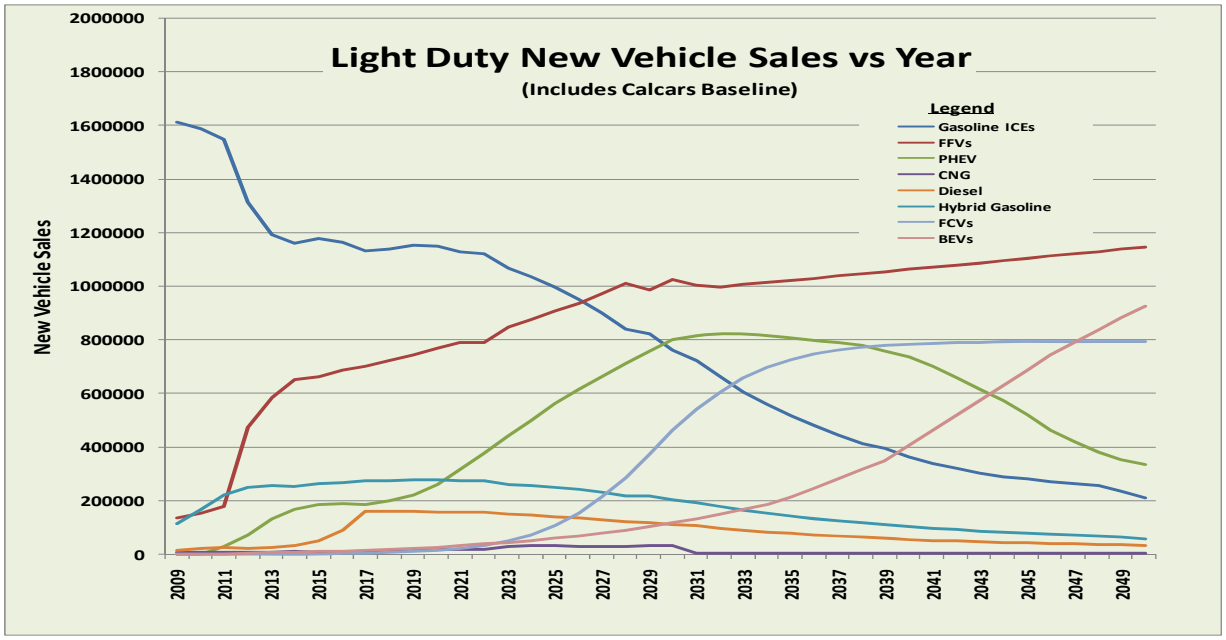
[205] Million metric tons carbon dioxide emissions.

Figure A-2: California Light-Duty Vehicle GHG Emissions



Source: California Energy Commission

Figure A-3: California Light-Duty New Vehicle Sales Including Scenarios



Source: California Energy Commission

Medium- and Heavy-Duty Vehicles

This analysis extends the evaluation of the *2050 Vision* for light-duty vehicles to medium- and heavy-duty vehicles. [206] The emerging fuels and vehicle technologies included in this analysis are renewable diesel, hydraulic hybrids, battery-electric hybrids, full-electric vehicles, fuel cell vehicles, propane, compressed natural gas, and liquefied natural gas vehicles.

