Alternative and Renewable Fuel and Vehicle Technology Program

DRAFT FINAL PROJECT REPORT

Alternative Fuel Readiness Plan for San Mateo County

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PREFACE

Assembly Bill 118 (Núñez, Chapter 750, Statutes of 2007), created the Alternative and Renewable Fuel and Vehicle Technology Program (ARFVT Program). The statute, subsequently amended by AB 109 (Núñez) Chapter 313, Statutes of 2008), authorizes the California 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 about $100 million and provides financial support for projects that:

- Develop and improve alternative and renewable low-carbon fuels.
- Enhance alternative and renewable fuels for existing and developing engine technologies.
- Produce alternative and renewable low-carbon fuels in California.
- 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 technology centers.

The Energy Commission issued solicitation PON-13-603 to provide funding opportunities under the ARFVT Program for the development of Alternative Fuel Readiness Plans. To be eligible for funding under PON-13-603, the projects must also be consistent with the Energy Commission's *ARFVT Investment Plan*, updated annually. In response to PON-13-603, the recipient submitted an application, which was proposed for funding in the Energy Commission's Notice of Proposed Awards May 9, 2014, and the agreement was executed as ARV-13-018 on June 26, 2014.

ABSTRACT

In light of the importance of addressing climate change impacts caused by transportation fuels, and in the interest of preparing for fast growing alternative fuel vehicle technologies, the City/County Association of Governments of the County of San Mateo have undertaken the preparation of an Alternative Fuel Readiness Plan. This document serves as guidance to public agencies, private companies, and individuals regarding the incorporation of alternative fuel vehicles and alternative fuel infrastructure into San Mateo County. This Plan provides an overview of each alternative fuel and presents the motivations for having an alternative fuel readiness plan, including existing legislation and incentives, environmental benefits, and economic factors. The growth of alternative fuel markets will depend on having sufficient refueling infrastructure and affordable and desirable alternative fuel vehicle options. Governments can help with infrastructure development and vehicle purchasing through incentives, funding, regulations, and outreach and education programs. The Plan lays out a number of policy options for local governments to consider. This may include zoning plans, streamlined permitting, coordination with other agencies to increase government fleet alternative fuel vehicle purchases, and regional siting plan development. The Plan also presents outreach strategies and marketing materials, and provides aggregated training resources for emergency personnel. An analysis of future vehicle populations and fuel demand in San Mateo County was performed shows a projected decline in gasoline. Demand for all forms of alternative fuels used in vehicles will increase, and will require a corresponding increase in public refueling dispensers. Local governments will be best prepared for this increase if they begin to plan for alternative fuel readiness now.

Keywords: Alternative fuel, readiness plan, San Mateo County, C/CAG, public policy, infrastructure planning, electric vehicle supply equipment, zero emission vehicle

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EXECUTIVE SUMMARY

The transportation sector is a large contributor to California's greenhouse gas (GHG) emissions, accounting for about 40% of total GHG emissions per year (CaFCP, 2012). California has ambitious goals and targets for reducing its climate change impacts in the next twenty five years, and meeting these will require reducing the emissions from transportation. A key aspect of California's plan for achieving these reductions is an increase the use of non-gasoline or diesel alternative fuels in passenger vehicles and trucks.

In light of the importance of addressing the climate change impacts caused by transportation fuels, and in the interest of preparing for fast growing alternative fuel vehicle technologies, the City/County Association of Governments of San Mateo County (C/CAG) has undertaken the preparation of an Alternative Fuel Readiness Plan. This document will serve as guidance to public agencies, private companies, and individuals regarding the incorporation of AFVs and alternative fuel infrastructure (AFI) into San Mateo County.

Policy Background

California has enacted a series of laws and executive orders over the past decade regarding its environmental and climate change goals. These goals motivate many of the initiatives now driving alternative fuel vehicle and infrastructure development in California. They include GHG emission reduction targets, zero emission vehicle goals, and renewable electricity requirements. California will achieve these goals through a mix of incentives, grant and funding opportunities, and legal requirements. So far, California is on track to meet or exceed its 2020 goals of a reduction in GHGs to 1990 levels and an electric grid that is 33% renewable (Clegern, 2015). The Bay Area also expects to exceed its sustainable community goal of a 7% per capita reduction in GHGs from cars and light-duty trucks by 2020.

Alternative fuel readiness requires a comprehensive understanding of the current state of alternative fuels in San Mateo County, expected future demand for alternative fuels, and new policies, strategies, and educational plans to address this changing landscape. Integrating alternative fuels into the current mix will require overcoming a number of challenges, including differences in retail cost from fossil fuels, demand for increased availability of refueling infrastructure, the need to adapt local rules and regulations for alternative fuels, and the need to educate consumers and government officials on the benefits of alternative fuels and the incentives available to support them. This plan provides the information to address many of these challenges.

Scope of the Plan

The Alternative Fuel Readiness Plan for San Mateo County covers the following topics:

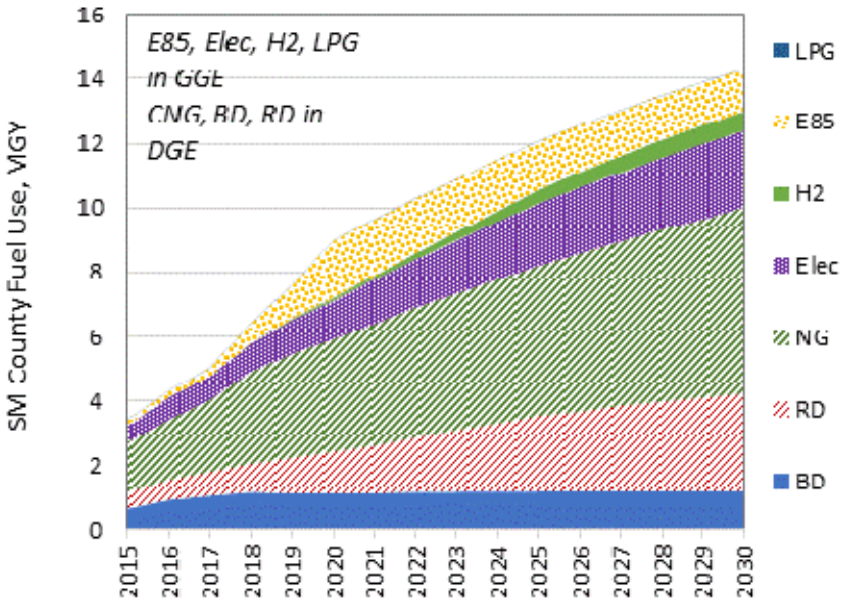
- Background information about alternative fuels and alternative fuel vehicles, including federal and state legislation, existing programs to increase alternative fuel use.
- A list of all the federal, state, and local programs and incentives for alternative fuels.
- The challenges to the growth of the AFV market and its supporting infrastructure.

- Local policy options to increase the use of alternative fuels.
- Training recommendations and resources for government employees and safety officials.
- Outreach and communication strategies to raise awareness about alternative fuels.
- Fuel, vehicle, and infrastructure demand projections for San Mateo County between the years 2015 and 2030.
- Next steps for implementing alternative fuel readiness in San Mateo County.

Alternative Fuel Demand in San Mateo County

Life Cycle Associates modeled the expected changes in San Mateo County's vehicle populations through 2030 based on purchasing trends and regulatory mandates. The California Air Resources Board's EMFAC 2014 model was used to estimate the number of AFVs that will be registered in San Mateo County through 2030 and fuel volumes in million gallons per year (MGY) of diesel or gasoline equivalent (CARB, 2014a). Fuel demand for hydrogen fuel cell electric vehicles and plug-in electric vehicles is expected to grow quickly, although it will remain a small percentage of total vehicle fuel demand. Renewable diesel, biodiesel, and ethanol volumes are presented here as isolated fuels, but will primarily be blended into gasoline and diesel in practice, and are also expected to grow in volume. Natural gas shows considerable growth due to increased use in large vehicles and trucks. These expected changes are illustrated in Figure 1.

Figure 1. Projected Fuel Demand



Policy Options to Increase the Use of Alternative Fuels

AFVs offer many advantages over conventionally fueled vehicles, such as reduced GHG emissions, lower noise pollution, and less smog and other air pollutants. As with any new

technology, the adoption of AFVs faces some obstacles. Our research shows that the challenges facing AFV adoption, AFI development, and local readiness for AFVs fall into four main categories: economic, technical, regulatory, and educational. Many of these challenges can be addressed through effective development and implementation of government policies.

One obstacle is that up-front vehicle prices tend to be higher for alternative fuel than conventional vehicles. To help attract consumers, federal tax credits are available for plug-in electric vehicles that range from $2,500 to $7,500, and state and local rebates are available for plug-in and hydrogen fuel cell electric vehicles that range from $900 to $5,000. Vehicle rebates are one of many types of incentives that exist to encourage the production and distribution of alternative fuels and the purchase of alternative fuel vehicles.

Technical challenges like infrastructure density, driving range, or refueling time are currently being addressed in research efforts from the private sector, which can be supported through business friendly tax policies, public-private partnerships, and streamlined permitting for alternative fuel infrastructure construction.

Local governments also have an important role to play in developing regulations that encourage the use of alternative fuels, such as adopting new standards and codes for alternative fuels. In addition, governments can launch outreach and educational campaigns to increase awareness of alternative fuels by consumers, investors, emergency response personnel, and other agencies.

Training Resources

Many stakeholders and obligated parties, such as vehicle operators, first responders, and government officials are unfamiliar with the specific techniques and practices needed for safe vehicle operation, maintenance, and refueling. In the coming years, it will be increasingly important for them to become familiar with:

- Alternative fuel properties
- Codes, standards, and signage rules
- Infrastructure and facility requirements
- Safety and permitting guidelines
- Environmental and health considerations
- First responder training protocols

Retail and Infrastructure Plan

Ideally, distribution of alternative fuel infrastructure will be planned so as to allow all of San Mateo County's residents to have convenient access to these fuels without oversaturating the market in any one area. Desirable public refueling site qualities include:

- High residential density
- High commercial density
- Proximity to major roads and highways
- Reasonable driving distance between refueling stations of the same type
- Accessibility to low-density tourist destinations like beaches, parks, etc.

Public agencies can choose to play a role in achieving optimal public refueling accessibility. City and County planners may emphasize the need for even distribution of refueling infrastructure through new zoning laws and development plans. Agencies can also collaborate throughout the region to develop integrated infrastructure siting plans.

Demand for all types of alternative fuels will increase in San Mateo County between 2015 and 2030, which will, therefore, necessitate the development of additional fueling and charging stations. Gasoline volumes are expected to decrease by one-third by 2030, so it is estimated that gasoline stations will decrease by the same amount. However, liquid fuels will replace gasoline in some of those locations. Other stations may be retired or converted to new uses. Electric vehicle charging infrastructure is expected to increase seven fold in residential locations and by a factor of fourteen in work places. Electricity is the alternative fuel that will see the fastest rate of growth in number of stations. Natural gas, propane, and hydrogen stations are also projected to increase in numbers throughout San Mateo County.

Conclusions & Next Steps

San Mateo County will be the site of significant growth in alternative fuel demand in the years to come. Cities will be far more prepared for this increase if they consider its possible requirements and impacts in advance. The first step is to understand the current state of alternative fuels in California: what they are, how they work, what incentives are available for them, and how they are regulated. The second step is for each government entity to consider the role it chooses to play in their integration into the vehicle network of its fleets and its residents. Policies and incentives should be developed to make alternative fuels more available and appealing. Third, it is necessary to assess the local influx of alternative fuels that is expected in the coming years. With this knowledge, cities can collaborate to develop siting and zoning plans to ensure sufficient coverage of each fuel. And last but not least, cities need to communicate these plans and this knowledge to residents, investors, and the community at large.

Next steps for cities and the County to consider in implementing the Plan may include:

1. Educate and train government staff on issues related to alternative fuels regulation.
2. Implement outreach and marketing strategies specified in the Plan.
3. Introduce initiatives to increase alternative fuel vehicle use in San Mateo County fleets.
4. Explore public-private partnership opportunities.

CHAPTER 1:
Introduction and Background Information

Transportation accounts for nearly 40 % of California's total energy consumption and roughly 39 % of the state's greenhouse gas emissions (CEC, 2013). Gasoline and diesel-powered vehicles produce about 50% of California's criteria pollutants and 38% of its greenhouse gas emissions (CaFCP, 2012). For this reason, transportation related emissions have become a major focus of California's efforts to reduce its climate change impacts and other vehicular pollutants. California has set ambitious statewide goals and targets for reducing its greenhouse gas emissions (GHGs) and is employing a variety of strategies to achieve these goals, many of which include reducing impacts from transportation. Cities and counties have an important role to play in achieving these goals.

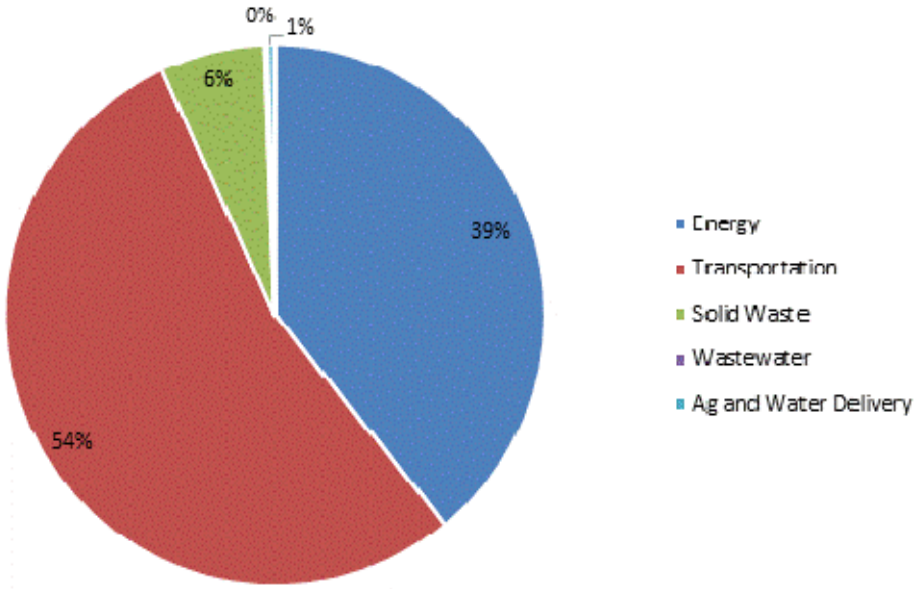
Climate change will have direct effects in San Mateo County. Rising sea levels could have negative impacts on the Bay Area's shoreline, a sensitive ecological area with desirable waterfront property. Many utilities, such as waste water treatment plants and hazardous material sites, may be affected by rising sea levels. Important aspects of the Bay Area's transit infrastructure, such as the San Francisco International Airport, Caltrain lines, and sections of highway 101, are also vulnerable to sea level rise and floods. City and County infrastructure and facilities at risk in San Mateo County from such a flood include:

- $23 billion worth of buildings, mostly along the Bay
- 492 miles of roadways
- 10 miles of railroads
- San Francisco International Airport (SFO), including the 31 MW United Cogen power plant located there
- Wastewater treatment plants operated by the Cities of South San Francisco/San Bruno, City of Millbrae, City of San Mateo, South Bayside System Authority, Mid-Coastside Sewer Authority, and SFO (total treatment capacity of approximately 44 MGD)
- 78 EPA-regulated hazardous materials sites
- 34 square miles of coastal wetlands (C/CAG, 2015; Heberger, 2009).

The cities of Redwood City, Menlo Park, and East Palo Alto are at especially high risk of damage from sea level rise (Kema Services Inc., 2012).A study performed by the Pacific Institute, an Oakland-based non-profit, found that 110,000 people currently live in areas of San Mateo County that are vulnerable to a 100-year flood event if water levels rise 1.4 meters rise from current sea levels (Heberger, 2009). Such events will become more common with rising baseline water levels. Increases in average temperatures are associated with more frequent heat waves, and California will likely experience more droughts. Heat waves can create dangerous conditions for vulnerable populations such as the sick, the elderly, and the homeless. These factors are also associated with hotter and more frequent fires.

Based on data provided by C/CAG's Regionally Integrated Climate Action Planning Suite (RICAPS) project and the sum of 2010 community emission inventories of all cities in San Mateo County, transportation is the source of approximately 55% of GHG emissions in San Mateo County, as shown in Figure 2.

Figure 2. San Mateo County GHG Emissions for 2010



In the Draft Transportation Climate Action Plan (TCAP) CAP for San Mateo, currently being developed, County sets a goal of reducing transportation-related GHG emissions to 10% below a 2005 baseline by 2020 (C/CAG, 2015).

Alternative fuel vehicles (AFVs) offer an important option for reducing GHG emissions. They allow for the continued use of personal vehicles but reduce the environmental impacts from transportation throughout the state. In light of the importance of addressing climate change impacts caused by transportation fuels, and in the interest of preparing for fast-emerging AFV technologies, C/CAG has undertaken the preparation of an Alternative Fuel Readiness Plan. This document will serve as guidance to both public agencies and private companies and individuals regarding the incorporation of AFVs and alternative fueling infrastructure (AFI) into San Mateo County.

California has established ambitious climate change goals over the last decade through a variety of laws and executive orders, including greenhouse gas reduction goals, renewable electricity requirements, and zero emission vehicle infrastructure plans. These goals motivate many of the initiatives driving alternative fuel vehicle and infrastructure development in California. California's climate change targets are summarized in Figure 3. It is clear that many changes will have to take place throughout the state if these goals are to be accomplished. This will involve the participation of cities and counties, and will be achieved through a mix of incentives, grant and funding opportunities, and legal requirements. So far, California is on

track to meet or exceed its 2020 GHG reduction goals. The Bay Area also has plans to exceed its ARB appointed sustainable community goals of 7 % per capita reduction in GHGs from cars and light-duty trucks by 2020.

California has enacted a series of laws and executive orders over the past decade supporting its environmental and climate change goals. These goals motivate many of the initiatives now driving alternative fuel vehicle and infrastructure development in California. California's various climate targets, as shown in Figure 3, include GHG emission reduction targets, zero emission vehicle population goals, renewable electricity requirements, and a 50% reduction in overall petroleum use. The recent passage of SB 350 (Leon, 2015) sets ambitious interim targets for 2030 of a 40% reduction in GHGs, 50% renewable electricity generation, a 50% energy efficiency increase in buildings, and requires public utilities to invest in electric vehicle charging infrastructure.

These will be achieved through a mix of incentives, grant and funding opportunities, and legal requirements. So far, California is on track to meet or exceed its 2020 goals of a reduction in GHGs to 1990 levels and an electric grid that is 33% renewable (Clegern, 2015). The Bay Area also expects to exceed its SB 375 sustainable communities' goal of a 7% per capita reduction in GHGs from cars and light-duty trucks by 2020.

Figure 3. Major Goals and Targets for Greenhouse Gas Reductions in California

GREENHOUSE GAS EMISSIONS	• 2020: GHGs reduced to 1990 levels [1] • 2030: GHGs reduced to 40% below 1990 levels [6] • 2050: GHGs reduced to 80% below 1990 levels [2]
SUSTAINABLE COMMUNITIES	• 2010: ARB sets reduction goals for metropolitan areas [3] • 2020: Metropolitan areas meet 1st GHG reduction targets [3] • 2035: Metropolitan areas meet 2nd GHG reduction targets [3]
ZERO EMISSION VEHICLES	• 2015: Metropolitan areas have infrastructure plans for ZEVs [4] • 2020: California infrastructure supports 1 million ZEVs [4] • 2025: 15% of new cars sales are ZEVs, 1.5 million ZEVs total on roads [4] • 2050: Transportation GHGs are less than 80% of 1990 levels [4]
RENEWABLE ELECTRICITY	• 2013: 20% of electricity from renewable sources [5] • 2020: 33% of electricity from renewable sources [5] • 2020: 12,000 Megawatts of new electricity generated after 2010 [5] • 2030: 50% of electricity from renewable sources [6]
GREEN STATE BUILDINGS	• 2018: State agency energy purchases 20% less than 2003 [7] • 2020: State agency GHGs 20% less than 2010 levels [7] • 2025: 50% of state agency buildings will be Zero Net Energy [7] • 2030: 50% increase in energy efficiency in existing buildings [8]
SOLID WASTE REDUCTION	• 2025: 75% recycling, composting, or source reduction of solid waste [8]
PETROLEUM REDUCTION	• 2030: 50% reduction in petroleum use [9]

1. California Global Warming Solutions Act of 2006 (Assembly Bill 32 (AB 32); Stats. 2006 chapter 488). http://www.leginfo.ca.gov/pub/05-06/bill/asm/ab_0001-0050/ab_32_bill_20060927_chaptered.pdf
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4. Brown, G. 2012. Executive Order B-16-12. http://gov.ca.gov/news.php?id=17472.
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9. Brown, G. 2015. Executive Order B-30-15. https://www.gov.ca.gov/news.php?id=18938

Alternative Fuel Readiness Plan

This Alternative Fuel Readiness Plan for San Mateo County (the "Plan") is intended to provide guidance to the cities and County of San Mateo regarding the introduction and scaling of alternative fuels used for transportation. San Mateo County, as a whole, can expect AFV populations and alternative fuel demand to rise in the coming decades. Adequate preparation at this time will allow San Mateo County to capitalize on the benefits of new technologies as alternative fuels are integrated into the county.

Alternative fuels can help San Mateo County achieve climate action mitigation goals and air pollution targets. San Mateo County agencies can encourage its residents to embrace AFVs by implementing policies that incentivize purchase of AFVs or installation of AFI. San Mateo County and its cities may also want to integrate the use of alternative fuels into their own transit fleets. This Plan provides recommendations regarding policies and financing to enable increased use of AFVs in San Mateo County.

San Mateo County could be subject to additional legal responsibilities or emission targets in future climate change legislation. These may be in the form of expectations from the California Air Resources Board (CARB) or the Bay Area Air Quality Management District (BAAQMD), or statewide requirements such as road taxes, signage requirements, and comprehensive GHG reporting. These goals will be much easier to achieve if the cities are already well-educated on alternative fuels and have strategies in place for their increased use.

One important aspect of preparedness is to ensure that local codes and regulations are appropriate for managing alternative fuels. The wording of fuel or vehicle related regulations may be specific to conventional fuels. New codes and standards may need to be adopted in order to accommodate alternative fuel producers, distributers, retailers, and vehicle owners. Planners and building inspectors must be trained on these new rules, and they must be easy for developers to follow.

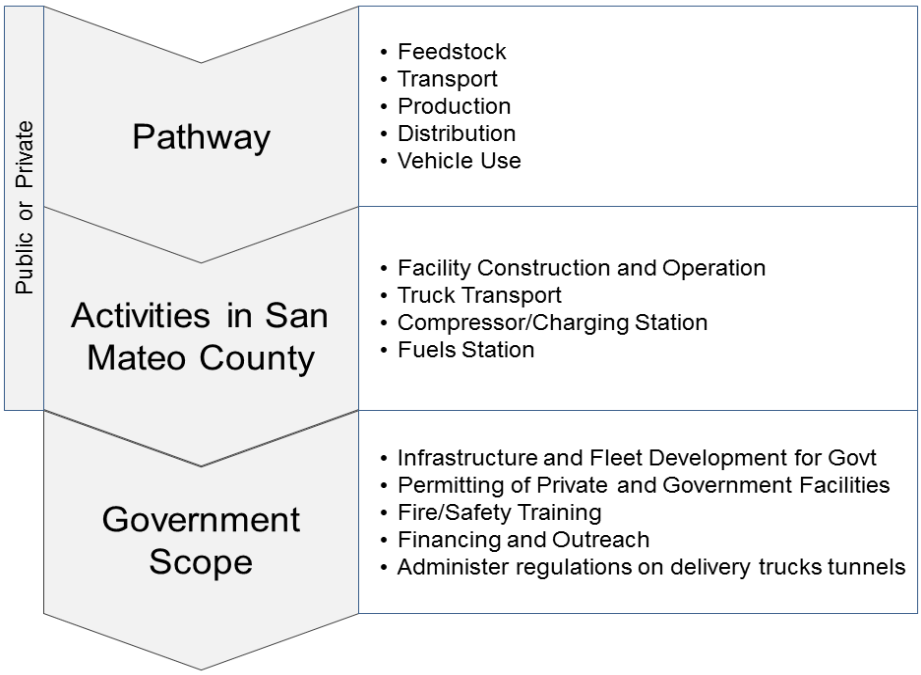
The increased presence of AFVs and AFI will also require safety personnel to be properly informed and prepare for new protocols. Fire officials need to be educated about the behavior of different alternative fuels, and first responders must know about any safety concerns that are particular to non-conventional vehicle fuels. Historically, emergency personnel have not received sufficient training on alternative fuels, however first responders are already working to increase training referenced in this Alternative Fuel Readiness Plan.

In addition, San Mateo County potentially stands to gain both environmentally and economically from being alternative fuel ready. San Mateo County will be better prepared to capture these economic opportunities if it engages in a preemptive investigation of the costs and benefits of alternative fuels. This Plan is intended to serve as a supportive tool for government officials, planning officials, developers, residents, and commercial entities interested in preparing for the increased use of alternative fuels in San Mateo County.

Each type of alternative fuel has a slightly different production, distribution, and use pattern. Each fuel also affects activities in San Mateo County in different ways. Figure 4 displays the steps a fuel undergoes throughout its lifetime, the related activities occurring in San Mateo

County, and the scope of relevant government actions. Each fuel type passes through several stages, starting with feedstock extraction and concluding with vehicle end use. This full chain of activities is referred to as the "fuel pathway". Understanding the fuel pathway allows us to predict which activities could potentially occur in San Mateo County. For example, we can probably expect there to be transportation of ethanol via truck or installation of charging stations for electric vehicles. The government scope is defined by specifying all the responsibilities the government could encounter with regard to the alternative fuel activity in question.

Figure 4. Impact of Alternative Fuels on San Mateo County



Legislative and Regulatory Background

Legislative and societal pressure to reduce transportation-related GHG emissions is increasing at both local and national levels. At the Federal level, the Corporate Average Fuel Economy (CAFE) standard and the Renewable Fuel Standard (RFS2) are the two primary initiatives that encourage the sale and use of alternative fuels. The Federal Corporate Average Fuel Economy (CAFE) standards are pushing car manufacturers to increase the efficiency of their vehicle fleets. The Energy Independence and Security Act (EISA) requires an increase in fuel economy from passenger cars and light trucks to a combined 35 miles per gallon (mpg) in 2016 and 54.5 mpg by 2025, up from roughly 24 mpg in 2007 (Agency, 2012; NHTSA, 2012). Manufacturers can achieve this fleet average by making more efficient gasoline and diesel cars, or by including AFVs in their fleets. The Renewable Fuel Standard, another key federal initiative for alternative fuels, requires transportation fuels sold in the United States to contain an annual minimum volume of renewable fuels, which it partially achieves by issuing saleable renewable identification numbers (RINs), which are similar to carbon credits.

California is a national and global leader in its efforts to combat climate change. A variety of California laws and executive orders have been passed to require or encourage the increased deployment of AFVs inside the state. Some California laws have set statewide goals to increase the number of AFVs being used and develop the infrastructure required to support them. Statewide targets also have an indirect impact on cities and counties since the number of AFVs will increase throughout the state. Local governments and municipalities will need to be prepared to accommodate these vehicle as well as meet local and regional GHG and air quality requirements.

California was one of the earliest states to implement policies to address climate change. California Assembly Bill 1493, known as the Clean Car Standards, was passed in 2002 and was one of the first significant pieces of legislation in the country to attempt to quantify and regulate GHG emissions from vehicles (AB 1493, Pavley, 2002).

In 2005, Governor Arnold Schwarzenegger passed Executive Order (EO) S-3-05, in which he laid out concrete GHG reduction goals for California. EO S-3-05 required that California reduce its GHG emissions to 2000 levels by 2010 and 1990 levels by 2020. By 2050, the state aims to reduce GHG emissions to 80% below 1990 levels. In 2007, he passed EO S-01-07, which further expanded upon plans for climate change initiatives in California by setting a transportation specific goal of reducing the carbon intensity of transportation fuels 10% by 2020 and laying out the framework for the Low Carbon Fuel Standard (LCFS).

Assembly Bill 32 (AB 32) translated these goals into law with the California Global Warming Solutions Act of 2006, which committed the state to reducing annual GHG emissions to 1990 levels by 2020 (Nunez, 2006). It named the ARB to be the lead agency in charge of implementing the law, and charged the ARB with developing a Scoping Plan and laying out the regulations necessary to establish and enforce a market-based carbon reduction mechanism.

In 2007, the California Assembly passed Assembly Bill 1007, a bill that required the State Energy Resources Conservation and Development Commission, in partnership with all other relevant state agencies, to develop and adopt a state plan to increase the use of alternative transportation fuels (AB 1007, Pavley, 2007). The plan needed to include an evaluation of alternative fuels on a full fuel-cycle basis assessing emissions of criteria air pollutants, air toxics, greenhouse gases, water pollutants, and other substances that are known to damage human health, and to look for ways to reduce oil consumption.

The market-based mechanism that was put in place is California's Cap and Trade program. Cap and Trade sets annual statewide limits on GHG emissions and distributes or auctions off carbon emission allowances to obligated parties. The limits apply to sources that are collectively responsible for 85% of the state's GHG emissions, meaning that the vast majority of emissions are covered by this regulation. California's statewide GHG cap will decline an average of 3% per year.

The major transportation emission reduction strategies highlighted by the ARB in their 2014 Update to the Climate Change Scoping Plan shows how the state conceptualizes the role of AFVs under AB32. The strategies they list are to:

(1) "improve vehicle efficiency and develop zero emission technologies,
(2) reduce the carbon content of fuels and provide market support to get these lower-carbon fuels into the marketplace,
(3) plan and build communities to reduce vehicular GHG emissions and provide more transportation options, and
(4) improve the efficiency and throughput of existing transportation systems."

Source: (CARB, 2014b)

The first two strategies are directly indicative of the importance of alternative fuel vehicles to California's future transportation fleet. The third and fourth strategies discuss the need to plan communities in a way that makes it convenient for residents to reduce their emissions.

The ARB held its first cap-and-trade auction in November of 2012, and credits began trading in 2013. All the money collected by the State Air Resources Board from the auction or sale of allowances is deposited in the Greenhouse Gas Reduction Fund for GHG reduction programs.

One such program is the Air Quality Improvement Program (AQIP), a voluntary, mobile source incentive program that focuses on reducing criteria pollutant and diesel particulate emissions with concurrent reductions in GHG emissions, created under AB 118 in 2007. In FY 2014-2015, the ARB received $200 million for AQIP projects. This number was increased to $350 million in the state's 2015-2016 budget in proportion with higher auction proceeds. This increase in earnings is largely due to the fact that transportation fuel producers became obligated parties under the Cap and Trade program for the first time in 2015 (CARB, 2015a). ARB has proposed that the following programs receive funds in fiscal year 2015-2016 (CARB, 2015a):

- Clean Vehicle Rebate Program (CVRP): $160 for clean vehicle rebates at time of purchase of approved zero emission and transitional zero emission vehicles.
- Light duty pilot project to benefit disadvantaged communities: $37 million
- Heavy duty vehicle and equipment projects: ~$150 million for a range of programs to incentivize the use of cleaner or zero emission technologies in heavy duty vehicles.

The LCFS is a carbon credit trading system exclusively for transportation fuels that was established through AB32 and EO S-01-07. The LCFS requires that obligated parties achieve a reduction in the carbon intensity of transportation fuels that are sold, supplied, or offered for sale in the state by a minimum of 10% from 2010 levels by 2020. The carbon intensity (CI) of a fuel is measured on a well-to-wheels basis in units of grams of carbon dioxide equivalent per unit energy of fuel (gCO_2e/MJ). Regulated parties can achieve this reduction in CI by either reducing the carbon intensity of their aggregated products, or by purchasing carbon credits from alternative fuel producers. The LCFS system creates an additional source of revenue for alternative fuel producers and encourages more investment in this area by the private sector.

Senate Bill 375 (SB 375), passed in 2008, requires metropolitan planning organizations (MPOs) to develop a Sustainable Communities Strategy (SCS) for meeting the GHG reduction targets agreed upon with the ARB. The targets set by the ARB for the Bay Area, which includes San Mateo County, are a 7% per capita reduction in GHGs from cars and light-duty trucks by 2020

and a 15 % per capita reduction by 2035. The SCS proposed by the Association of Bay Area Governments (ABAG) and the Metropolitan Transportation Commission (MTC) was reviewed by the ARB, which confirmed that the plan would in fact exceed the minimum required GHG emissions, creating a 10% per capita GHG emissions reduction in 2020, and a 16% reduction in 2035 (CARB, 2014c). These goals will be achieved through a variety of grants and incentive programs funded by ABAG and other agencies to encourage adoption of AFVs at the local level.

In Governor Jerry Brown's 2015 State of the State address, he outlined ambitious interim goals for reducing California's climate change impacts by 2030, including:

- increasing renewable electricity generation from 33% in 2020 to 50% in 2030
- reducing the use of petroleum based fuels in cars and trucks 50% from current levels by 2030
- doubling energy savings in existing buildings and developing cleaner heating fuels by 2030

These targets are intended as midpoint goals to ensure that California is on track to meet its 2050 target of 80% below 1990 GHG emission levels. SB 350 (de Leon, 2015) put the majority of these goals into law, although the 50% reduction in petroleum requirement was removed. However, the law offers a lot of support for electric vehicles by requiring utilities to put together detailed plans for using zero-carbon resources, supporting demand response planning, electric vehicle supply equipment, and energy storage. It also includes streamlined EV infrastructure permitting requirements for local governments.

On March 23, 2012, Governor Jerry Brown issued Executive Order (EO) B-16-12, supporting and expanding upon California's existing climate laws and previous Executive Orders (Brown, 2012). Executive Order B-16-2012 lays out a number of goals for the state, and focuses on the expansion of zero-emission vehicles (ZEVs). Zero emission vehicles are defined as vehicles that "produce zero exhaust emissions of any criteria pollutant (or precursor pollutant) under any and all possible operational modes and conditions" for model years 2009-2017, and for model years 2018 and on this definition is expanded to include GHG emissions as well (13 CCR: Section 1962). In effect, this means that only BEVs and FCEVs are considered ZEVs. PHEVs are also included in the mandate as transitional ZEVs (TZEVs).

The ZEV mandate says that the state's major metropolitan areas should be able to accommodate ZEVs by 2015, and that by 2020 the state should be able to support 1 million ZEVs, with this number increasing to 1.5 million ZEVs in 2025. Furthermore, it requires that 10% of new state-owned light-duty vehicles be ZEVs by 2015, increasing to 25% by 2020. It emphasizes the increasing need for easy access to ZEV infrastructure to support these vehicles, and orders the state to support increased ZEV manufacturing and research efforts. The order anticipates that ZEVs will displace at least 1.5 billion gallons of petroleum fuels per year, and sets an ambitious goal of reducing GHG emissions from the transportation sector to 80% below 1980 levels by 2050. The ARB's *Vision for Clean Air* document states that in order to meet California's carbon goals, the light-duty vehicle segment will need to become largely zero emission by 2050, and

that California needs to make a similar commitment to developing and implementing zero emission heavy-duty trucks (Carb, 2012).

These ZEV goals were adopted under the ARB's Advanced Clean Cars program and corresponding Zero Emission Vehicle Regulations. These regulations require car manufacturers in California to have an increasing percentage of the cars in their fleet be zero emission vehicles (ZEVs). Newly manufactured light-duty vehicle fleets are required to reduce their GHG emissions by 4.5% per year from 2017-2025. This means that by 2025, the fleet GHG emissions average will be approximately half of the 2015 level (CARB, 2014b).

Under the ZEV regulations, manufacturers with annual vehicle sales of greater than 20,000 have a total annual ZEV requirement as well as a minimum ZEV floor. The floor is the percentage of vehicles that must actually be ZEVs, while the rest of the requirement may be met with transitional ZEVs, such as PHEVs. Smaller manufacturers with annual sales between 4,501 and 60,000 have alternative compliance options that include producing low emission vehicles or purchasing ZEV credits (Carb, 2014a, 2014b). Discussions between ARB and the auto industry are ongoing regarding the exact number of ZEVs that companies are required to produce each year, but the emphasis will remain on increasing the number of ZEVs.

State fleets are subject to Executive Order B-16-12, which requires that at least 10 % of fleet purchases of light-duty vehicles be zero-emission by 2015 and at least 25 % of fleet purchases of light-duty vehicles be zero-emission by 2020. Local fleets are currently subject only to air quality requirements. However, discussions are ongoing regarding the 15% zero emission bus purchase requirements for public transit fleets of over 200 vehicles under the Transit Fleet Rule that was passed in 2009. The requirement has been postponed pending a technology review (Resolution #09-49, California Air Resources Board, 2010), but ARB has stated the need for a complete transition to a zero emission bus fleet by 2040 or sooner (Source, 2015). The transition of a fleet can take years, since the requirement would only apply to a small portion of new vehicle purchases. Hence, it would be prudent for the state's vehicle fleets to begin their transition sooner rather than later.

As of January, 2017, AB 692 requires that at least 3% of the transportation fuel purchased by the state government be very low in carbon, which is defined as 40% lower CI than gasoline. This includes: 1. biogas or biomethane from landfills, dairy/feedlot sources and anaerobic digestion of food/green waste and wastewater; 2. biodiesel and renewable diesel from used cooking oil, tallow and plant sources; or 3. hydrogen, depending on the fuel source and production process. The percentage required will increase by 1 percentage point annually through 2023, and state agencies must report to the Department of General Services on their progress each year.

The California Alternative and Renewable Fuel, Vehicle Technology, Clean Air, and Carbon Reduction Act of 2007 (ARFVTP), created in 2007 and updated and reauthorized under AB 8 in 2013, provides as $100 million in grant funding annually towards innovative transportation and fuel technologies. The ARFVTP is administered by the CEC, and provides grants for businesses, vehicle and technology manufacturers, workforce training partners, fleet owners, consumers

and academic institutions to develop and deploy alternative and renewable fuels and advanced transportation technologies. AB 8 added a requirement that the California Energy Commission (CEC) allocate $20 million annually to support hydrogen infrastructure until there are 100 publically available stations throughout the state. It also increased the compensation for replacement vehicles for low-income vehicle owners.

Senate Bill 1275 (Charge Ahead California) (De Leon, Chapter 530, Statutes of 2014), was passed in 2014. It instructs ARB to develop a long-term plan to put one million ZEVs on CA roads by 2023 and to increase low-income populations' access to those vehicles and their benefits. The ARB is directed to do this by offering a special rebate for low-income residents who voluntarily retire passenger vehicles and light-duty and medium-duty trucks that are high polluters and replace them with cleaner vehicles or "mobility options" such as carpooling or public transit.