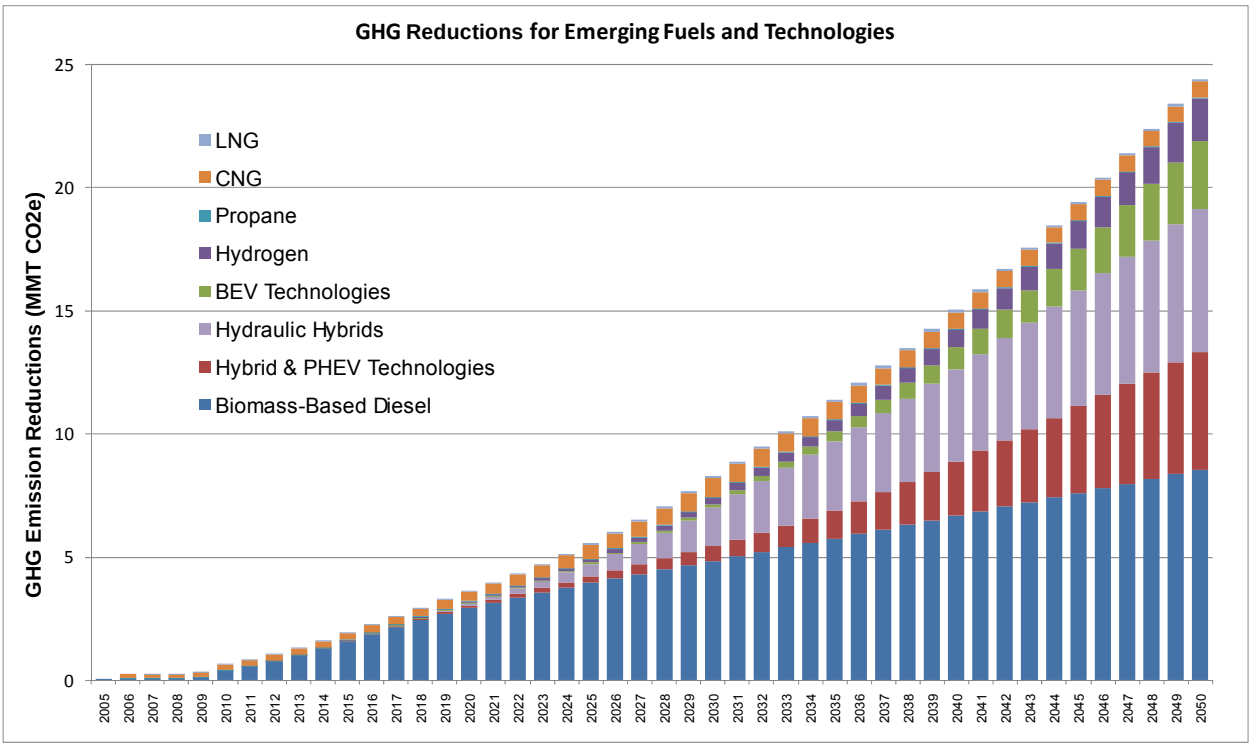
The total GHG reduction from medium- and heavy-duty vehicles is developed by adding GHG reductions for all categories over the 2009 to 2020 and 2009 to 2050 periods, and then specific percentages of the total are derived for each category eligible for program funding.

As in the light-duty assessment, the GHG emission reduction scenario presented here was "unconstrained" in that projections had no limitations for cost, fuel supply, or biomass feedstock availability placed upon them, even though the updated fuel and technology market information is influenced by costs and considers barriers to market penetration. Still, these fuels and vehicle technologies were evaluated independently and do not reflect interactions in a competitive marketplace. The Energy Commission used a simple accounting method to calculate the estimated emission reductions over a 42-year period for the medium- and heavy-duty vehicles and fuels based on market information developed in the preparation of the AB 1007 *State Alternative Fuels Plan*. The final GHG emission reduction scenario used in this evaluation assumed the moderate market development penetration estimates of the emerging fuels and vehicle technologies in the four categories.

Figure 4 shows how each fuel/vehicle category contributes to achieving the total medium/heavy-duty GHG emission reductions through 2050.

[206] The full Medium- and Heavy-Duty Vehicle Analysis is in Appendix B.

Figure A-4: Estimated GHG Reductions from Each of the Categories



Source: California Energy Commission

Medium- and Heavy-Duty Vehicle Analysis Conclusions

The medium- and heavy-duty results displayed in Table 2 below reflect the initial evaluation of GHG emission reductions from the different categories needed to meet the state's climate change requirements and goals for 2020 and 2050. The ARB's Low-Carbon Fuel Standard was not applied.

Table A-2: 2020 & 2050 Medium- and Heavy-Duty GHG Emissions Reductions

Category	2020 GHG Emission Reduction ($MMTCO_2e$)	2020 GHG Emission Reduction (Percent)	2050 GHG Emission Reduction ($MMTCO_2e$)	2050 GHG Emission Reduction (Percent)
Biomass-Based Diesel	2.9	80%	8.5	46%
Hybrids (PHEV& Hydraulic)	0.2	5%	5	26%
Battery Electric Vehicle	0.01	0.3%	2.8	15%
Hydrogen	0.07	2%	1.75	9%
Propane	.01	0.3%	.04	0%
CNG	.38	10%	0.6	3%
LNG	.05	1.5%	0.1	1%
Total Reductions[207]	3.63	100 %	18.6	100%

Source: California Energy Commission

Combined Results — Light-, Medium-, and Heavy-Duty Vehicles

Staff determined final, overall percentages by combining the light-duty vehicle GHG emissions reductions with those from the analysis of medium- and heavy-duty vehicles. The final GHG emission reduction percentages for meeting California's 2020 and 2050 GHG emission reduction goals, for the designated categories, are displayed in Table 3 below.