Senate Bill 1204 (Lara, Chapter 524, Statutes of 2014) creates the California Clean Truck, Bus, and Off-Road Vehicle and Equipment Technology Program to fund the development, demonstration, pre-commercial pilot, and early commercial deployment of zero- and near-zero emission technologies, with priority given to projects that benefit disadvantaged communities. The program is funded by Cap-and-Trade revenues. ARB has budgeted $167 million for heavy duty vehicle and equipment investments and has committed to spending over 50% of its funds on programs that benefit low-income communities.

Governor Jerry Brown has been working to create partnerships with other regions around the world that are willing to commit to ambitious ZEV goals. In 2013, seven other state governors signed a Memorandum of Understanding (MOU) committing the states to a coordinated effort to have 3.3 million ZEVs in use by 2025. Not only does this result in direct emission reductions in those areas, but it also places economic pressure on the vehicle manufacturing companies, which have an incentive to mass produce the same types of cars for the whole country due to economies of scale.

In 2015, Governor Jerry Brown signed a second memorandum in which international leaders from 11 other states and provinces, collectively representing more than $4.5 trillion in GDP and 100 million people, agreed to limit the increase in global average temperature to below 2 degrees Celsius (Under 2 MOU). Signatories include: California, USA; Acre, Brazil; Baden-Württemberg, Germany; Baja California, Mexico; Catalonia, Spain; Jalisco, Mexico; and Ontario, Canada, as well as; British Columbia, Canada; Oregon, USA; Vermont, USA; Washington, USA; and Wales, UK.

Table 1 and Table 2 summarize all of the major executive orders and legislations that have been enacted in California over the last decade that are likely to either directly or indirectly affect the number of AFVs on California's streets. Table 3 reviews some of the largest and most important programs that have resulted from these laws and are relevant to San Mateo County.

Table 1. State Legislation Resulting in Increased AFVs on California Roads

Legislation	Issued By	Year	Major Targets
Executive Order S-01-05	Gov. Schwarzenegger	2005	Reduce GHG emissions to 1990 levels by 2020. Reduce GHG emissions to 80% below 1990 levels by 2050.
Assembly Bill 32 (Nunez)	CA Assembly	2006	Requires California to reduce GHG emissions to 1990 levels by 2020. Requires ARB to prepare a Scoping Plan. Requires ARB to establish a system of market-based declining annual aggregate emission limits (Cap-and-Trade).
Assembly Bill 1007 (Pavley)	CA Assembly	2007	Required Energy Resources Conservation and Development Commission to develop and adopt a state plan to increase the use of alternative fuels by June 30, 2007.
Executive Order S-01-07	Gov. Schwarzenegger	2007	Goal to reduce the carbon intensity of California's transportation fuels by at least 10% by 2020. Establishes Low Carbon Fuel Standard (LCFS).
Senate Bill 375 (Steinberg)	CA Senate	2008	Requires metropolitan planning organizations (MPOs) to develop a Sustainable Communities Strategy (SCS) for meeting agreed upon GHG reduction targets set by ARB. ARB target for Bay Area: 7% per capita reduction by 2020 and 15% per capita reduction by 2035 from cars and light-duty trucks.
Executive Order B-16-12	Gov. Brown	2012	Accommodate ZEVs in CA's major metropolitan areas by 2015. Support 1 million ZEVs in CA by 2020. Support 1.5 million ZEVs in CA by 2025. Requires 10% of new state light-duty vehicles be ZEVs by 2015. Requires 25% of new state light-duty vehicles be ZEVs by 2020. Reduce GHG emissions from transportation to 80% below 1980 levels by 2050.

Table 2. State Legislation Resulting in Increased AFVs on California Roads

Legislation	Issued By	Year	Major Targets
Senate Bill 1204 (Lara)	California Senate	2014	Funds zero- and near-zero emission truck, bus, and off-road vehicle and equipment technologies and related projects. Priority given to projects benefiting disadvantaged communities.
Senate Bill 1275 (De Leon) "Charge Ahead California"	California Senate	2014	Bring one million electric cars, trucks and buses to California by 2023. Ensure that low-income Californians, who are disproportionately impacted by air pollution, benefit from the transition to a clean transportation sector.
2015 Inaugural Address	Gov. Brown	2015	Increase renewable electricity generation from 33% in 2020 to 50% in 2030. Reduce the use of petroleum based fuels in cars and trucks 50% from current levels by 2030. Double energy savings in existing buildings and develop cleaner heating fuels by 2030.
Executive Order B-30-15	Gov. Brown	2015	Establishes the goal of reducing California GHG emissions to 40% below 1990 levels by 2030.
ARB Resolution #09-49: Transit Fleet Rule ZBus Requirements (Postponed)	California Air Resources Board	2010	Transit agencies with 200 or more urban buses would be required to acquire 15% of all new buses as Zero Emission Buses. Implementation currently pending technology review.

These laws lay out the state's goals and prescribe methods for achieving them, but they may require the implementation of new programs to achieve their goals. Table 3 lists some of the major California programs associated with these laws, although this is by no means a comprehensive list.

Table 3. Major Programs Associated with State Climate Change Legislation

Program	Agency	Year Started	Major Targets and Requirements
LCFS	ARB	2012	Requires a reduction in the carbon intensity of transportation fuels that are sold, supplied, or offered for sale in the state by a minimum of 10% by 2020.
AQIP	ARB	2013	Provides over $20 million per year equipment project, air quality and AFV research, vehicle purchasing, and training and education.
ARFVTP	CEC	2013	Provides approximately $120 million per year for development and production of low carbon fuels, technology demonstration projects, infrastructure projects, workforce training, and other issues related to commercialization of efficient low emission vehicles.
Cap-and-Trade	ARB	2013	Annual GHG cap and set number of emission allowances. In 2015, suppliers of transportation fuels, natural gas, and other fuels come under the regulation, expanding the covered pollution by about 1½ times.
Bay Area SCS	ABAG	2014	Sets goals of a 10% per capita GHG emissions reduction in 2020, and a 16% reduction in 2035 from cars and light-duty trucks in Bay Area.
ZEV Production Program	ARB	2010	Manufacturers with annual sales greater than 60,000 vehicles must produce and deliver a minimum percentage of ZEVs for sale in California. For MYs 2015-2017, this is 14%, and can include a certain percentage of partial ZEVs.

Alternative Fuel Vehicles Considered in the Plan

Different government entities categorize AFV's in different ways. The following products are defined as alternative fuels by the federal Energy Policy Act (EPAct) of 1992: pure methanol, ethanol, and other alcohols; blends of 85% or more of alcohol with gasoline; natural gas and liquid fuels domestically produced from natural gas; liquefied petroleum gas (propane); coal-derived liquid fuels; hydrogen; electricity; pure biodiesel (B100); fuels, other than alcohol, derived from biological materials; and P-Series fuels (42 USC 13211).

The Internal Revenue Service (IRS) defines alternative fuels as being: liquefied petroleum gas/propane, compressed natural gas, liquefied natural gas, liquefied hydrogen, liquid fuel derived from coal through the Fischer-Tropsch process, liquid hydrocarbons derived from biomass, and P-Series fuels. Biodiesel, ethanol, and renewable diesel are not considered

alternative fuels by the IRS. While the term "hydrocarbons" technically includes ethanol, biodiesel, and renewable diesel, the IRS specifically excluded these fuels from the definition (26 USC 6426).

For the purposes of this Alternative Fuel Readiness Plan, the following alternative fuel vehicles will be considered:

- Battery Electric Vehicles (BEVs)
- Plug-in Hybrid Electric Vehicles (PHEVs)
- Natural Gas Vehicles (NGVs); compressed (CNG) and liquefied (LNG) fuels
- Liquefied Petroleum Gas/Propane Vehicles (LPGV)
- Hydrogen Fuel Cell Electric Vehicles (FCEV)
- Flexible Fuel Vehicles (FFV) running on 85% Ethanol (E85)
- Biodiesel Vehicles (BD)

AFV Activity in California and San Mateo County

Alternative Fuel Vehicle Populations

Between March of 2010 and July of 2015, a total of 112,838 purchasers of AFVs have received rebates from the CVRP program. This gives an idea of how many AFVs there are in the state, but is almost certainly an underestimate since some owners do not apply for the rebate, and because some car models were not immediately approved for the rebate. According to data from CARB that was analyzed by the California Plug-In Electric Vehicle Collaborative, California's sales of PEVs exceeded 100,000 in September of 2014, as measured from the start of the PEV market in 2010 (PEVC, 2014). Navigant Research asked respondents of a survey on AFV purchasing to identify themselves as "early adopters, early majority, late majority, or laggards" (Vyas, 2013). More than 70% of those interested in owning a BEV or PHEV as their first choice described themselves as early or late majority consumers, indicating that PEVs may have reached a relatively mainstream status (Vyas, 2013).

This is particularly true in the Bay Area, which has the highest rate of per capita EV ownership in the country. According to PG&E, as of February of 2015, the number of PEVs in the Bay Area had increased to 60,000 (PG&E, 2015). In 2013, approximately 30 % of state PHEV rebates and 41 % of state BEV rebates had also been distributed to Bay Area residents in spite of being only 17 % of the State's population (ICF International, 2013a). In fact, BEVs have significantly outsold PHEVs in the Bay Area (ICF International, 2013a). In San Mateo County, the number of rebates dispensed to BEV owners by July, 2015 was 3,361 (71% of the total) while PHEV rebates numbered only 1,277 (27.2% of the total). By comparison, California's statewide rebates for BEVs are 57.3% of the total and PHEVs are 42.1% (CSE, 2015).

Projected vehicle populations for the year 2030 and the corresponding fuel volumes are shown in Table 4. Vehicle populations and fuel use are estimated from vehicle modeling tools. Fuel use and vehicle populations provide the basis for estimating alternative fueling stations required in San Mateo County. The basis for the population estimates is also indicated. The distribution of AFVs differs from the state-wide average due to the population of vehicle types in the county. Chapter 8 provides more details on vehicle, fuel, and station projections for San Mateo County.

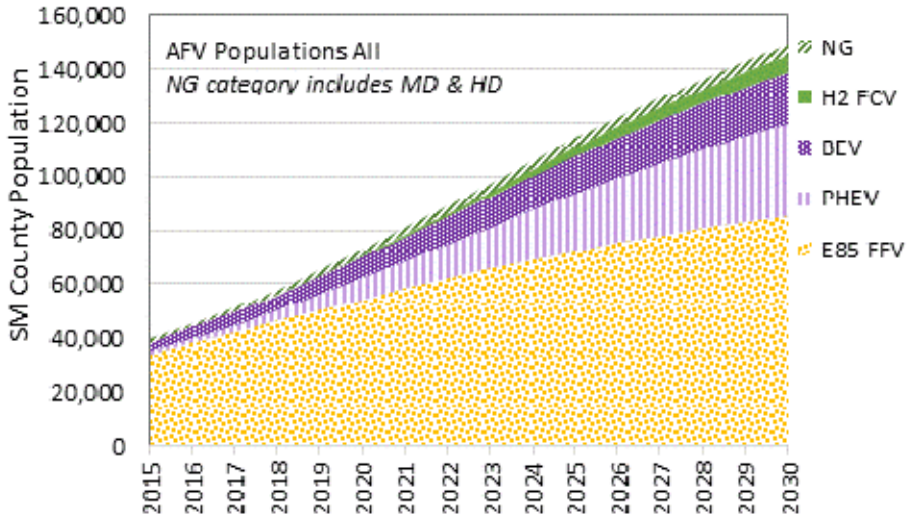
The projected alternative vehicle populations for San Mateo County are shown in Figure 5, which highlights the large increase expected in the county for every type of alternative fuel vehicle, especially zero and partial zero emission vehicles like PHEVs, BEVs, and FCEVs.

Table 4. Vehicle Population Projections for 2030

	Projected SM County Population in 2030[5]			Basis for Estimate
	LD	MD	HD	
Gasoline	486,057	3,150	1,136	EMFAC less LD PHEV, FFV, CNG
Diesel	13,106	9,537	2,210	EMFAC less MD and HD CNG
BEV[1,2]	19,207	0	0	EMFAC and ZEV Mandate "Likely Compliance Scenario" for BEV, PHEV, and FCEVs
PHEV[1,2]	34,429	0	0	
FCEV	6,197	0	0	
NG[3]	3,539	195	55	LD subset of EMFAC gasoline, MD/HD subset of EMFAC diesel. Utilized VISION model CNG shares.
E85 FFV[3,4]	85,000	0	0	Subset of EMFAC's gasoline category, utilized VISION model ratio of FFV to gasoline.

1. EMFAC's electric category includes BEVs, FCEVs and 40% of PHEVs. Balance of PHEVs in gasoline category.
2. Adjusted based on CVRP Rebate statistics: https://cleanvehiclerebate.org/eng/rebate-statistics.
3. Argonne National Laboratory VISION Model.
4. Represents the number of FFVs using E85 only, not regular gasoline.
5. LD=Light Duty; MD=Medium Duty; HD=Heavy Duty

Figure 5. Projected AFVs registered in San Mateo County



According to modeling projections associated with this report, San Mateo County can expect to see increased demand for all alternative fuels corresponding to the volumes (in million gallon gasoline or diesel equivalents per year) shown in Table 5 by the year 2030.

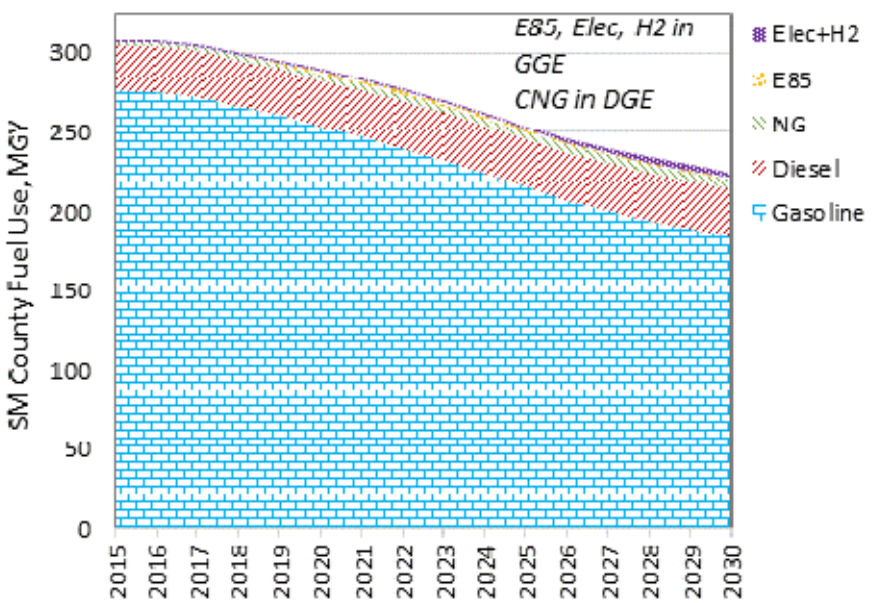
Table 5. Fuel Volume Projections for 2030 (Million Gallons per Year equivalents)

Fuel	Units	Quantity	Sources
Gasoline (E10)[1]	Million gal/yr as gasoline	185	EMFAC/IEPR
Diesel[1]	Million gal/yr as diesel	30	EMFAC/IEPR
Ethanol[1]	Million gal/yr as E10	18.5	LCFS
	Million gal/yr as E85	1.7	LCFS
CNG[2]	Millon gal/yr as diesel	5.8	LCFS
Electricity	MWh/yr	77,082	EMFAC/CVRP
Hydrogen	Million kg/yr	591	EMFAC/CVRP
Biodiesel[4]	Million gal/yr as diesel	1.2	LCFS/EMFAC
RD[4]	Million gal/yr as diesel	2.71	LCFS/EMFAC
LPG[5]	Million gal/yr as gasoline	10,025	DMV

1. Projection for CA gasoline, diesel, and E85 based on CEC IEPR.
2. Projection for CA NG assumes LCFS scenario ratio of NG: Diesel increases linearly from 2020 to 2030.
3. Projection for CA Electricity and Hydrogen assumes LCFS consumption increases linearly from 2020-2030.
4. Projection for CA BD/RD assumes 2020 blend % from ARB LCFS Scenario remains constant from 2020 to 2030.
5. LPG volume calculated based on DMV data and held constant.

Figure 6 shows the projected fuel volumes that will be sold in San Mateo County between the years 2015 and 2030. The most notable change is the decline in gasoline consumption that is expected. This is partially due to the increase in EV and FCEV vehicles in use and partially due to CAFE standards that have mandated significant increases in fuel economy for all vehicles.

Figure 6. Projected Fuel Use in San Mateo County



Increasing vehicle populations and fuel consumption will require development of new alternative fueling infrastructure (AFI). Table 6 shows the number of stations of each fuel type currently operating in San Mateo County and also the projected total number that we estimate will be needed in 2030 (See Chapter 8). Demand for gasoline infrastructure is expected to decrease by one-third, but all of the alternative fuels will need additiowdse nal refueling capacity.

Table 6. Infrastructure Demand in San Mateo County

Fuel Type	2015[1]	2030[2]
Gasoline	197	130
Diesel	109	123
Electricity[3]*		
MUD Charging		
Level 2- Residential	3408	26,944
Level 2- Work	222	3056
Level 2- Public	152	222 to 370
DCFC	22	22
Hydrogen	0 (4 in development)	5 to 8
NG	3	17
BD	1 (now sells RD)	5
RD	1	Blended into Diesel
E85	1	13

1. AFDC, 2015. Alternative fueling station counts by state. http://www.afdc.energy.gov/fuels/stations_counts.html
2. EMFAC model.
3. Level 2 residential charging calculated based on assumption of 90% BEV owners and 30% PHEV owners.
*Shows number of individual charging ports, not stations.

Alternative Fuel Production in San Mateo County

Only a few types of alternative fuels are likely to be produced within San Mateo County. It is not an agricultural area, and thus is unlikely to have anyone producing fuels from biomass feedstocks. However, several waste products exist in San Mateo County that could potentially be converted into biofuels.

Anaerobic biodigester technology turns organic matter from municipal waste and yard trimmings into methane biogas. For example, South San Francisco Scavenger Company is currently converting organic waste into fuel. They collect trash, yard trimmings, and recycling from residents and businesses in South San Francisco, Millbrae, Brisbane, and the San Francisco International Airport. In 2014, Scavenger Company finished construction of an anaerobic biodigester that takes the organic matter they collect and converts it into compressed natural gas that supplies enough fuel for half of their collection trucks.

Another example of biofuel production in San Mateo County is the waste water treatment plant (WWTP) Digester Biogas to CNG project currently in development in the City of San Mateo. The CNG it produces will be used to fuel the city fleet vehicles, which will be modified to run on CNG instead of gasoline. The project is partially funded by CEC grant money, and is estimated to have a payback time of approximately 4 years with the CEC funding included.

Scope of the Plan

The following Plan will address these topics in depth in the following chapters:

Chapter 1 provides an introduction to the motivations for being alternative fuel ready, including federal and state legislation, state and local goals, and existing programs to increase alternative fuel use.

Chapter 2 gives an overview of alternative fuels and alternative fuel vehicles, including fuel production, vehicle operation basics, and the fuel, vehicle, and infrastructure costs.

Chapter 3 includes a description of all the federal, state, and local programs and incentives that exist to encourage the production of alternative fuels, the construction of alternative fuel infrastructure, and the purchase of alternative vehicles.

Chapter 4 outlines challenges to the growth of the Alternative Fuel Vehicle market and its supporting infrastructure, including economic challenges, regulatory challenges, and educational needs.

Chapter 5 provides potential solutions to these problems and offers recommendations for the Cities within San Mateo County and the County of San Mateo to improve its readiness for Alternative Fuel Vehicles and increase procurement.

Chapter 6 outlines training recommendations and resources that can help to prepare government employees and safety officials for the infusion of Alternative Fuel Vehicles and Alternative Fuel Infrastructure in San Mateo County.

Chapter 7 introduces outreach and communication strategies to teach San Mateo County stakeholders about alternative fuel readiness.

Chapter 8 provides assistance strategies for infrastructure development, including vehicle population projections, fuel volume projections, minimum infrastructure requirements, and a siting plan for public stations.

Chapter 9 describes general conclusions and next steps that San Mateo County can take to implement the policies and changes recommended by the Plan.

Chapter 2:
Overview of Alternative Fuels

Over the past decade, alternative fuels have been recognized as an important means of addressing three national and statewide challenges: a desire to lower carbon emissions, the need for more energy security, and rising or volatile oil prices. The increasing popularity of alternative fuels has resulted in higher levels of production and infrastructure development, as well as a wealth of efficient technologies for alternative fuels used for transportation. The most common alternative fuels are: Ethanol, Biodiesel, Hydrogen, Liquefied Petroleum Gas, Compressed Natural Gas, Liquefied Natural Gas, and Electricity. Using these fuels instead of conventional fuels helps to reduce petroleum use, air pollution, and greenhouse gas emissions from transportation.

Alternative biofuels are liquid fuels produced from biological raw materials, such as:

- Sugar and starch crops: e.g. corn, sugarcane, sugar beets
- Cellulosic materials: e.g. switchgrass, forest residue, bagasse, waste
- Biogas: e.g. landfill gas, waste water treatment digester gas
- Vegetable oil and fats: e.g. soybean oil, used cooking oil, algae oil

Sugar and starch crops and cellulosic feedstocks are primarily used to produce ethanol, a clean burning liquid fuel that is used in vehicles classified as Flexible Fuel. These cars can run on either conventional gasoline or blends of ethanol and gasoline of up to 85% ethanol. Biogas refers to methane produced from renewable biomass or waste sources, such as emissions from the biodegradation of landfill or the organic matter in waste water. Once biogas has been cleaned and compressed, it provides a clean burning source of fuel for natural gas vehicles. Vegetable oils and animal tallow are used to produce biodiesel and renewable diesel, another low GHG option for vehicle fuel. No special technology is required to consume these fuels, they are simply burned in regular diesel vehicles.

Natural gas vehicles use liquefied or compressed natural gas in a compression or spark-ignited engine. Between 80%-90% of the natural gas used in the United States is domestically produced. Most natural gas is drawn from wells or extracted in conjunction with crude oil production. Natural gas can also be mined from subsurface porous rock reservoirs through extraction processes, such as hydraulic fracturing (DOE, 2013a). As mentioned above, natural gas can be produced from organic materials and other waste products as well. This type of natural gas is considered to be a renewable fuel, and has a very low carbon intensity.

Electricity is another option for powering alternative fuel vehicles. In California, the majority of power plants run on natural gas, making its power grid relatively low carbon intensity compared to other parts of the country. By 2020, California's electricity supply must be produced from 33% renewable sources such as wind, solar, and hydropower, bringing the emissions profile for the California grid down even more. This is one reason that electric vehicles in California, which have no tail pipe emissions, are much lower in emissions than

gasoline or diesel cars. This reduction in emissions is multiplied by a factor of about 3 due to the high efficiency of energy conversion in electric vehicles.

Fuel cell electric vehicles take hydrogen fuel and break the molecules into protons and electrons to create an electric fuel cell in the car. The electricity is then used to power the vehicle's motor, so the ultimate driving mechanism is an electric motor. Like EVs, FCEVs emit no tailpipe emissions. Fuel cell vehicles are 2 to 3 times more efficient than internal combustion engine vehicles (ICEV) (DOE, 2013a). Most hydrogen fuel is currently produced by steam reforming of natural gas, although it can also be produced through electrolysis. There are also efforts under way to mimic photosynthesis and produce H_2 directly from water (hypersolar.com, 2015). In California, 33.3% of the hydrogen sold must be produced using renewable energy sources, such as wind or solar, and California law requires that on a statewide basis, well-to-wheel emissions of greenhouse gases for the average hydrogen powered vehicle in California are at least 30 % lower than emissions for the average new gasoline vehicle in California when measured on a per-mile basis (SB 1505, Lowenthal).

Liquefied petroleum gas, also known as propane, is a liquid fuel used to power light-, medium- and heavy-duty propane vehicles. LPG is a by-product of natural gas processing and crude oil refining. It is stored under pressure, and as pressure is released, the liquid propane vaporizes and turns into gas that is used for combustion. Propane vehicles work much like spark-ignition gasoline-powered vehicles, and have similar power, acceleration, and cruising speed. Driving range is also comparable, though the energy density of propane is lower than that of gasoline. Propane vehicles may be manufactured or converted from gasoline or diesel using qualified retrofit systems. Public LPG fueling infrastructure is typically limited to locations that are also used for non-vehicle uses, like trailer fuel and propane grill refilling.

Plug-in Electric Vehicles (PEV, BEV, PHEV)

A large variety of primary energy sources, including oil, coal, natural gas, water, wind, and solar energy, are potential sources of electric power. When used as an alternative fuel in vehicles, electricity can provide power for 100% battery-electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs), which run on a combination of gasoline and electric battery power. Both types of vehicles draw electricity directly from the grid and store it in rechargeable batteries. Charging takes place either at home (or at fleet facilities, in the case of fleets) as shown in Figure 7, or at public charging stations usually located near libraries, shopping centers, hospitals, and businesses as shown in Figure 8.

Figure 7: Electricity to EV Home Charging Station

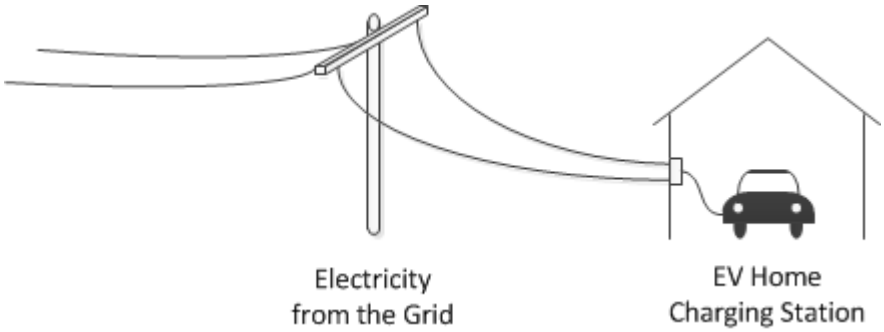
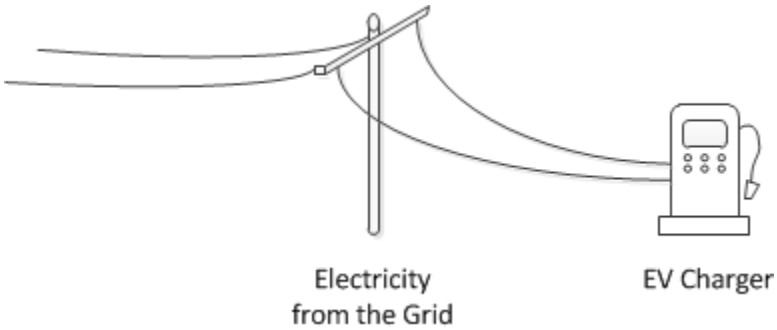


Figure 8: Electricity to EV Charger



On average, PHEVs can travel on battery power alone for 15 – 35 miles, and 300+ miles in gasoline-electric hybrid mode. The average BEV can travel between 70 and 100+ miles on a fully charged battery, although Teslas have a range of up to 250 miles (CARB, 2015b). However, the typical BEV range is increasing quickly. Manufacturers expect that in 2017 we will see 3 BEV models with driving ranges of 150-200 miles for under 40 thousand dollars; the Chevy Bolt, the Tesla Model 3, and the Nissan Leaf v2 (BACC, 2015). BEVs may be available later in the decade that have ranges of up to 350 miles (Schorske, 2011).

Plug-in hybrid electric vehicles (PHEVs) are distinct from traditional hybrid electric vehicles (HEVs). While both cars contain an internal combustion engine (ICE) and an electric motor, they differ in their primary source of energy. HEV's use their electric motor at low speeds, and at higher speeds the ICE takes over. They use regenerative braking to charge the battery, which is then used to power the electric motor. This allows HEVs to get much better fuel economy than conventional ICE vehicles (ICEV).

PHEVs, on the other hand, run primarily on their electric motor, which is charged by grid electricity. The ICE only turns on when the battery is almost out of charge and provides power to the electric motor to extend the car's range. PHEVs also capture energy from regenerative braking, but must be plugged in regularly to achieve sufficient charge to power the vehicle. In this report, we will be discussing only PHEVs, not HEVs, since PHEVs are considered a transitional zero emission vehicle (TZEV) in California but HEVs are not.

EVs do not produce tailpipe emissions when running on their battery. However, emissions may be generated during the production of the electricity that goes into them, especially when they are powered by the electric grid. The fact that 33% of the state's electricity is mandated to be from renewable sources by 2020 under the California Renewable Power Standard (RPS) means that increasing the use of EVs and PHEVs equates to a significant reduction in California's GHG emissions. EVs and PHEVs are also highly efficient at converting electricity into power, achieving conversion rates of 59-62% as compared to gasoline powered vehicles, which have an efficiency of between 17-21% (fueleconomy.gov, 2015).

There are several different types of electric vehicle supply equipment (EVSE), each of which charges EV batteries at different rates. AC Level 1 charging stations are the most basic, making use of the typical household AC 120 volt (V) plug. Most EVs come with a cord and adapter that allows the driver to connect directly to AC 120 V outlets. Level 1 chargers add about 2 to 5 miles of range per hour of charging. AC level 2 chargers use 240 V outlets (usually residential) or 208 V outlets (usually commercial), and require installation of special charging equipment). These add between 10 and 20 miles per hour of charging. DC fast chargers (DCFC) use 480 V DC input and allow for rapid charging. DCFCs can add 60 to 80 miles to a PHEV or EV in about 20 minutes (DOE, 2013a). Table 7 shows typical charging times to a full battery for PHEVs and BEVs using different types of charging equipment. These charge times may vary depending on battery capacity. Current models of PHEVs do not always have the ability to charge on DCFCs, but this could easily change over time if the prevalence of DCFC stations increases.

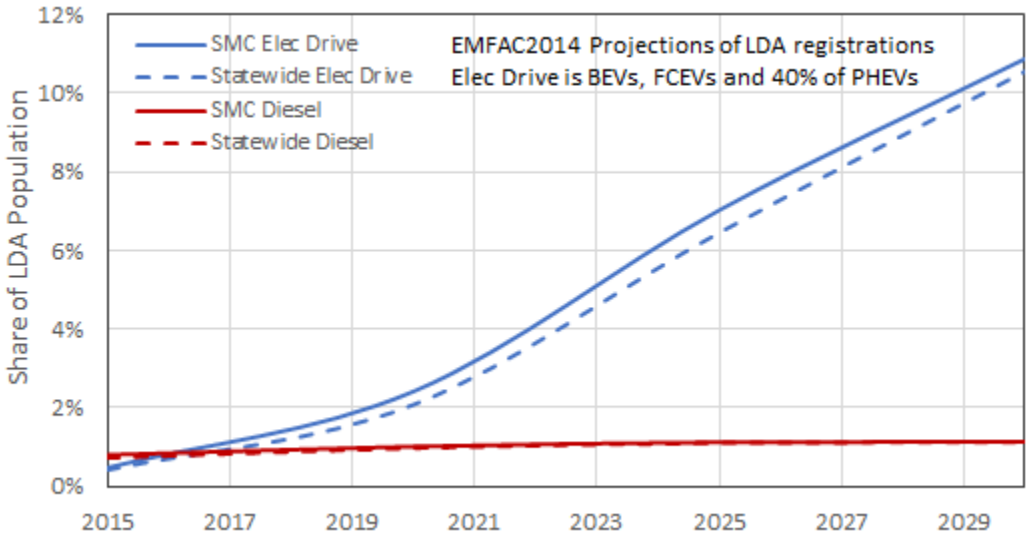
Table 7. EV Charging Times

Charger Type	PHEV time to full charge[1]	BEV time to full charge[1]	Charge Rate[2]
AC Level 1	3 hours	8 to 37 hours	1 kw
AC Level 2	1.5 hours	3 to 16 hours	3-20 kw
DC Fast Charger	n/a	~30 minutes	40-100 kw

1. ICF International, 2013. Bay Area Plug-In Electric Vehicle Readiness Plan Summary 2013; prepared for BAAQMD.
2. Drive Electric Florida. 2012. https://www.fpl.com/environment/pdf/charging-equipment.pdf.

In July of 2015, the Bay Area had more than 42,600 light-duty PEVs. This represents a significant proportion of the PEVs in California, over 38% of the 112,000 PEVs sold in the state (energycenter.org, 2015). San Mateo County alone had 4,638 PEVs that had received state rebates at that time. PEVs are projected to increase faster for San Mateo County than for California as a whole. Figure 9 shows a comparison of EMFAC projections for statewide and SMC light auto registrations as % of total light autos registered. Diesel vehicles, on the other hand, have followed statewide trends, indicating that residents here are not higher consumers of vehicles in general but are particularly likely to purchase PEVs and FCEVs.

Figure 9. Electric Drive Vehicle Projections for San Mateo County

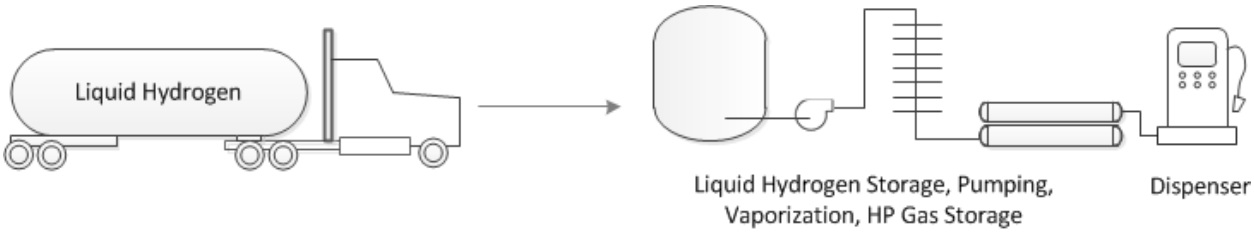


(EMFAC, 2014)

Hydrogen Fuel Cell Electric Vehicles (FCEV)

Hydrogen fuel is produced through steam reforming, gasification, or electrolysis. Hydrogen feedstocks can include natural gas, biomass, or refinery coke, which are broken apart to isolate the hydrogen molecules. When this process is powered with a renewably sourced power grid mix, the carbon intensity of hydrogen is much lower than with a conventional electric grid mix. Hydrogen fuel can be used to power vehicles (either fuel cell electric vehicles or internal combustion engine vehicles), electric devices, and aircrafts.

Figure 10. Hydrogen Dispensing Station



Several hydrogen fuel cell vehicle models are currently or will soon be available on the US commercial market. In June of 2014, Hyundai became the first car company to release an FCEV for private consumer purchase. Toyota released its Mirai FCEV in 2015, and Honda unveiled a concept FCEV, the FCX Clarity, for sale in California in 2015 in limited quantities. California's first Annual Evaluation of Fuel Cell Electric Vehicle Deployment and Hydrogen Fuel Station Network Development finds that 125 FCEVs are currently registered with the DMV, and projects that this will increase to 6,650 by 2017 and 18,500 by 2020 (CARB, 2014d). FCEVs are not currently sold in San Mateo County because there are no hydrogen fueling stations open at this time. However, 4 stations are currently in development and should be open by the end of 2016.

Fuels cells work by combining hydrogen fuel with oxygen from the surrounding air using a proton exchange membrane. Each fuel cell produces less than 1.16 volts of electricity, so a stack of fuel cells is needed to power a whole vehicle. The power a fuel cell stack is capable of generating depends on the number and size of the fuel cells (Office of Energy Efficiency and Renewable Energy, n.d.).

Work performed by UC Irvine, UC Davis, and the California Fuel Cell Partnership determined that an initial network of 68 strategically placed stations operating statewide by 2016 would enable the launch of an early commercial market of 10,000-30,000 FCEVs (CaFCP, 2012). 45 of the stations will be located in 5 cluster communities (Berkeley, South San Francisco/Bay Area, West Los Angeles, Torrance, and Orange County) and 23 additional stations will seed new markets in less populated areas or provide destination fueling (Rubin, 2013). Four stations are planned for San Mateo County in the cities of South San Francisco, Foster City, Redwood City, and the Town of Woodside.

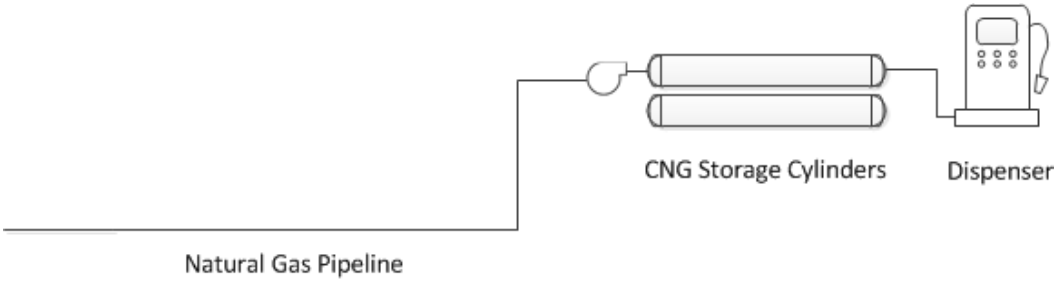
Compressed and Liquid Natural Gas Based Fuels (CNG, LNG)

Natural gas is a clean burning fuel that is already widely used in the United States for heating and cooking in homes, stationary industrial equipment, and electricity generation, and it accounts for about a quarter of the energy used in the United States. (DOE, 2013a). As such, it is widely available through the existing utility infrastructure. Most natural gas is fossil fuel based. Feedstocks for biomass-based natural gas include decaying organic materials, such as yard trimmings, landfill material, wastewater, and livestock

Natural gas vehicles can be either bi-fuel, meaning they can run equally well on gasoline/diesel and natural gas, or dedicated, meaning they can only run on natural gas (Whyatt, 2010). Due to its gaseous property at room temperature and atmospheric pressure, natural gas is used to fuel vehicles in either a compressed or liquefied form. Compressed natural gas (CNG) is a compressed, highly pressurized form of natural gas, where the gas is stored in cylinders at a pressure of 3,000 to 3,600 pounds per square inch. Liquefied natural gas (LNG) is a super-cooled (-260°F) liquefied version. Most natural gas fueling stations dispense CNG, which is more widely available than LNG. CNG-fueled engines can be spark-ignited, like conventional gasoline-fueled engines, or they can be compression-ignited, like conventional diesel engines (Whyatt, 2010). CNG vehicles typically get about the same fuel economy as a conventional ICE vehicle.