[207] Note: Total values may not add up exactly due to rounding errors.

Table A-3: Summary of GHG Emissions Reductions

Category	2020 GHG Emission Reduction ($MMTCO_2e$)	2020 GHG Emission Reduction (Percent)	2050 GHG Emission Reduction ($MMTCO_2e$)	2050 GHG Emission Reduction (Percent)
Biomass-Based Diesel	29.90	38.58%	119.69	5.05%
PHEV	16.89	21.79%	594.87	25.10%
BEV	2.27	2.93%	268.04	11.31%
Hydraulic Hybrid	0.29	0.37%	64.29	2.71%
Hydrogen	0.71	0.91%	402.69	16.99%
Propane	0.52	0.67%	12.41	0.52%
CNG	7.51	9.69%	45.55	1.92%
LNG	0.78	1.00%	4.62	0.19%
Ethanol (FFV)	7.23	9.33%	372.80	15.73%
Total Reductions	77.51	100%	2369.94	100%

Source: California Energy Commission

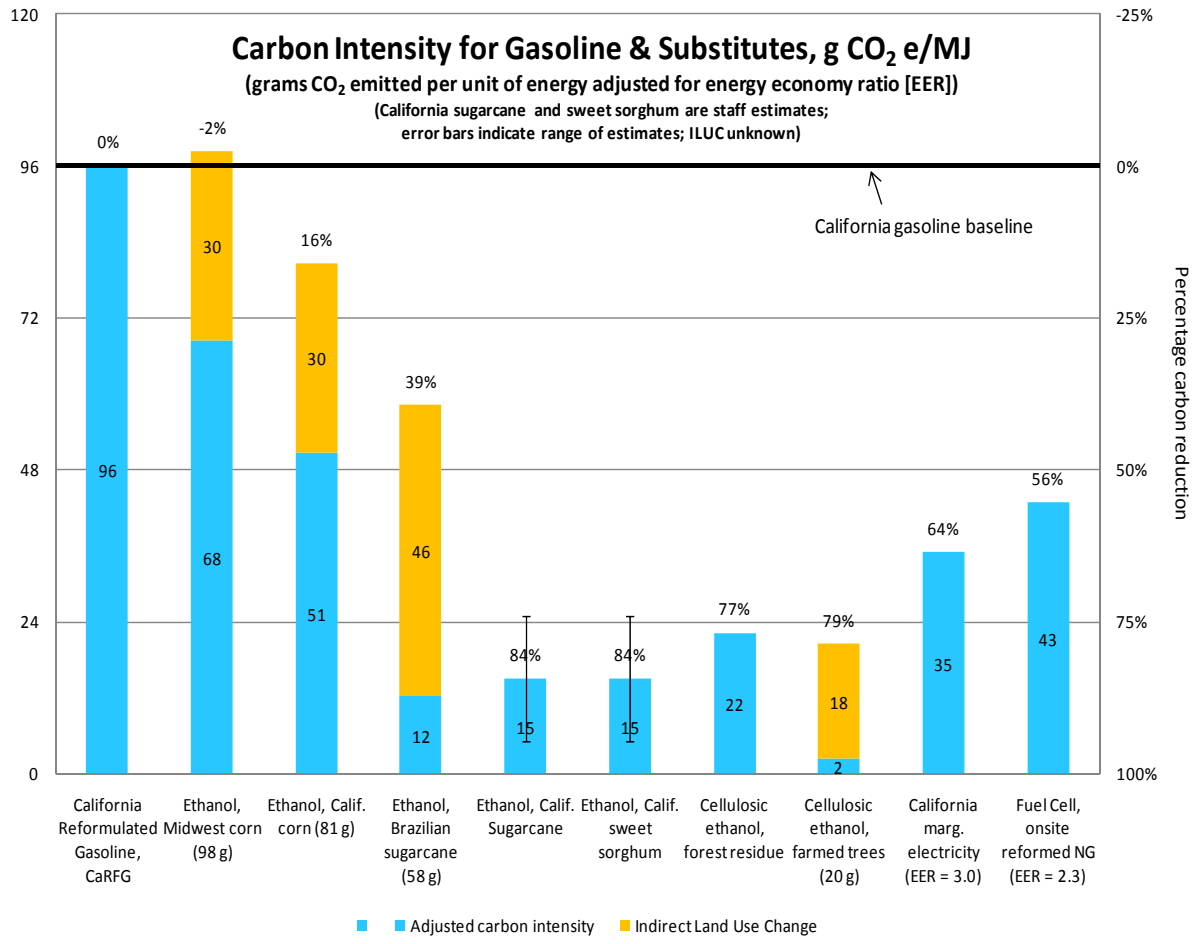
The percentages resulting from this analysis serve as a benchmark to help guide the Energy Commission in allocating program funds to projects that will help the state attain its climate change requirement for 2020, and assure the proper trajectory for fuels and vehicle technology development to achieve the 2050 GHG reduction goals. With this analysis the Energy Commission developed the funding allocation described in the next section through an assessment of the state of the technology, market, and existing funding sources for each alternative fuel and vehicle category.