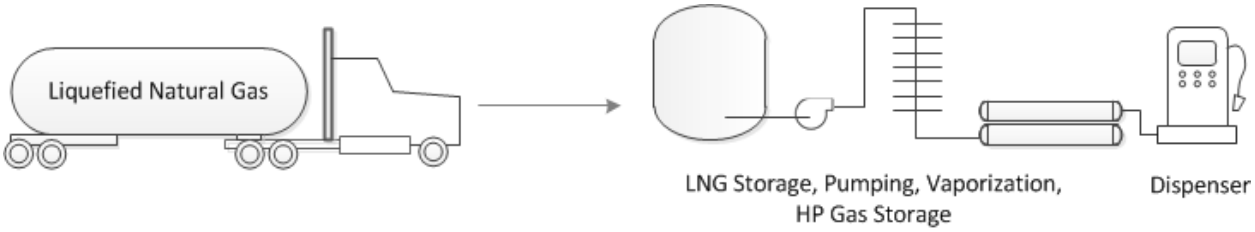
As shown in Figure 11, most CNG dispensers receive natural gas from utility pipelines. The natural gas is stored under pressure in cylinders and is typically used in light-, medium-, and heavy-duty vehicles.

Figure 11. CNG Dispensing Station



LNG is stored at cold temperatures in double-walled, vacuum-insulated pressure vessels. Because liquid is more dense than gas, more LNG than CNG fits into any given tank, making it a good option for larger vehicles or those needing to cover a longer range. As shown in Figure 12, LNG is typically delivered to the station in liquid form by truck. Storage and pumping of LNG occur onsite. LNG is typically used in medium- and heavy-duty vehicles.

Figure 12. LNG Dispensing Station



Natural gas vehicles have similar driving capabilities to gasoline and diesel vehicles in terms of acceleration, speed, and power. However, the CNG driving range is shorter for an equivalent tank size since the volume of the natural gas is higher, which results in a lower energy content per unit volume. The fuel is stored in a highly pressurized tank in the vehicle's trunk, which is typically larger than the fuel tank of a gasoline or diesel car, but still not equivalent in energy content. Both heavy-duty and light-duty natural gas vehicles are available in the United States, but publically available CNG fueling stations are rare. There are 4 CNG charging stations in San Mateo County currently per the DOE's station locator (AFDC, 2015).

Natural gas has several advantages over petroleum fuels. For one, if it is spilled, it evaporates immediately and does not create a hazardous liquid pool like gasoline or diesel. Natural gas also has lower GHG emissions from combustion than gasoline and diesel, and lower levels of other air pollutants.

Ethanol in Flexible Fuel Vehicles (E85)

Bioethanol is an alcohol made by fermentation, mostly from carbohydrates of sugar or starch crops including corn, sugarcane, sweet sorghum, and cassava, to name a few. Another feedstock used for ethanol production is cellulosic biomass, which refers to non-food feedstocks like wood, grass, and the inedible parts of plants. Cellulosic biomass is an abundant and diverse

raw material compared to sugar or starch crops, but it requires a greater amount of processing for ethanol conversion. It is technically possible to use ethanol as a fuel for vehicles in its pure form, but it is usually used as a fuel additive to increase octane and improve vehicle emissions. The highest percentage of ethanol sold is E85, which is 85% ethanol and 15% gasoline.

Figure 13 shows the pathway for E85 production and dispensing. Table 8 outlines the different fuel pathway options for ethanol, including potential raw materials and feedstocks, storage and transportation options, production methods for converting the feedstock into ethanol, distribution channels, and end uses.

Figure 13. E85 Dispensing Station

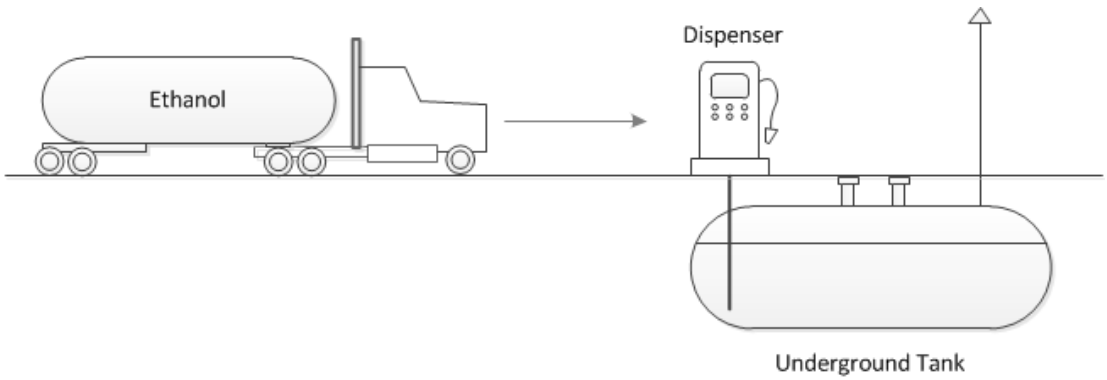


Table 8. Ethanol Fuel Pathways

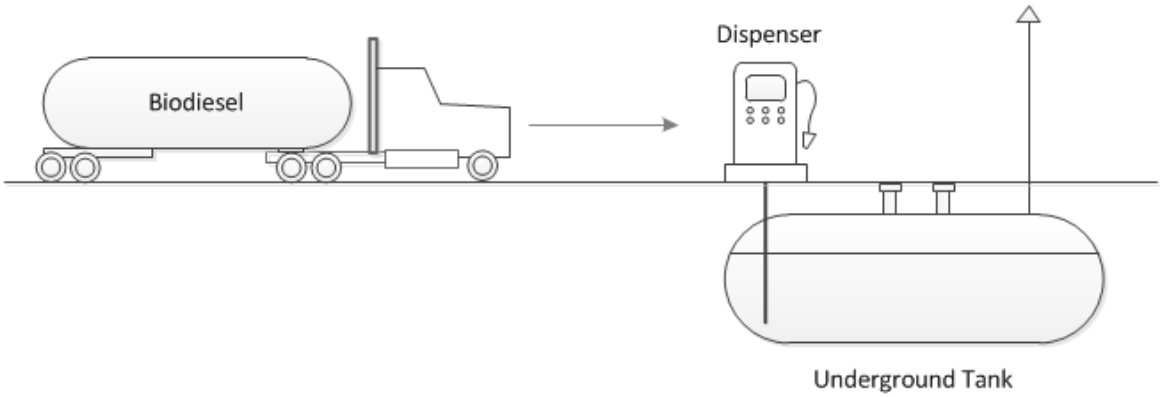
Feedstock	Storage and Transport	Biofuel Production	Distribution	Vehicle End Use
Sugar/Starch Food Crops Starch Energy Crops	Grain silo or other storage	Sugar fermentation	Rail Car Pipeline	
Cellulose crops Cover crops Residue	Baling Moisture protection	Cellulosic fermentation	Tanker Ship Tank Truck	E85
Waste	Continuous Feedstock	Gasification Cellulosic Conversion	Tank Truck	
Possible Activity Midwest, California, Brazilian and other ethanol production facilities.			8000 gal tank truck Fueling station Underground tank	Public Cars FFV vehicles
Permitting			Fuel Station	

Flexible fuel vehicles (FFVs) are capable of running on a range of ethanol and gasoline blends of up to 85% ethanol by volume. Ethanol has a lower energy content than gasoline, so drivers get less mileage for the same volume of fuel. However, handling is similar if not improved, since ethanol has a higher octane level than gasoline and affords the driver increased power and performance (DOE, 2013a). Special diagnostic equipment in the FFV detects the ethanol-to-gasoline ratio, and adjusts its performance accordingly.

Biodiesel (BD) and Renewable Diesel (RD)

Biodiesel is a cleaner-burning alternative to petroleum diesel, produced from vegetable oils or animal fats using transesterification. Soybean, palm, and rapeseed oils are the feedstocks most commonly used. Evolving sources of oils include algae and halophytes. Biodiesel can be used as a fuel for vehicles in its pure form, but it is usually used as a diesel additive to reduce levels of particulates, carbon monoxide, and hydrocarbons from diesel-powered vehicles.

Figure 14. Biodiesel Fueling Station

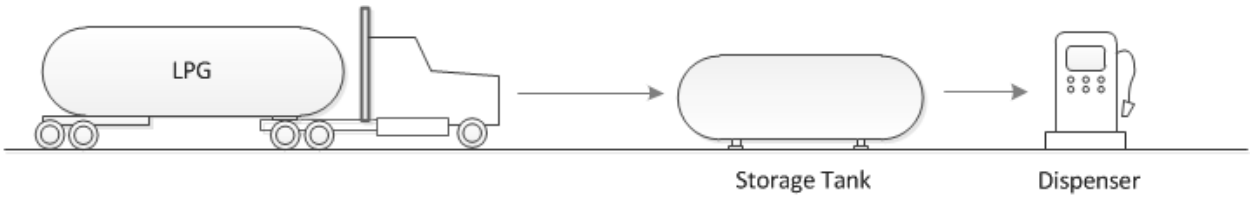


Renewable diesel (RD) is a diesel fuel made entirely from renewable biomass, such as vegetable oils or animal tallow. It is then hydro-treated to be indistinguishable from petroleum-based diesel. In fact, it may even result in higher engine performance than diesel. HPR meets the petroleum diesel ASTM specification and can be used in any diesel vehicle without concern that it will harm the engine or void the warrantee (DOE, 2013a).

Liquefied Petroleum Gas or Propane (LPG)

Liquefied petroleum gas, also known as propane, is a clean-burning, high-energy liquid fuel used to power light-, medium- and heavy-duty propane vehicles. LPG is colorless and odorless, has a high octane rating, and excellent properties for spark-ignited internal combustion engines. LPG is produced as a by-product of natural gas processing and crude oil refining.

Figure 15. LPG Dispensing Station



Propane currently accounts for less than 2% of the energy used in the United States, and most of this is in non-vehicle uses. However, it is non-toxic and has the potential to emit lower air pollutants and greenhouse gases than conventional transportation fuels. When used as a transportation fuel, it is stored in a tank under high pressure (150 pounds per square inch), at which pressure it becomes a liquid. As pressure is released, the liquid propane vaporizes and turns into gas that is used for combustion (DOE, 2013a).

Propane vehicles work much like spark-ignition gasoline-powered vehicles, and have similar power, acceleration, and cruising speed. Driving range is also comparable, though the energy density of propane is lower than that of gasoline. Both light-duty and heavy-duty LPG vehicles are currently available for sale, but public LPG fueling infrastructure is very limited. Gasoline vehicles can also be converted to use propane fuel. According to the Propane Education and Research Council, there are more than 147,000 on-road propane vehicles in the United States, most of which are part of public fleets such as police cars or school buses. Currently, there are no LPG fueling stations in San Mateo County (DOE, 2013a).

Blended Liquid Fuels

Several of the alternative fuels discussed can be used in vehicles as stand-alone fuels, but in practice are primarily blended into gasoline or diesel fuels. Ethanol and low level blends of biodiesel and renewable diesel are already sold in some existing gasoline stations. The fact that they are blended into petroleum fuels may not be advertised to the consumer since they are drop-in fuels that don't significantly change the quality of the fuel. The use of ethanol and biodiesel in blends is limited by current fuel specifications. The approved blend levels are 10% ethanol, which is the default blend for gasoline sold in California, and 5% biodiesel. Renewable diesel has no blend limit because it is indistinguishable in quality from diesel.

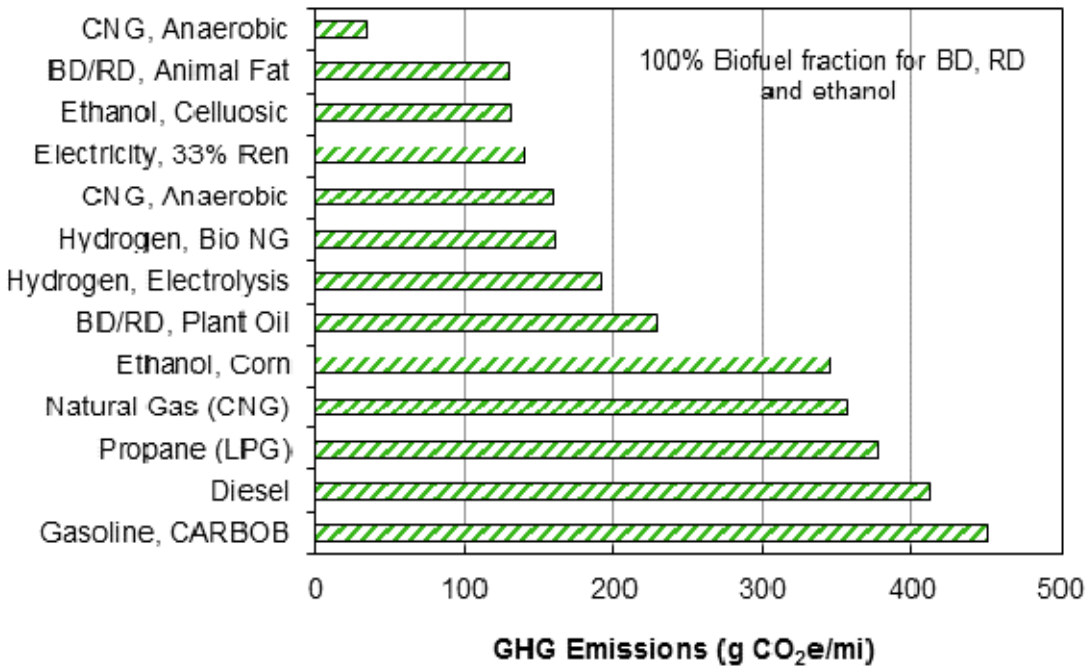
Higher level blends are a means of increasing alternative fuel usage even more. The highest percentage blend levels would be: ethanol (85%), biodiesel (20%), and renewable diesel (up to 100%). Selling higher level blends allows fuel marketers greater flexibility in realizing the economic value of alternative fuel incentive programs. Fuel distribution logistics are different than those for low level blends. High level blends are sold in dedicated dispensers such as the fuels sold by Propel Fuels in Redwood City. They must be clearly marked since only specific cars are approved for their use.

Greenhouse Gas Emissions

One of the main benefits of using alternative fuels in vehicles is to generate a reduction in GHG emissions over petroleum based options. However, all fuels generate some amount of GHG emissions throughout their life cycle. The life cycle of a fuel includes producing the feedstock, processing the feedstock into fuel, distributing the fuel to dispensing locations, and using the fuel in a vehicle. The full GHG footprint of a fuel is referred to as its well to wheels (WTW) carbon intensity (CI), expressed in grams of CO_2 equivalents emitted per MJ of fuel burned (g CO_2e/MJ). The lower a fuel's CI, the more GHGs are avoided by use of that fuel in place of gasoline or diesel.

Some fuels have the potential to provide much greater GHG reductions than others. Figure 16 shows an estimate of the amount of GHG emissions generated by the production and combustion of a wide range of fuels that are used to power vehicles. ARB provides a list of default carbon intensities for each type of fuel under the LCFS. We have adjusted the carbon intensity of the fuels based on the energy density of each fuel and the average fuel economy of the type of vehicle that fuel is used in. This gives an estimate of the grams of CO_2e emitted per mile, which allows for a comparison of fuels based on their actual usage activities. As Figure 16 shows, the method of production makes a large difference in the CI of the fuel. For example, the emissions per mile of BioCNG made from anaerobic digestion of waste water sludge are much lower than the emissions per mile of CNG produced from landfill gas. The vehicle is also an important factor in the total WTW CI. For example, petroleum based diesel has a lower WTW CI as compared to gasoline because diesel vehicles are more efficient than gasoline vehicles.

Figure 16. Greenhouse Gas Emissions per Mile



Source: Carbon intensities calculated from CARB, July 2015. Proposed third LCFS 15-day regulation order. http://www.arb.ca.gov/regact/2015/lcfs2015/lcfs15appa.pdf. See Appendix C for more detail.

Note: In Figure 16, the emissions shown for biodiesel, renewable diesel, and ethanol, which are typically blended into petroleum fuels, are based on the assumption of a 100% fraction of that alternative fuel. Electricity grid assumes 33% renewable sources. NGVs are assumed to be spark-ignited ICEVs.

Cost

Alternative fuels and alternative fuel vehicles may or may not provide cost savings over comparable petroleum options. In some cases, the vehicle may be more expensive than an ICEV but the fuel may cost less. On the other hand, if the net cost of owning and operating an alternative fuel vehicle exceeds that of a gasoline vehicle, that AFV is unlikely to succeed in the marketplace over the long term. Therefore, most AFVs typically cost about the same as or less than gasoline vehicles, when fuel economy and fuel costs are accounted for. Those that are currently more expensive to manufacture often benefit from rebates and tax credits that bring down the purchase price. Additionally, the price of most AFVs is expected to go down over time as volumes increase and economies of scale reduce the unit price. Gasoline vehicles, on the other hand, are expected to increase in price slightly because of CAFE requirements that are tightening the fuel economy of ICEVs and making them more expensive to produce.

Vehicle Cost

As pointed out, AFVs are often more expensive to make than ICEVs, partially due to the parts required and partially due to the small production volumes. The difference in cost between producing an AFV versus an ICEV is called the incremental cost. The incremental cost of producing the vehicle may be defrayed through incentives or rebates that reduce the difference in retail price.

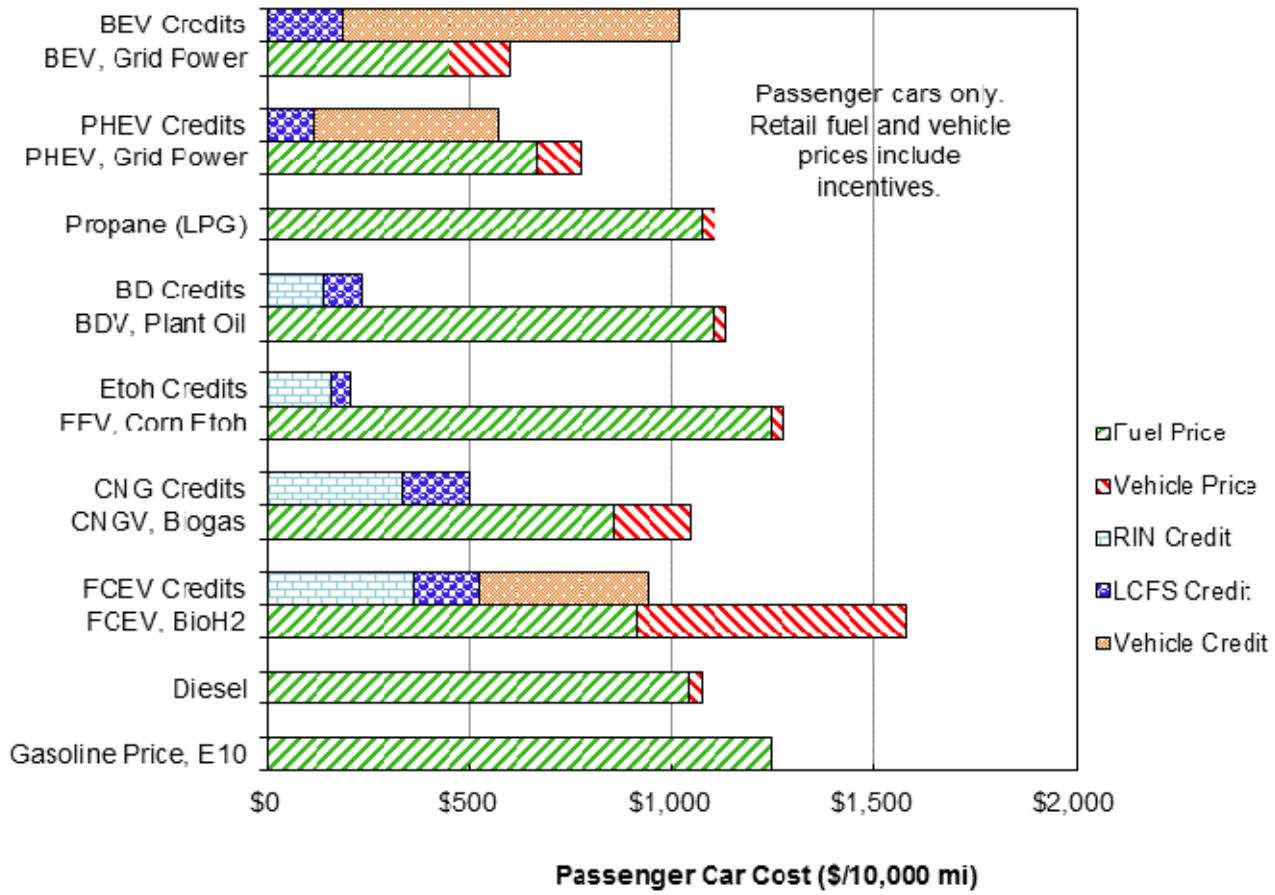
There is also a difference in the cost of producing alternative fuels as compared to the cost of producing petroleum based fuels. Here again, government incentives generate additional revenue for the producers of alternative fuels. Producers of low carbon intensity fuels can generate carbon credits through the California Low Carbon Fuel Standard (LCFS credits) and the EPA's Renewable Fuel Standard (RINs). This reduces the retail price that consumers pay for fuels as well.

Figure 17 shows a comparison of the incremental retail price of owning and fueling an AFV over 10,000 miles, as well as the incentives that go into bringing that price down from its base cost of production. No incentives are available for propane, gasoline, or diesel fuels or vehicles. In the graph below, the top bar shows the credits and incentives (LCFS, RIN, and vehicle), and the bottom bar shows the retail price of the fuel and vehicle. The numbers are calculated over 10,000 miles of driving based on a 120,000 lifetime mileage.

As can be seen below, while all AFVs cost more than ICEVs, in some cases the efficiency of the vehicle, its low maintenance costs, and the cost of the fuel amount to a net savings to the consumer over 10,000 miles. This is the case with all of the PEVs and every form of diesel (BD, RD, and petroleum based). Hydrogen vehicles are currently more expensive than gasoline

vehicles, but are expected to decrease over time as sales volumes increase and establish economies of scale. CNG passenger vehicles have a higher incremental cost than gasoline, and are not expected to grow significantly as a sector. The prices of BEVs, PHEVs, and FCEVs have been adjusted to account for the currently available federal and state incentives ($10,000 for BEVs, $5,500 for PHEVs, and $5,000 for FCEVs). Gasoline is assumed to be sold at $3.27 a gallon.

Figure 17. 2015 Incremental Vehicle Cost[1,2]



1. Fuel prices from Energy Information Administration 2015 Annual Energy Outlook.
2. Vehicle costs taken from Transitions to Alternative Vehicles and Fuels, National Academy of Sciences, 2013 and adjusted for tax credits and rebates.

For vehicles that are not yet being produced in large volumes, the costs reported in the NAS analysis are much lower than current retail prices because the NAS numbers are based on a scenario which assumes economies of scale have already been reached. For example, NAS assumes a 2015 retail price of $33,296 for FCEVs when in fact, the 2016 Toyota Mirai is expected to retail for about $57,000 before incentives. Therefore, in Figure 17 we have adjusted the 2015 NAS incremental price for FCEVs, BEVs, and PHEVs to reflect current listing prices. We have subtracted the maximum incentive value from the California rebate and the federal tax credit to estimate the current vehicle retail price that consumers are likely to pay. The total cost of ownership also includes the cost of buying fuel for the lifetime of the vehicle. Vehicles are assumed to last for 120,000 miles in this analysis. The green striped section of the bars in Figure

17 shows the cost of fueling the vehicle over its lifetime. Fuel prices will be discussed further in the following section.

Table 9 shows some of the calculations and assumptions that factor into the incremental vehicle costs shown in Figure 17. Fuel economy for the different vehicles is based on the lower heating value of the fuel, and for hydrogen and electricity, it also factors in the ARB approved energy efficiency ratio (EER) of 2.5 for hydrogen and 3.4 for electricity. The cost of fuel consumed in a vehicle over 10,000 miles is calculated based on the fuel economy of the vehicle and the price of the fuel as reported by the Energy Information Administration. Incremental vehicle costs are averaged over the 120,000 mile lifetime of the vehicle and scaled to 10,000 miles.

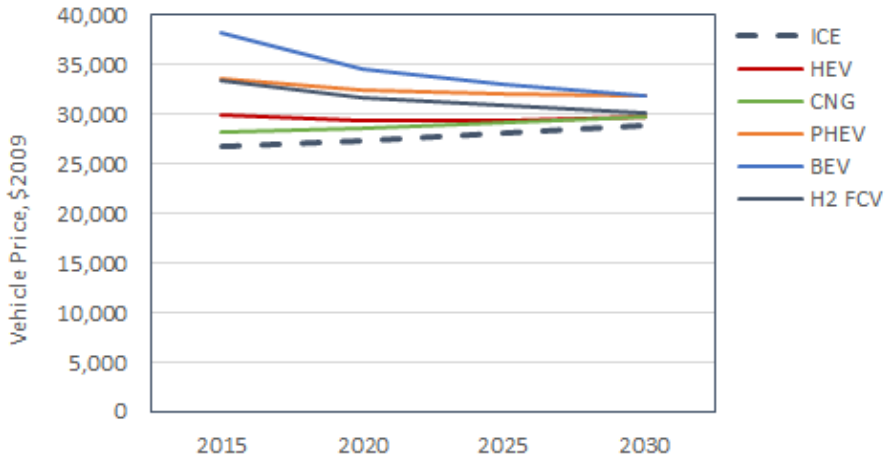
Table 9. Incremental Vehicle Costs

				Fuel Economy	LHV	Fuel	Vehicle	RIN[1]	LCFS[3]	Vehicle
Fuel	**Price**	**Unit**	**EER**	**(mi/unit)**	**(Btu/unit)**	**($/10,000 mi)**		**Credit ($/10,000 mi)**		
Gasoline, E10	$3.27	gallon	1	26.3	113,300	$1,243	$0			
Diesel	$3.46	gallon	1	33.3	127,464	$1,039	$33.33			
FCEV, Renewable H2	$7[2]	kg	2.5	66.0	113,760	$909	$1,083	$358	$162	$417
CNGV, Landfill Gas	$2.25	GGE	1	19.3	82,970	$854	$191	$332	$166	
FFV, Corn Ethanol	$2.39	gallon	1	19.3	82,970	$1,243	$33	$156	$49	
Biodiesel, Plant Oil	$3.36	gallon	1	30.6	117,000	$1,100	$33	$136	$94	
Propane (LPG)	$2.11	gallon	1	19.7	84,950	$1,071	$33.33			
PHEV, Grid Power	--	--	--	0.2	2,139	$665	$106		$111	$458
BEV, Grid Power	$0.12	kWh	3.4	2.7	3,412	$446	$984		$186	$833

1. OPIS Ethanol and Biodiesel Information Service. November 23, 2015. Volume 12, Issue 47. http://www.opisnet.com/images/productsamples/EBISnewsletter-sample.pdf
2. Joseck, F. & E. Sutherland. 2014. Early market hydrogen cost target calculation. Department of Energy. http://hydrogen.energy.gov/pdfs/14013_hydrogen_early_market_cost_target.pdf
3. Assumes LCFS average value of $60 based on ARB's October, 2015 LCFS trading report. http://www.arb.ca.gov/fuels/lcfs/credit/20151110_octcreditreport.pdf

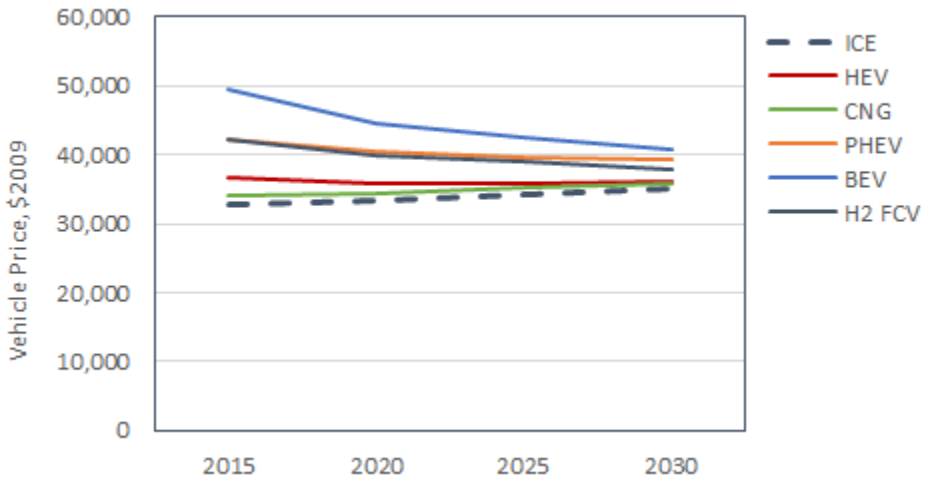
In Figure 18 and Figure 19, incremental costs are shown for light-duty auto and light-duty trucks from the year 2015 through 2030. Incremental production costs were taken from a National Academy of Sciences study that calculated the incremental cost based on the cost of the car's components (NAS, 2013). We added these incremental costs of production to the base ICEV price of $26,341 to get the estimated cost of each vehicle over time as predicted by the NAS study. As shown in Figure 18, the cost of most AFVs is expected to decrease over time, while ICEV cost is expected to rise slightly. BEV and FCEV prices are expected to come down significantly, whereas ICEVs, conventional hybrids, and CNG vehicle prices are expected to increase slightly. (For further discussion of vehicle population projections, see Chapter 8.)

Figure 18. Light Duty Auto Projected Prices



Source: Transitions to Alternative Vehicles and Fuels, National Academy of Sciences, 2013

Figure 19. Light-Duty Truck Projected Prices



Source: Transitions to Alternative Vehicles and Fuels, National Academy of Sciences, 2013

The incremental cost of an alternative vehicle is difficult to estimate because the baseline vehicle price is not always known. For example, Tesla does not build a gasoline baseline vehicle, and even if such a vehicle were available, it would be configured with different power, transmission, range, and other attributes than the BEV version.

The highest initial purchase cost increments are for electric drive vehicles, including battery EVs, PHEVs, and hydrogen fuel cell vehicles. The cost of the battery pack can range from $5,000 to $10,000 for PHEVs and from $12,000 to $15,000 for a BEV, and on average amounts to about 25% of the cost of a BEV (NREL, 2007; Ramsey, 2012; Sun, 2012). The battery pack is not the only factor that affects electric drive vehicles. Electric motors replace internal combustion engines, and in the case of PHEVs, this allows for a reduction in the engine size that results in cost savings (EPRI, 2001; Dodge, 2014). Many EVs are specially built models (Nissan Leaf, BMW i3,

Tesla S). Thus the baseline vehicle cost used in life cycle cost calculations from VISION may vary based on individual considerations.

That said, the cost of a battery in terms of dollars per kWh has fallen significantly over the last few years, from about $1000 in 2007 to as low as $300 in 2014 (Nykvist, 2015). This reflects that batteries are being produced more cheaply relative to their charge capacity, which correlates to a higher driving range. In other words, the price of the battery included in a BEV may not have dropped, but the amount of charge drivers are getting for the same cost has increased. If prices keep falling at this same rate of about 14% per year, in the near future (as soon as 2020) battery costs could reach $150 per kWh, the cost at which BEVs could become cost competitive with ICEVs.

CNG vehicles are also configured with costly fuel storage. High pressure tanks (4000 psi) can cost several thousand dollars. CNG vehicle manufacturers benefit from federal incentives, although the amount by which they benefit is expected to decrease. A gasoline gallon equivalent (GGE) of natural gas is currently counted as just 0.15 gallons of gasoline under federal Corporate Average Fuel Economy (CAFE) standards. This means that producing NGVs brings down the manufacturer's fleet-wide fuel economy because their rating is an average of conventional and natural gas vehicles. Beginning in model year 2016, the equivalency value for NGVs must be calculated based on GHG emissions instead of the 0.15 GGE fuel economy that was previously assumed. The GHG emissions from NGVs are 20-25% below an equivalent gasoline vehicle, so manufacturing NGVs will still bring down the OEM's fleet average GHG emission ratings by a meaningful amount, but far less than the 0.15 multiplier.

LPG and diesel passenger cars are also more costly to manufacture than a baseline gasoline vehicle. In the case of diesel vehicles, the engines are manufactured in smaller volumes. Furthermore, diesel engines are equipped with direct injection fueling systems and relatively new NOx reduction systems. Biodiesel (up to 20% depending on warranty) and renewable diesel can operate in diesel engines without modification.

Ethanol FFVs are sold at no incremental cost. Like with NGVs, car manufacturers receive CAFE credits for FFVs that bring down the average fuel economy of their fleet. Starting in 2015, these credits depend on the actual amount of ethanol sold, so the credit value is smaller than in prior years. The actual cost of manufacturing an FFV includes emission certification as well as specifying alcohol compatible fuel system components, but amounts to only a few hundred dollars.

Fuel Price

Electricity, diesel, biodiesel, renewable diesel, and CNG all provide fuel cost savings compared to gasoline in passenger cars. The cost savings for diesel, biodiesel, and renewable diesel result from fuel efficiency improvements relative to gasoline. The retail price of diesel is similar to the retail price of gasoline. At some fuel stations, diesel may sell for a price premium. BD and RD are usually available at the same volumetric prices as diesel. Some of these fuels have been sold with a slight discount to incentivize consumer purchases. Similarly, ethanol will be sold at a price that is energy equivalent with gasoline. CNG is cheaper on an energy basis than gasoline

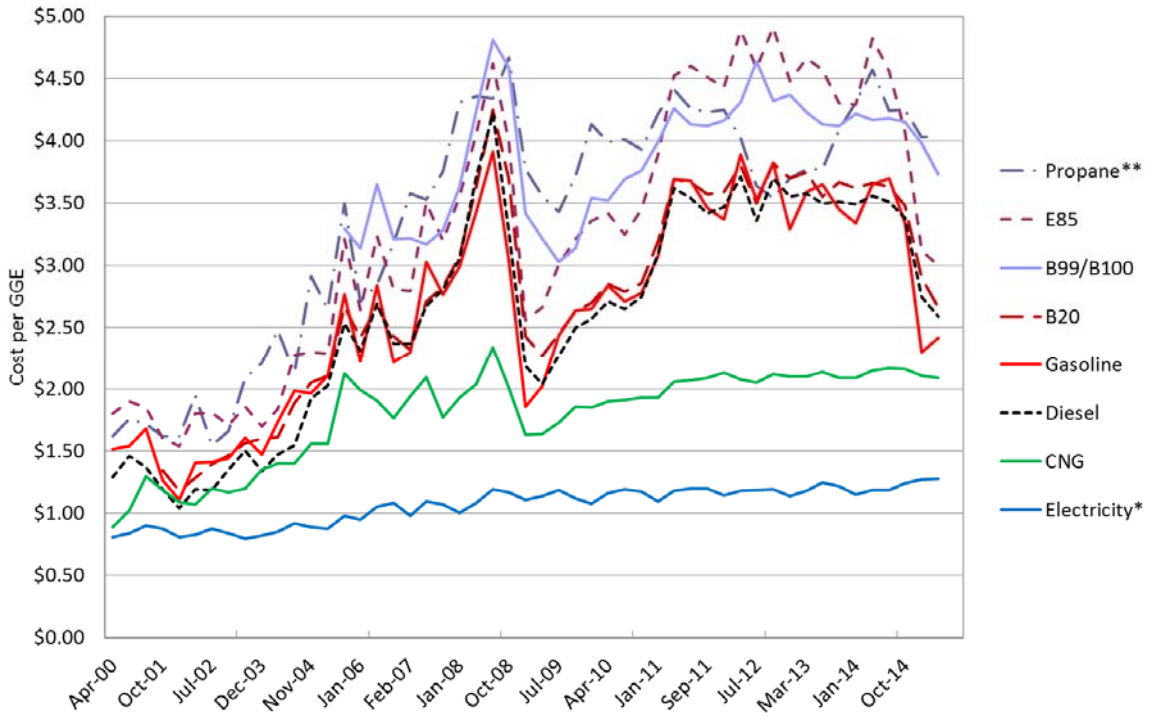
due to the current abundant domestic supply. Electric drive trains are more efficient than combustion engines, so they require less energy per mile driven. Charging electric vehicles during off-peak times, when electricity is at its cheapest, results in much lower fuel costs per mile than gasoline ICEVs.

Fuel savings from alternative fuel vehicles are intimately tied to gasoline prices, which means that AFV sales drop when gasoline prices are low and rise when they are high. For example, in 2014, gasoline prices dropped, resulting in decreased sales of PEVs. From April 2014 to April 2015, sales of electric and hybrid vehicles have dropped from 3.4% to 2.7% in market value while purchases of sports utility vehicle rose from 31.6% to 34.4% (Ulrich, 2015).

Vehicle fuel prices have proven to be highly variable over time. From the year 2000 through 2015, United States average gasoline prices ranged from as little as $1.50 in 2000 to almost $4.00 in 2008. The price of liquid alternative fuel prices is closely tied to the price of petroleum fuels, as shown in in Figure 20. Liquid alternative fuels are primarily used in vehicles, and petroleum options are a viable substitute if alternative fuel prices rise too high. However, natural gas and electricity prices are more independent of petroleum price because transportation only accounts for a small portion of their markets.

As shown in Figure 20, E85 prices have roughly followed the same pattern as gasoline over the last 15 years, but have typically remained 50 cents to over a dollar more expensive. B20 also closely mirrors the price of gasoline. B99/B100 is a rare fuel that is sold to consumers who are highly committed to using only biodiesel in their vehicles, and this is reflected in its relatively high price. CNG and electricity, on the other hand, are consistently sold at prices well below that of all of the other fuels, and show a much less volatile pattern. This is one of the major selling points of CNG as a fleet fuel for companies that need to make long-term economic plans. The price of propane in this graph is inflated due to the fact that the prices reflect the inclusion of propane sold for non-vehicle uses, which is typically sold at higher prices. Hydrogen is not shown on this graph because until 2015 it was not commercially available.

Figure 20. United States Average Retail Fuel Prices



Notes: Fuel volumes are measured in gasoline-gallon equivalents (GGEs). *Electric prices are reduced by a factor of 3.4 because electric motors are 3.4 times more efficient than internal combustion engines. **Propane prices reflect the weighted average of "primary" and "secondary" stations.

Sources: Alternative fuel prices taken from Clean Cities Alternative Fuel Price Reports (http://www.afdc.energy.gov/fuels/prices.html). Electricity prices are taken from EIA's Real Prices Viewer (http://www.eia.gov/forecasts/steo/realprices/).