Measurement of Greenhouse Gas (GHG) Reduction (Carbon Intensity)

It is important to define "GHG reduction" for the various fuel pathways since GHG reduction is one of the primary objectives of AB 118. Emissions of carbon dioxide, and other greenhouse gases, are measured by carbon intensity (or GHG intensity) in units of carbon dioxide-equivalents per mega joule of energy CO2-eq/MJ). Carbon intensity values for alternative fuels are calculated with what is known variously as a well-to-wheels, full fuel-cycle, or lifecycle analysis. Well-to-wheels measures the amount of carbon released during all phases of production and use of a vehicle fuel. It is important to remember that the production of the fuel

contributes to the carbon intensity. For example, electric vehicles and hydrogen fuel cell vehicles both have significant carbon intensity because production of electricity and hydrogen releases greenhouse gasses into the atmosphere. Electric drive fuel paths are afforded an Energy Efficiency Ratio (EER) of two to three times the Internal Combustion Engine (ICE) efficiency baseline, thereby rendering those pathways very attractive on an overall GHG-per-mile comparison. See figures 5 and 6 below for the carbon intensity for gasoline and substitute fuels.

Figure A-5: Carbon Intensity for Gasoline & Substitutes

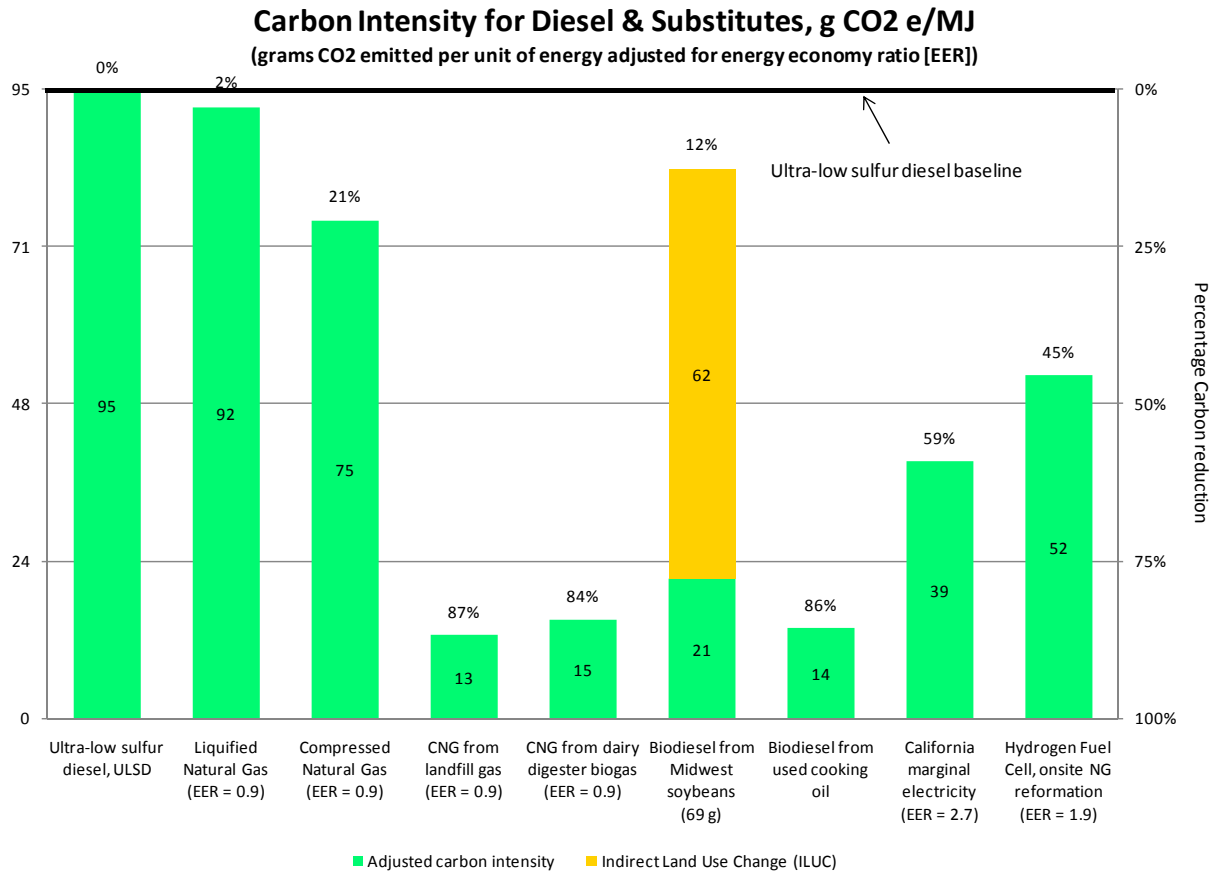


Source: California Air Resources Board LCFS website unless otherwise indicated.

A full fuel-cycle analysis may be performed with the "Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation" package, more commonly known as GREET. It counts the emissions and energy expended starting from the extraction point (well) and captures all direct (and later indirect)[208] emissions as the fuel is processed, transported, sold and used by the final consumer. In California, a version known as CA-GREET is used, which includes default values

and calculations particular to California. This is an Excel spreadsheet-based model that calculates carbon intensity for fuel production inputs specified by the user. For gasoline, a well-to-wheels analysis would include the carbon released during oil drilling, transportation of the oil, refining the oil into gasoline, transporting and distributing the gasoline, and combustion of the gasoline in a vehicle engine. Corn or sugarcane ethanol would include carbon released from farming; producing agricultural inputs such as pesticide, herbicide, and fertilizer; transporting

Figure A-6: Carbon Intensity for Diesel & Substitutes



Source: California Air Resources Board LCFS website.

the harvested crop; refining it into ethanol; and transporting and distributing the ethanol. For ethanol or other biofuels, the California GREET model does not include combusting the fuel. The carbon in the fuel is biogenic in origin: it was in the atmosphere, but through photosynthesis became part of the plant that was then converted into ethanol, and when it is combusted in the vehicle engine the carbon returns to the atmosphere where it had been a few months earlier.

In response to concerns about the potential for land use change associated with the development of biofuels and bioenergy crops, the Air Resources Board's LCFS program

regulations require indirect land use change (ILUC) greenhouse gas emissions to be added to the direct emissions calculated for fuel pathways involving bioenergy crops for feedstocks. Commodity scale crops that can also be used for food or animal forage, such as corn and soy beans, are most likely to trigger land use changes as their production increases. The Energy Commission includes the ILUC estimates into the fuel pathway greenhouse gas emissions estimates used during evaluation of AB 118 funding proposals.[209]

[209] The ILUC figures presented here are current as of January 2010, but are subject to revision by the Air Resources Board.

APPENDIX B: Zero Emission Vehicle Regulation

The Zero Emission Vehicle (ZEV) regulation was first adopted by the California Air Resources Board (ARB) in 1990 as part of the Low Emission Vehicle Program. Although it has been modified several times over the years, it still remains an important program for meeting California's air quality and greenhouse gas (GHG) emission reduction goals, and has spurred many new technologies that are being driven on California's roads today. The regulation's intent has consistently been to have zero emission technologies on the roads on a mass scale as soon as possible. The ARB, however, has appropriately weighed the state of technology, market factors, economic impact, and policy goals in adapting the program over time.