Fueling Infrastructure Cost

The cost of developing and constructing a refueling station varies widely based on the ground footprint, tank storage requirements, fuel and pipeline availability, and many other factors. EV charging stations, which range from $500 for home charging to $40,000 for public DC Fast Charging, are the least costly type of alternative fueling station to install since they have the smallest footprint and need only be connected to the existing electric grid network. EV charging can also be done for free using a typical household outlet, although it is difficult to achieve a full charge on modern PEVs using that method alone. According to PG&E, the cost of installing electrical equipment for a second meter ranges from $1,000 to $3,000. The second meter itself costs $100. E85 and biodiesel don't require the construction of a new station, but are dispensed at existing gasoline stations using converted pumps. Hydrogen and natural gas fueling stations, which require storage tanks and have a larger physical footprint, are much more expensive. When compared to the cost of building a conventional gasoline and diesel fueling station ($50,000 to $150,000), hydrogen stations are intimidatingly expensive at $1 million or more. See Table 10 for additional detail about infrastructure installation costs.

Table 10. Infrastructure Installation Cost

Fueling Station Type	Fuel Type	Cost of Single Station
Level 1 Basic Charging EV	Electricity[1]	$0 to $1000
Level 2 Basic Charging EV		$500 to $2,600
Level 2 Smart Charging EV		$4,500 to $17,000
DC Fast Charge EV		$19,000 to $40,000
CNG Time-Fill	Natural Gas[2]	$5,500 to $50,000
CNG Fast-Fill		$400,000 to $1.8 Million
LNG Fast-Fill[3]		$1 to $4 Million
250 kg/Day[4]	Hydrogen	$0.9 Million
400-500 kg/Day[5]		$1.5-$4 Million
1000-2000 gallon storage	LPG[6]	$45,000-$70,000
12,000-18,0000 gal storage		$120,000-$220,000
30,000 gallon storage		$225,000-$300,000
1 Fueling Island	E85[7,8,9]	$50,000-$150,000
1 Fueling Island	Biodiesel[7,8,9]	$50,000-$150,000
1 Fueling Island	Gasoline/Diesel[7,8,9]	$50,000-$150,000

[1] California Department of General Services. 2014. Electric Vehicle Supply Guidance Document.
[2] Department of Energy, Energy Efficiency and Renewable Energy. 2014. Costs Associated With Compressed Natural Gas Vehicle Fueling Infrastructure.
[3] Energy Information Administration. 2015.AFDC.energy.gov.
[4] Tyson Eckerle, Garderet, R. 2012. Incentivizing Hydrogen Infrastructure Investment Phase 1. Energy Independence Now Report.
[5] California Fuel Cell Partnership, 2014. *Hydrogen Fueling Stations*. http://cafcp.org/sites/files/H2-Station-profiles_public-compr.pdf.
[6] Smith, M., Gonzales, J. 2014. Costs Associated With Propane Vehicle Fueling Infrastructure. Department of Energy Report.
[7] EPA RFS2 Final Regulatory Impact Analysis, Feb 2010. http://www.epa.gov/otaq/renewablefuels/420r10006.pdf
[8] Provided by NBB Petroleum Liaison to Shelby Neal (NBB), email dated September 11, 2014.
[9] Electric Vehicle Transportation Centery. 2014. Hydrogen Fueling Stations Infrastructure. http://evtc.fsec.ucf.edu/reports/EVTC-RR-02-14.pdf.

Advantages and Disadvantages of Each AFV

Drivers are accustomed to the prices and activities associated with petroleum fueled vehicles. However, AFVs contain new and different technologies, and require new approaches to fueling, use, and maintenance. The strengths and weaknesses of each type of AFV should be well understood so that consumers and policy makers can make informed decisions. For example, some vehicles are more cost effective but have a shorter travel range while others require more expensive fuel but have a longer driving range. Refueling/recharging time may also be an important consideration. A brief overview of the advantages and disadvantages of each AFV is presented here. A more detailed discussion of this topic follows in Chapter 5, Alternative Fuel Infrastructure and Deployment Challenges.

Plug-in Electric Vehicles

PEVs are already quite popular in California, and they offer many advantages. They are convenient to own because drivers can charge them overnight at home, allowing consumers to capture fuel cost savings by using off-peak electricity in this fuel efficient vehicle. Over the lifetime of the vehicle, these savings should off-set any added cost from the up-front purchase price. Many drivers also enjoy the fact that PEVs are almost silent to drive. Electric charging infrastructure is relatively easy to permit and install because it is similar to an ordinary electric outlet. BEVs are also zero-emission vehicles (ZEVs) under California law, and their emissions during use come only from electricity generation, which in California is mandated to be 33% from renewable sources.

BEVs do suffer from the disadvantages of limited driving range and relatively long charging time, although the driving range has consistently increased as the technology has developed and is expected to continue doing so. Also, only drivers who own their own homes or have access to charging infrastructure in their building can charge their vehicles overnight.

PHEVs are considered transitional ZEVs (TZEVs) since they have low but not zero tailpipe emissions. PHEVs also offer large reductions in GHG and other air pollutants. They are largely operated in electric mode, but also have a backup gasoline tank that decreases the range anxiety of running out of charge and provides extended range.

Continued education is needed to ensure that PEV owners are using their vehicles to their greatest advantage. Public charging infrastructure must also be planned carefully to ensure to that employees who need to charge their vehicles at work are able to do so, and renters and multi-unit dwellers are not prohibited from owning PEVs due to EVSE installation obstacles.

Hydrogen Fuel Cell Electric Vehicles

Fuel cell electric vehicles have several major advantages. FCEVs have a relatively long driving range, only slightly less than many gasoline vehicles. They are also scalable: fuel cells are capable of powering larger vehicles without resulting in a large increase in the overall vehicle weight. They are considered zero emission vehicles under California regulations, and are highly efficient at converting hydrogen into power. Like PEVs, FCEVs are also quiet to drive.

On the other hand, FCEVs have special challenges. Both the vehicle and the fuel are currently quite expensive, the former due to the materials needed to make the fuel cell and the latter due to the high up-front infrastructure cost of installing fueling stations. Infrastructure development is made particularly difficult because the National Fire Protection Association (NFPA) codes require large setback distances (up to 50 feet from the nearest wall) for hydrogen refueling, greatly restricting the number of locations that are suitable for hydrogen retail stations.

Natural Gas Vehicles

Natural gas vehicles are another low emission AFV option with a relatively long driving range. Natural gas is the lowest carbon intensity fossil fuel and it burns quite cleanly, producing few non-GHG air pollutants. When produced from organic waste matter, its carbon intensity is even lower and it is considered a renewable fuel. One selling point for NGVs is that natural gas is currently being produced in large quantities domestically at low and consistent prices relative to other vehicle fuels. Natural gas is primarily used in bus, taxi, and light-duty trucks. However, the only commercially available NG-dedicated passenger vehicle, the Honda Civic CNG, is being discontinued. Another disadvantage of NGVs is that their primary fuel, methane, is a potent greenhouse gas, which has large climate change impacts in the case of leaks.

E85 and Flexible Fuel Vehicles

Flexible fuel vehicles (FFVs) running on E85 may offer a reduction in GHGs and other air pollutants over gasoline and diesel, depending on the production pathway of the ethanol. The carbon intensity of a given ethanol blend depends on its feedstock and production method, but at the low end offers GHG emission reductions of up to 60%. It is relatively inexpensive to make a vehicle that can run on a range of ethanol and gasoline blends, which makes it an appealing option for manufacturers and consumers alike.

Ethanol is largely domestically produced, and the EPA's Renewable Fuel Standard sets ethanol production goals that will result in quantities that exceed current demand. Consuming this ethanol will either require increased use of E85 in FFVs, or increasing the standard gasoline blend from a 10% to a 15% or higher ethanol content for all new vehicles.

An FFV running on E85 has a shorter driving range than that same vehicle driving on gasoline by about a hundred miles, but the resulting range of about two hundred miles is still higher than many other AFVs. FFVs also offer the flexibility to fuel on regular gasoline when E85 is not available, making them largely immune to infrastructure density problems and range anxiety.

Biodiesel and Renewable Diesel

There is no such thing as a biodiesel dedicated vehicle. Any diesel vehicle can be fueled with diesel made from biological or renewable feedstocks. However, many vehicle manufacturers will void the warrantee on a new vehicle if it is fueled with higher than a 5% biodiesel blend due to concerns about potential engine damage. Renewable diesel, which is biodiesel that has undergone the additional step of hydrotreating, carries no such quality concerns and can be blended with petroleum diesel with no distinguishable difference. Diesel vehicles are more efficient than gasoline vehicles, and when run on biodiesel or renewable diesel, offer life cycle WTW GHG emission reductions of up to 80%.

Liquefied Petroleum Gas/Propane

Liquefied petroleum gas (LPG) or propane can be used in manufactured or converted vehicles. One advantage of LPG is that can be used in larger vehicles, including light-, medium-, and heavy-duty trucks. Propane's high octane combined with its low-carbon and low oil-contamination characteristics have resulted in improved engine life compared to conventional gasoline engines, making it attractive to fleet managers whose vehicles experience heavy usage and wear. Propane vehicles have comparable power, performance, and range to gasoline vehicles.

Propane typically costs less than gasoline, but propane vehicles may cost several thousand dollars more, so the economics often break even (see Figure 19). An additional obstacle is that conversions of conventional vehicles to propane must be certified by the ARB, usually a rigorous process. Also, public infrastructure for propane is rare, and vehicle population densities have been dropping in recent years.

Conclusions

Every type of alternative fuel and alternative fuel vehicle offers advantages, which are balanced out by trade-offs in other areas. The key to making good choices in vehicle purchasing and planning is to fully understand these trade-offs and to choose the option that is best for the intended purpose. For example, BEVs are perfect for individuals who have access to convenient nighttime charging and a short to medium length commute to work every day. A travelling sales representative who drives hundreds of miles a day may be more comfortable with a PHEV than a BEV. CNG or biodiesel are better options for a fleet of trucks that have to carry heavy loads and drive for long distances.

Table 11 displays a brief overview of the pros and cons of each type of alternative fuel vehicle. It also shows the carbon intensity of each AFV from fuel production through combustion in a vehicle. For comparison purposes, the default well to wheel carbon intensity of gasoline is about 100 g CO_2e/MJ. For some fuel types, different production methods and feedstocks can result in different carbon intensities, and in these cases, several representative values are shown in Table 11.

The CI's below have also been adjusted based on their energy economy ratios, where appropriate. Energy Economy Ratio (EER) is the dimensionless value that represents the efficiency of a fuel as used in a powertrain as compared to a reference fuel, in this case a gasoline gallon equivalent (gge) between two fuels. The energy economy ratio of electricity relative to gasoline is 3.4, and the energy economy of hydrogen is 2.5. Dividing the CI of the fuel by this number allows you to determine the emissions based on how far a given fuel will actual transport a vehicle.

Table 11. Advantages of Different Alternative Fuels

AFV Fuel	Well to Wheel Carbon Intensity[1] (gCO_2e/MJ)	Pros	Cons
Electricity[2]	32.5	ZEV & very efficient Low fuel cost Many incentives available for vehicle purchase	High vehicle price Short driving range Long charging time Second meter needed for lowest EV rates
Hydrogen[3,4]	Bio CNG Reforming: 35.33 Electrolysis: 42.3	ZEV & very efficient Long driving range Short fueling time Scalable in size	High vehicle cost High fuel cost Low infrastructure density
Natural Gas	RNG[5]: -34.7 to 46 Fossil CNG: 76 Fossil LNG: 94.4	Low fuel cost Clean burning fossil fuel Long driving range	Low infrastructure density Low efficiency compared to diesel
Ethanol	Corn Stover: 41.05 Sugar Cane: 56.7 Corn: 75.97	Large quantities available Works in existing stations Vehicle cost is like ICEV Long driving range Short fueling time	E85 fuel cost is higher than gasoline
Biodiesel/ Renewable Diesel	Animal fat: 38/32 Plant oil: 57/53 Used Cooking Oil: 20/18	Works in existing stations Long driving range Short fueling time Used in diesel vehicles	Warrantee may be voided by high biodiesel blends Limited supply
Propane (not in LCFS yet)	78 to 83[6]	Long driving range Short fueling time ICEVs may be converted	Low infrastructure density Few dedicated vehicles available for sale

1. CARB. 2015. LCFS 2015 Final Regulation.
2. Electricity CI is EER adjusted by a factor of 3.4.
3. NG reformed hydrogen assumes 100% renewable biogas feedstock. Electrolysis assumes California grid electricity, 33% renewable sources.
4. Hydrogen CI is EER adjusted by a factor of 2.5.
5. Based on established LCFS pathways.
6. Western Propane Gas Association study by Life Cycle Associates, unpublished.

CHAPTER 3:
Incentives for AFV and AFI Adoption

AFVs offer many advantages over conventionally fueled vehicles. They create lower GHG emissions throughout their life cycle and produce lower quantities of air pollutants such as dust particulates, smog, and sulfur dioxide. Communities may also enjoy economic benefits from reduced public health costs associated with improvements in air quality from AFVs. PEVs and FCEVs reduce noise pollution since electric batteries are much quieter than the combustion engines in conventional vehicles. Additionally, many alternative fuels like renewable electricity, hydrogen gas, and biofuels are typically domestically produced, resulting in an increase of energy independence.

As with any new technology, there are challenges to the extensive employment of alternative fuel vehicles. The challenges to widespread adoption of AFVs involve economic, technical, regulatory, and behavioral hurdles. These challenges will be discussed fully in Chapter 4.

Since the public benefit of increasing the use of AFVs is significant in spite of these obstacles, various incentives exist in order to make them more attractive to consumers and speed their deployment. The various incentives that currently exist for consumers, businesses, and agencies in San Mateo County are covered in depth throughout this chapter.

This chapter partially fulfills the requirements of Task 2 of the C/CAG agreement with the CEC. Chapter 3 reviews existing federal, state, and regional/local incentives to increase the use of AFVs and the development of AFI. Potential future incentives that could be enacted by San Mateo County and its cities are covered in Chapter 5.

Governments can incentivize the production and use of alternative fuels in a variety of ways. Incentives may target different parts of the value chain, including production of alternative fuels from biomass feedstocks, installation of infrastructure and fueling locations, and the purchase, fueling, and use of alternative fuel vehicles. Some incentives must be applied at the federal or state level, such as tax exemptions or subsidies. Others work best at the regional or local level, such as free parking or free charging stations, and still others are ideally suited to public-private partnerships.

The following list summarizes the types of policies and incentives that governments frequently employ to encourage the use of AFVs and the construction of alternative fueling infrastructure:

- tax credits, exemptions, and deductions
- vehicle purchase subsidies and rebate programs
- AFV refueling equipment deductions
- reduced vehicle registration fees for AFVs
- corporate tax credit for EV purchase/recharge equipment
- HOV lane access
- free parking or charging

Some mandatory requirements and regulations have also been put in place that are likely to result in an increase in the use of AFVs, such as:

- criteria air pollutant and greenhouse gas emission regulations
- fuel economy regulations
- government fleet AFV or ZEV requirements.

Table 12 summarizes the types of major incentives that are currently offered for alternative fuel producers and AFV users located in San Mateo County.

Table 12. San Mateo County Incentives

	Tax Credit	Low-Cost Financing	Rebate	HOV Lane Access
Federal	✓	✓		
State	✓	✓	✓	✓
Regional/Local		✓	✓	
Private		✓		

Rebates and tax credits can bring down the purchase price of an alternative fuel vehicle significantly. Table 13 summarizes the monetary incentives available from different government entities for the purchase of new AFVs. (EM refers to electric motorcycles.) Note that the Bay Area Air Quality Management District incentives are only available to public agencies. Values shown are for the maximum amount possible at this time.

Table 13. Vehicle Purchase Rebates and Tax Credits

	BAAQMD Public Agency PEV Program	CARB Clean Vehicle Rebate Program	IRS Tax Credit
BEV	$2,500	$2,500	$7,500
PHEV	$1,000	$1,500	$4,000
EM	$2,500	$900	$2,500
FCEV	$2,500	$5,000	$0

Existing Incentives

Table 14 through Table 16 show the various federal, state, and local/regional programs that are currently operating in San Mateo County. The name of the program is listed in the first column. The "Administrator" column displays the name of the agency in charge of running the program. The tables also list the types of alternative fuel vehicle technologies that may be eligible for funds under a given program, and the range of monetary or non-monetary incentive values available. Recipient refers to whether incentives are available to individuals (I), commercial entities (C), or government agencies (G). Following the tables are detailed descriptions of each program.

Table 14. Federal AFV Programs

Program	Incentive Value	Administrator	Recipient	Eligible AFVs
Excise tax credits	Varies	IRS	I C G	LPG, NG, FCEV
Renewable Fuel Standard	~$0.50/RIN	EPA	I C G	E85, LPG, BD, CNG
EV Tax Credits	$2,500 to $7,500 depending on battery capacity	IRS	I, C	PEVs
ATVMLP	Loans for up to 30% of the cost	DOE	C	Ultra-efficient vehicles
MAP-21	Up to 80% of fleet vehicle purchase costs	DOT FTA	C, G	All
DOE Loan Guarantees	Loan guarantees for up to 100% of the amount of the loan for an eligible project	DOE	C, G	New or significantly improved technologies
DOE SBIR and STTR Programs	Phase 1: up to $225,000. Phase 2: up to $1.5 million	DOE	C	R&D in innovative technology
Airport ZEV and AFI Pilot	50% of cost of AFVs or infrastructure	FAA	G	BEV, FCEVs
CAFE Standard	Fleet fuel economy requirements	EPA, NHTSA	C	All
Clean Cities Program	Grants are available to DOE coalitions	DOE	G	All
EV Everywhere Workplace Challenge	Companies install EVSE in return for technical assistance	DOE	C	PEVs

Table 15. California AFV Programs

Program	Incentive Value	Administrator	Recipient	Eligible AFVs
SB-1257 Utility User Tax Exemption	Exemption of public vehicles from local user tax	CA Tax Board	G	PHEV, BEV, CNG
California Low Carbon Fuel Standard (LCFS)	Carbon credits with values ranging from $28 to $51 per credit[1]	CARB	C G	All
DGS EV Charging	Free charging in state lots and discounted parking	DGS, DOT	G	PEVs, FCEV
ARFVTP	Up to $100 million annually in grants.	CEC	C G	All
EVCS Financing	Up to $500,000 for EVCS installation in workplaces	CA Treasurer	C	PEVs
AB8 Hydrogen Fuel Cell Infrastructure	$20 million annually until 100 FCEV fueling stations have been built statewide	CEC	C G	FCEV
CA Alternative Energy and Advanced Transportation Financing (CAEATFA)	Sales and use tax exclusions ($100M) PACE Loss Reserve Program ($10M)	State Treasurer	C	Advanced transportation technologies
Clean Vehicle Rebate Project (CVRP)	Rebates: $5,000 for hydrogen FCVs $2,500 for 100% EVs $1,500 for PEVs $900 for motorcycles	CARB, CSE	I C G	FCEV, BEV, PHEV
Hybrid and Zero-Emission Truck and Hybrid Voucher (HVIP)	$8,000 – $65,000 depending on truck weight, fleet size, and PHEV vs. BEV	CARB CALSTART	C G	PHEV, BEV
HOV Lane	N/A	CA DMV	I C G	BEV, FCEVs
Advanced Tech Demo Projects	Varies	CARB	C G	All
Accelerated Vehicle Retirement	$1,000- $1,500 for retiring vehicles that failed their last smog test	CARB	I	ICEVs

[1] Values based on 2014 sales

Table 16. Local AFV Programs

Program	Incentive Value	Administrator	Recipient	Eligible AFVs
Clean Vehicles Feebate Program	$25 million annually towards purchase of more fuel-efficient vehicles	ABAG/MTC	I	Varies
Vehicle Buy-Back/ Purchase Incentive	$120 million annually	ABAG/MTC	I	PHEV, BEV
Climate Initiatives Innovative Grants	$226 million annually in grants to decrease GHG emissions	ABAG/MTC	G	Varies
Regional Electric Vehicle Charger Network	$80 million for EVSE installation at workplaces, commuter hubs, and other destinations	ABAG/MTC	C	EVSE
PG&E EV Rate Plans	Special rate plans for customers who charge electric vehicles at home	PG&E	I, C, G	EVSE
Charge! Program	$5 million initially, $10k to $600k per applicant	BAAQMD	G	EVSE
Public Agency PEV Rebate Program	$2,500 for each qualified BEV or FCEV; $1,000 for each PHEV purchased or leased by a public entity	BAAQMD	G	PHEV, BEV
Light-Duty EV Program	Grant funding for Light-Duty ZEV and PZEV Vehicles in fleets; $ TBD	BAAQMD	C,G	PHEV, BEV, FCEV
Heavy-Duty EV Program	Grant funding for fleet ZEV and PZEV medium & heavy-duty vehicles and urban buses; $ TBD	BAAQMD	C, G	PHEV, BEV, FCEV
Property Assessed Clean Energy (PACE)	Financing for renewable energy upgrades to buildings	San Mateo County	I, C	EVSE

Program Descriptions: Federal

A variety of different tax credits or other kinds of incentives have been offered by the federal government to encourage alternative fuel use in recent years. The following section describes the programs listed in Table 14 in greater detail. Descriptions are grouped based on the aspect of the AFV life cycle that they are designed to target.