As part of the ZEV regulation, large automakers are required to produce a certain number of "pure" zero emission and "near-zero" emission vehicles for sale in California as a percentage of their overall sales. This percentage increases over time, from 11 percent in model years 2009-2011 to 16 percent in model years 2018 and beyond. Automakers are awarded credits toward meeting their requirements through the sale of different levels of vehicle technologies, as categorized in Table B-1.[210]

Table B-1: Types of ZEVs Included in the Regulation

Category	Vehicle Acronyms	Technologies
Gold	ZEV	Battery; hydrogen fuel cell
Silver Plus	Enhanced AT PZEV	ATPZEV using a ZEV fuel, such as electricity or hydrogen. (Examples: plug-in hybrids or hydrogen internal combustion engine vehicles)
Silver	AT PZEV	Hybrid; compressed natural gas (CNG); methanol fuel cell
Bronze	PZEV	Extremely clean conventional vehicle with extended warranty and reduced evaporative emissions

Vehicles using the higher categories of technologies are worth more credits toward satisfying the ZEV requirements than those using the lower categories of technologies. Additionally, within the ZEV technology category, there are six different "types" with their own number of credits per vehicle, based on a particular vehicle's range and fueling capabilities.

The ZEV program continues to bring innovative, clean technologies to California's roads. Many of these cars, such as hybrids, have become widely accepted, like the Toyota Prius and Honda Civic Hybrid. More advanced technology vehicles have also been deployed throughout the

[210] http://o3.arb.ca.gov/msprog/zevprog/factsheets/overview.pdf

state, though these are often not yet at a commercial phase of deployment. The following table represents the number of vehicles placed between 1994 and 2008.[211]

Table B-2: Statewide Vehicle Deployments by ZEV Category, 1994-2008

ZEV Category	Technology Type	Vehicles Deployed
ZEV	Fuel cell	250
ZEV	Battery electric	4,800
ZEV	Neighborhood electric	28,000
AT PZEV	Hybrid or CNG	258,000
PZEV	Low-emission conventional	1,156,000

Updates to the ZEV Regulations

In March 2008, the ARB directed its staff to reassess the ZEV regulation, keeping in mind California's long-term air quality and greenhouse gas (GHG) emission reduction goals, and to return to them with an update and recommendation by the end of 2009. On December 11, 2009, the ARB convened to review these materials. [212] In its report to the ARB, the staff outlined a series of potential revisions to the ZEV regulation to take place after model year 2014, including the following:

- Closer alignment of the ZEV regulation with the state's 80 percent GHG emission reduction target for 2050.
- A renewed focus on pre-commercial development vehicle technologies (such as ZEVs and Enhanced PZEVs), rather than technologies that already have demonstrated their market potential (such as PZEV and AT PZEV).
- Moving PZEV and AT PZEV vehicle technologies out of the ZEV program and into the criteria pollutant standard (also known as the Low Emission Vehicle [LEV] standard).

[211] Ibid.

[212] A summary of the ARB staff's assessment can be found at: http://www.arb.ca.gov/msprog/zevprog/2009zevreview/zevwhitepaper.pdf

APPENDIX C: California Hydrogen Early Adopter Cluster Communities

The idea is to develop early "hydrogen communities" for passenger vehicles with clusters of retail hydrogen stations in four Southern California communities: Santa Monica, Irvine, Torrance and Newport Beach, with additional stations to support the next identified communities and a network of connector stations. (See map below).

Placing the first wave of stations will impact the locations for the second wave. Vehicles may be more popular in one community than in another. With the help of automakers (annually surveys of information about numbers and locations of their newly deployed vehicles), it will be ensured that the next wave of stations is being constructed at the most desirable and effective locations.

Figure C-1: California Hydrogen Early Adopter Cluster Communities

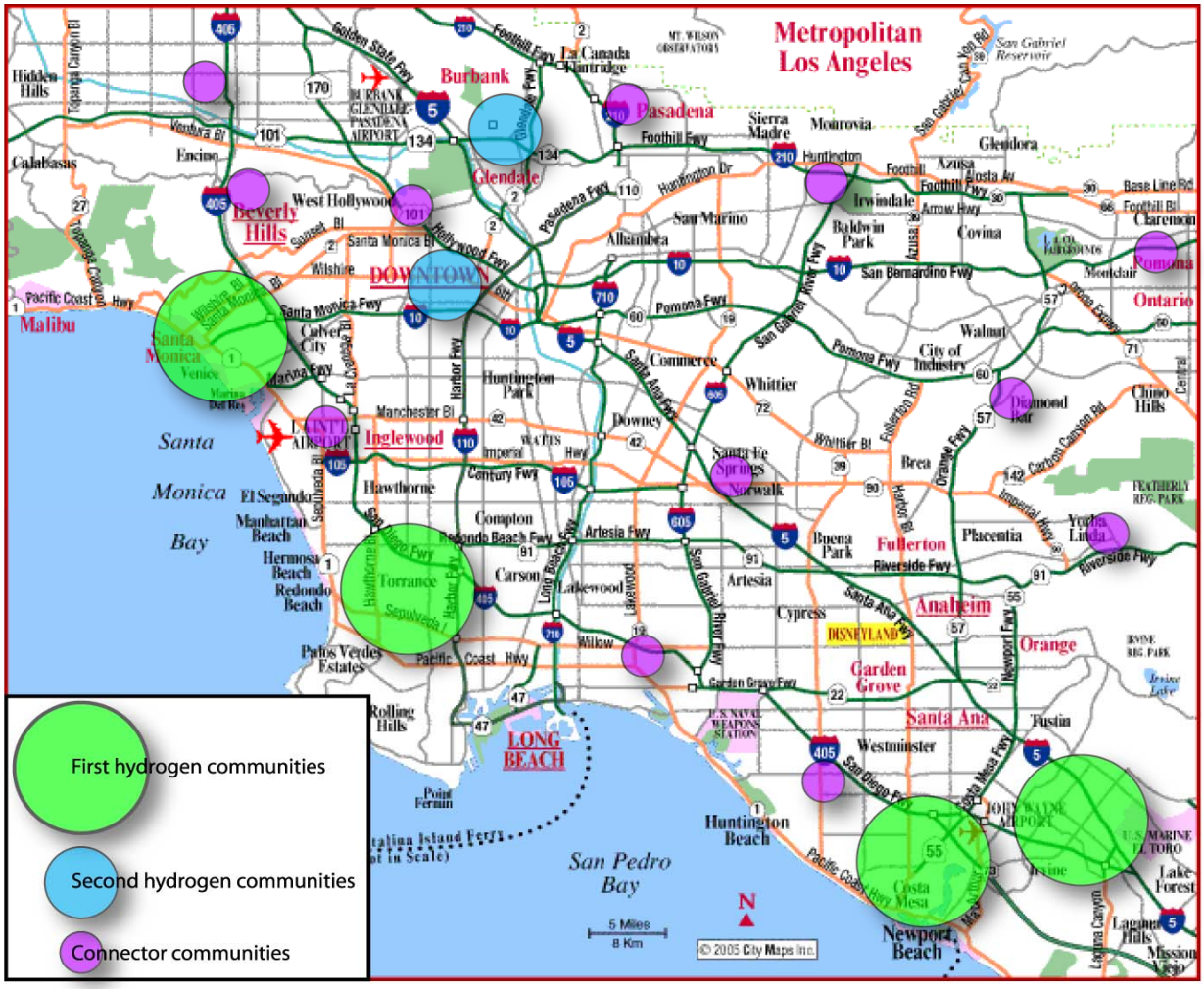


Table C-1: Hydrogen Fuel Demand and Capacity

Year	Region[213]	Vehicle Rollouts (From Table 8)	Hydrogen Demand (Kg/day)	Hydrogen Capacity (Kg/day)	Add'l Hydrogen Needed (Kg/day)
2010	Santa Monica (cluster)	25	25	12	13
	Torrance (cluster)	25	25	58	0
	Newport Beach (cluster)	23	23	0	23
	Irvine (cluster)	32	32	25	7
	Los Angeles (non-clusters)	30	30	339	0
	San Diego	4	4	0	4
	Bay Area	20	20	150	0
	Sacramento	17	17	158	0
	Other	16	16	172	0
	Total	192	192	914	47
2011	Santa Monica (cluster)	45	45	12	33
	Torrance (cluster)	45	45	108	0
	Newport Beach (cluster)	38	38	100	0
	Irvine (cluster)	47	47	25	22
	Los Angeles (non-clusters)	57	57	639	0
	San Diego	8	8	0	8
	Bay Area	34	34	330	0
	Sacramento	25	25	158	0
	Other	31	31	272	0
	Total	330	330	1,644	63
2012	Santa Monica (cluster)	73	73	12	61
	Torrance (cluster)	64	64	108	0
	Newport Beach (cluster)	53	53	100	0
	Irvine (cluster)	67	67	25	42
	Los Angeles (non-clusters)	88	88	639	0
	San Diego	8	8	0	8
	Bay Area	48	48	330	0
	Sacramento	38	38	158	0
	Other	56	56	272	0
	Total	495	495	1,644	111

[213] "Regions" are comprised of the stations listed in Table C-2

Year	Region[213]	Vehicle Rollouts (From Table 8)	Hydrogen Demand (Kg/day)	Hydrogen Capacity (Kg/day)	Add'l Hydrogen Needed (Kg/day)
2013	Santa Monica (cluster)	107	107	12	95
	Torrance (cluster)	91	91	108	0
	Newport Beach (cluster)	70	70	100	0
	Irvine (cluster)	104	104	25	79
	Los Angeles (non-clusters)	117	117	639	0
	San Diego	23	23	0	23
	Bay Area	91	91	330	0
	Sacramento	60	60	158	0
	Other	106	106	272	0
	Total	769	769	1,644	197
2014	Santa Monica (cluster)	193	193	12	181
	Torrance (cluster)	180	180	108	72
	Newport Beach (cluster)	208	208	100	108
	Irvine (cluster)	268	268	25	243
	Los Angeles (non-clusters)	382	382	639	0
	San Diego	33	33	0	33
	Bay Area	264	264	330	0
	Sacramento	117	117	158	0
	Other	194	194	272	0
	Total	1,839	1,839	1,644	637

Table C-2: Hydrogen Fuel Stations

Station	Region	Nominal Capacity (Kg/day)	Pressure (Mpa)	Operational Status	Funding Status
Oakland - AC Transit	Bay Area	150	35	Limited public access	Sept 2010
San Jose - Santa Clara VTA[214]	Bay Area	1000	35	Transit station only	2009
Emeryville - AC Transit	Bay Area	60	35/70	EXPECTED - 24/7 public access (for passenger FCVs)	(Opens Q3 2010)
San Francisco - SFO Airport	Bay Area	120	35/70	24/7 public access	(Opens Q3 2010)
Irvine - UCI	Cluster - Irvine	25	35/70	24/7 public access	2011
Irvine - UCI[215]	Cluster - Irvine	3	35	No public access	N/A
Newport Beach	Cluster - Newport Beach	100	35/70	24/7 public access	(Opens Q2 2010)
Santa Monica	Cluster - Santa Monica	12	35	Limited public access	2010
Torrance - Honda	Cluster - Torrance	4	35	No public access; OEM only (Honda)	N/A
Torrance - Honda	Cluster - Torrance	4	35	No public access; OEM only (Honda)	N/A
Torrance	Cluster - Torrance	50	35/70	No public access; OEM only (Toyota)	N/A
Torrance	Cluster - Torrance	50	35/70	24/7 public access	(Opens Q4 2010)
Harbor City	Cluster - Torrance	100	35/70	24/7 public access	(Opens Q2 2010)
Riverside	LA Non-Cluster	12	35	24/7 public access	2010
West LA	LA Non-Cluster	30	35	24/7 public access	2011

[214] Not included in Table C-1

[215] Not included in Table C-1

Station	Region	Nominal Capacity (Kg/day)	Pressure (Mpa)	Operational Status	Funding Status
Diamond Bar - SCAQMD	LA Non-Cluster	12	35	Limited public access	2010
Ontario	LA Non-Cluster	50	35	Limited public access	2010
Santa Ana	LA Non-Cluster	50	35	Limited public access	2010
Chino	LA Non-Cluster	9	35	No public access; OEM only (Hyundai)	2010
Culver City	LA Non-Cluster	30	70	No public access; OEM only (GM)	N/A
Los Angeles - LAX	LA Non-Cluster	30	70	No public access; OEM only (GM)	N/A
Los Angeles - CSU LA	LA Non-Cluster	60	35/70	EXPECTED - 24/7 public access	(Opens Q4 2010)
Fountain Valley - OCSD	LA Non-Cluster	100	35/70	24/7 public access	(Opens Q2 2010)
Westwood - UCLA	LA Non-Cluster	140	35/70	24/7 public access	(Opens Q1 2011)
Burbank	LA Non-Cluster	116	35/70	CURRENTLY CLOSED	2010
Thousand Palms	Other	160	35	24/7 public access	2012
Arcata - HSU	Other	12	35	Limited public access	N/A
Oceanside - Camp Pendleton	Other	30	35	Delayed opening with limited public access	(Opens TBD)
West Sacramento - CaFCP	Sacramento	150	35	Daylight hours public access	2010
Davis - UCD	Sacramento	8	35	CURRENTLY CLOSED	2009