Alternative Fuel Production and Use

Excise Tax Credits

Certain uses of alternative fuels are eligible for an excise tax credit or refund to be issued to the ultimate user of the fuel by the IRS (IRS, 2013). Excise taxes are often paid during bulk purchase of a fuel from a producer, and are typically passed on to the final buyer by being included in the price of the product. Covered fuels included biodiesel, renewable diesel, CNG, LPG, liquefied hydrogen and mixed alternative fuels. These credits expired at the end of 2013, but were retroactively reinstated for 2014.

Alternative fuel uses that are eligible for excise tax credits include use:

- for farming purposes
- off-highway business purposes
- in a boat engaged in commercial fishing
- in a school bus
- in a qualified local or intercity bus
- by a blood collector
- by a nonprofit educational organization
- by a state entity
- in an aircraft of vehicle owned by an aircraft museum
- in any boat operated by the United States for its exclusive use or for war purposes

Recently signed legislation modifies the highway excise tax on LNG so that it is now based on energy content, rather than volume, bringing the tax on LNG into parity with that of diesel. This will reduce the excise tax on LNG from $0.41 per diesel gallon equivalent (DGE) to $0.24 per DGE.

Website: http://www.irs.gov/publications/p510/ch02.html#en_US_201406_publink1000302016

Renewable Fuel Standard (RFS2)

Under the Federal Renewable Fuel Standard (RFS2), gasoline and diesel refiners and importers are required to purchase a certain amount of renewable fuels annually (40 CFR part 80). This is called their Renewable Volume Obligation, and it corresponds to the amount of gasoline and diesel they produce or import. In order to verify that their obligations have been met, obligated parties must submit renewable fuel credit verification to the EPA. These tradable credits are called Renewable Identification Numbers (RINs), which are generated through the production of biofuels. One RIN corresponds to 1 gallon of ethanol equivalent, and equivalencies are based on energy content.

Depending on the feedstock and production method, ethanol, LPG, biodiesel, and biogas may all generate RINs. Each type of RIN has its own price, and the value of RINs varies with supply and demand. As of July, 2014, the value of most RINs was close to 50 cents (OPIS, 2014), although it has ranged from several cents to over a dollar depending on the year and the type of RIN (United States Energy Information Administration, 2013). RIN sales provide an added source of revenue for renewable fuel producers.

Website: http://www.epa.gov/otaq/fuels/renewablefuels/index.htm

AFV Infrastructure Development

Refueling Equipment Tax Credit (Expired)

In 2013, the IRS offered a tax credit for installation of refueling equipment for alternative fuels, which included any fuel that was at least 85% ethanol, natural gas, CNG, LNG, LPG, or hydrogen, as well as B20 and electricity. The credit was worth either 30% of the cost of the property or $30,000 for business properties, whichever was less, and 30% of the cost or $1,000 for personal property, whichever was less.

Website: http://www.irs.gov/pub/irs-pdf/f8911.pdf

Zero Emissions Airport Vehicles and Infrastructure Pilot Program

The Federal Aviation Administration (FAA) has implemented the Zero Emissions Airport Vehicles and Infrastructure Pilot Program. This pilot program allows the FAA to provide funds to airports that wish to purchase zero emission vehicles (ZEVs) for use within the airport limits or to develop the infrastructure needed to fuel such ZEVs. The federal government will cover 50% of project costs.

Website: http://www.faa.gov/airports/environmental/zero_emissions_vehicles/

Vehicle Manufacture and Purchase

Advanced Technology Vehicles Manufacturing Loan Program (ATVMLP)

The Advanced Technology Vehicles Manufacturing Loan Program (ATVMLP) was authorized by Congress pursuant to the Energy Independence and Security Act (EISA) of 2007 and is administered by the DOE's Loan Program Office. It provides low-interest, minimal fee, long-term loans to manufacturers and component suppliers of ATVs in order to finance engineering integration and reequipping, expanding, or establishing manufacturing facilities in the United States to produce advanced technology vehicles (ATVs). Loans are available for up to 30% of the cost of re-equipping, expanding, or establishing manufacturing facilities in the United States used to produce qualified ATVs or ATV components (DOE, 2013a).

Website: http://energy.gov/lpo/services/atvm-loan-program

FCEV Tax Credits (Expired)

Until January of 2015, hydrogen fuel cell vehicles were eligible for federal tax credits, even if they were not new vehicles. Fuel cell electric vehicle (FCEV) tax credits were based on the weight of the vehicle and the date when it was placed into service. The tax credit for fuel cell vehicles weighing under 8,500 pounds was $8,000 if they were placed into service before Dec.

31, 2009, and $4,000 if they entered service after that date. Heavier vehicles could receive tax credits between $10,000 and $40,000 depending on their weight. This tax credit has expired, but FCEV manufacturers are lobbying for it to be reinstated and reducing vehicle prices in the interim.

PEV Tax Credits

Plug-in electric (PEV) vehicles are the only type of AFV that is currently eligible for federal tax credits. Plug-in electric drive vehicles acquired after Dec. 31, 2009 receive a credit of $2,500. If a vehicle draws propulsion energy from a battery that has 5 kilowatt hours of capacity, it receives an addition $417, plus $417 for each kilowatt hour of battery capacity in excess of 5 kilowatt hours. The maximum credit allowed for a vehicle is $7,500. This credit begins to phase out for a manufacturer's vehicles when at least 200,000 qualifying vehicles manufactured by that manufacturer have been sold for use in the United States. This tax credit applies to any vehicle that has a plug-in electric battery, including both hybrid and fully electric vehicles.

Website: http://www.irs.gov/Businesses/Plug-In-Electric-Vehicle-Credit-IRC-30-and-IRC-30D

Moving Ahead for Progress in the 21st Century (MAP-21)

On July 6, 2012, President Obama signed Moving Ahead for Progress in the 21st Century (MAP-21), reauthorizing surface transportation programs through fiscal year 2014. It is administered by the Department of Transit and the Federal Transit Administration. 65% of program funds must go to distributing grants to government agencies, private companies, or non-profits interested in acquiring or leasing a fleet of low- or zero-emission vehicles. The grant covers up to 80% of the cost of vehicles purchased. (Public Law 113-159, and 49United States Code 5312).

Website: http://www.fta.dot.gov/map21/

Corporate Average Fuel Economy (CAFE)

The Alternative Motor Fuels Act (AMFA) of 1988 created Corporate Average Fuel Economy (CAFE) standards for vehicle manufacturers. CAFE standards are set by NHTSA and the EPA and require vehicle manufacturers to achieve a certain average fuel economy for their annual fleet. Alternative fuels receive a multiplier to incentivize the production of alternative fuel vehicles, which helps to bring down the fleet average. The fuel economy goals and alternative fuel multipliers for years 2017-2021 are shown below in Table 17.

Website: http://www.nhtsa.gov/fuel-economy

Table 17. CAFE Standard Fuel Economy Incentive Multipliers

Year	2017-2019	2020	2021
LDV Fuel Economy (mpg)	36.6 to 40.0	41.7	44.7
FFV	based on actual usage		
CNG	1.6	1.45	1.3
PHEVs	1.6	1.45	1.3
BEV	2	1.75	1.5
FCEV	2	1.75	1.5

Source: Table III-15, from EPA/NHTSA, 2012 Café final rule 2017-2011.

Other

The United States Department of Energy (DOE) also has several funding opportunities that are not specific to any one aspect of the AFV system and may apply to many different projects.

For one, it provides loan guarantees to projects that reduce air pollution and GHG emissions or employ "new and significantly improved technologies" as compared to conventional "commercial technology" (42 United States Code 16513). DOE may issue loan guarantees for up to 100% of the amount of the loan for an eligible project.

Website: http://energy.gov/lpo/services/section-1703-loan-program

DOE's Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs are designed to support technological innovation through investment in small companies. These funds are typically distributed through competitions, where the winning company gets the full grant funding. Clean energy for use in vehicles is named as one of the main research topics for which companies are encouraged to apply.

Website: http://www.sbir.gov/about/about-sbir

The DOE has also been involved in setting up Clean Cities Coalitions throughout the United States. There are currently close to 100 Clean Cities Coalitions and 18,000 stakeholders nationwide. Coalitions are composed of local governments, fuel providers, vehicle manufacturers, national labs, and NGOs, all of whom are working together to reduce petroleum consumption from transportation and increase alternative vehicle use. The Clean Cities program assists with funding and financial opportunities, education and information resources, technical assistance, and coordination of multi-state fleets. The Clean Cities program reports that it is on track to meet its goal of saving 2.5 billion gallons of petroleum per year by 2020. Within the Bay Area, Oakland, San Francisco, and San Jose each have their own Clean Cities Coalitions.

Website: http://www1.eere.energy.gov/cleancities/

The DOE has another program aimed at company workplaces called the EV Everywhere Workplace Charger Challenge. The program encourages companies to take the Workplace Charging Challenge by pledging to install charging stations at the workplace to meet employees charging needs. In return, the DOE offers technical assistance, informational resources, and an information-sharing forum.

Website: http://energy.gov/eere/vehicles/vehicle-technologies-office-ev-everywhere-workplace-charging-challenge

Program Descriptions: California

California State also has many of its own incentive programs designed to encourage the use of alternative vehicles. Many of these are the result of various climate change laws, such as AB32, SB 375, and the executive orders outlined in Chapter 1.

AB 118 Air Quality Improvement Program

In 2007, Assembly Bill 118, known as the California Alternative and Renewable Fuel, Vehicle Technology, Clean Air, and Carbon Reduction Act of 2007, was signed into law in California (Nunez, 2007). AB 118 approved the use of $200 million annually through 2015 to fund air quality programs and support alternative fuel technology development. Currently funded programs include the following:

- Clean Vehicle Rebate Project
- Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project
- Advanced Technology Demonstration Projects
- Truck Loan Assistance Program

The first three programs are described in greater detail in the sections that follow. The Truck Loan Assistance Program is not specifically targeted at alternative vehicle technology and is not discussed.

Website: http://www.arb.ca.gov/msprog/aqip/aqip.htm

Alternative Fuel Production and Use Programs

SB-1257 Utility User Tax Exemption for Public Transit Vehicles

In 2012, the California legislature passed a bill that exempts vehicles used for public transit from any utility user tax imposed by a local jurisdiction on the consumption of CNG or electricity dispensed by a separately metered unit dedicated to providing fuel to motor vehicles (Hernandez, 2012). This refers to utility taxes levied at the local level, and is intended to ensure statewide uniformity of service and cost of providing public transit during the transition to increased alternative fuel use.

Website: http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201120120SB1257

CA Low Carbon Fuel Standard (LCFS)

California's low carbon fuel standard (LCFS) is designed to reduce the greenhouse gas emissions from transportation fuels inside California. An executive order was passed in 2007 that called for a reduction in the carbon intensity of California's transportation fuels by 2020 of at least 10%. A fuel's carbon intensity is measured in grams of carbon dioxide equivalents (gCO_{2e}) per unit energy (MJ) of fuel and is quantified on a lifecycle basis. The California Air Resources Board (CARB) became responsible for implementing this standard in 2009, and the law went into effect in 2011.

The LCFS utilizes a market-based trading mechanism to facilitate the reduction of statewide carbon emissions with minimal economic harm. All producers of petroleum based transportation fuels (typically gasoline and diesel) sold in the state of California are considered regulated parties. Renewable fuel producers of low carbon intensity products can opt into the system in order to be able to sell carbon credits to the regulated parties. Yearly CI targets are reduced each year until 2020, at which point the state should have achieved a 10% reduction from 2010 levels.

Each regulated fuel provider is required to ensure that the carbon intensity of the suite of fuels they produce meets the carbon intensity target for that year. Refiners have three options for complying with the CA LCFS. The first option is to blend low carbon intensity fuels into petroleum-based gasoline and diesel to lower the aggregate CI of the fuels they produce. The second option is to buy or produce low CI fuels to lower the average carbon intensity of their suite of fuel products. The third option is to buy carbon credits from producers of low CI fuels in the carbon credit market (ARB, 2009). The value of these carbon credits provides an added incentive for fuel producers to engage in the production of alternative fuels.

During the period from 2011 through mid-2013, a net excess of LCFS credits were generated, totaling 61% over the credits required to cover the generated deficits. Of the total credits generated in that time, 71% came from ethanol, 9% came from CNG and biodiesel (BD) each, 6% came from renewable diesel (RD), 3% came from LNG, and under 2% came from electricity. During that period, however, the portion of credits from ethanol decreased and the portion of credits from biodiesel and renewable diesel increased (Yeh, 2014).

The price of an LCFS credit has varied over time. According to CARB, the average price of a credit at the start of 2012 was $16. This price rose steadily to over $55 in Q3 of 2013, and then to $85 in mid-November (Yeh, 2014). The price dropped again in December of 2013 to about $50, although the quarterly average for Q4 of 2013 was $70 (CARB, 2014e; Yeh, 2014). The average credit price was $17 in 2012, $55 in 2013, and $31 in 2014. For the most recent Monthly LCFS Credit Transfer Activity Report, October of 2015, the average credit price was $60.

Website: http://www.arb.ca.gov/fuels/lcfs/lcfs.htm

DGS Free Charging and Parking

California Public Resource Code 25722.9 requires that that The Department of General Services (DGS) and the Department of Transportation (DOT) develop AFV parking incentives in all public parking facilities of 50 spaces or more operated by the DGS and park-and-ride lots owned and operated by the DOT. Some DGS parking is available only to state employees, while some lots are publically accessible. So far, 8 out of its 19 statewide garages have EV charging stations. State employees who drive a BEV, PHEV, or FCEV are eligible for discounted monthly parking of up to 55% off, first priority parking permits, and first-come first-served EV charging at reasonable hourly rates. DGS has contracted with the company Charge Point to install and manage EV stations in its lots. Charging is limited to 4 hours maximum, and you must be charging in order to be parked in an EV charging spot.

Website: http://www.dgs.ca.gov/dgs/About/parking.aspx

AFV Infrastructure Development

Alternative and Renewable Fuel and Vehicle Technology Program (ARFTVP)

In 2007, California created the Alternative and Renewable Fuel and Vehicle Technology Program (ARFVTP), to be administered by the California Energy Commission (CEC). ARFVTP is currently approved by the legislature through January 1, 2024. The ARFVTP is a widely applicable grant program that includes biodiesel, ethanol, biomethane, electric, hydrogen, propane, and natural gas fuels in its definition of eligible alternative fuels. The program's

objective is to develop and deploy alternative and renewable fuels and advanced transportation technologies. The program is expected to distribute up to 1.5 billion dollars by 2024. The annual budget is approximately $100 million for projects that include (but are not limited to):

- Produce alternative and renewable low-carbon fuels in California.
- Retrofit medium- and heavy-duty on-road and non-road vehicle fleets to alternative technologies or fuel use.
- Expand fuel infrastructure, fueling stations, and equipment.
- Expand infrastructure connected with existing fleets, public transit, and transportation corridors.

Website: http://www.energy.ca.gov/altfuels/

Electric Vehicle Charging Station Financing Program

Loans in the Electric Vehicle Charging Station Financing Program (EVCS) can be used for the design, development, purchase, and installation of qualified electric vehicle charging stations in the State of California. The charging station must be accessible to the business owner's employees, the general public, or to the tenants of a multi-unit dwelling.

The maximum enrolled loan amount is $500,000 per qualified borrower, and can be insured for up to four years (though the actual term of the loan can be longer). Lenders set the terms and conditions of the loans and decide which loans to enroll into the EVCS Program. The EVCS Program contributes 20% of the principal balance enrolled to a loss reserve account. CalCAP will contribute an additional 10%, up to a maximum of 30%, if the installation is in a multi-unit dwelling or located in a disadvantaged community as designated in the CalEnviroScreen 2.0.

Website: http://www.treasurer.ca.gov/cpcfa/calcap/evcs/summary.asp

AB 8 and FCEV Requirements

The same bill that creates the ARFTVP, Assembly Bill 8, specifies several requirements that are particular to FCEVs. For one, it requires the DMV to track the number of FCEVs that are sold or leased in CA each year. It also requires that the state board must evaluate, based on the number of vehicles expected over the next three years, "the need for additional publicly available hydrogen-fueling station, geographic areas where fuel will be needed, and station coverage." In addition, the commission must allocate $20 million annually to hydrogen station installation until at least 100 hydrogen fueling stations are operating in the state of California (AB 8, Perea).

No hydrogen fueling stations are open in San Mateo County currently, but several are already in various phases of permitting and construction. The ARB and the California Fuel Cell Partnership (CaFCP) have identified the locations for 68 fueling facilities that they intend to build by 2016, 4 of which are in San Mateo County. This is expected to provide enough coverage for around 10,000-30,000 early fuel cell vehicles.

Website: http://cafcp.org/stationmap

Sales Tax Exclusion

Under SB 1128, Padilla, the California Alternative Energy and Advanced Transportation Financing Authority (CAEATFA) provides a sales and use tax exclusion for advanced manufacturers and manufacturers of alternative source and advanced transportation products, components or systems. "Advanced transportation technologies" is defined in SB 1128 as "emerging commercially competitive transportation-related technologies identified by the authority as capable of creating long-term, high value-added jobs for Californians while enhancing the state's commitment to energy conservation, pollution and greenhouse gas emissions reduction, and transportation efficiency." The law is authorized through January 1, 2021.

Website: http://www.treasurer.ca.gov/caeatfa/

Vehicle Manufacturing and Purchase

Clean Vehicle Rebate Project (CVRP)

The State of California currently offers significant rebates for hybrid, battery electric, and fuel cell light-duty vehicle purchases. The Clean Vehicle Rebate Project (CVRP), a program funded by the ARB, offers $5,000 rebates for hydrogen fuel cell vehicles, $2,500 for 100% electric vehicles, $1,500 for plug-in hybrid electric vehicles, and $900 for neighborhood electric vehicles and motorcycles. Rebates are only offered for the purchase or lease of new, approved vehicles. Nearly 75% of California PEV buyers received rebates totaling more than $150 million since 2010.

Website: https://energycenter.org/clean-vehicle-rebate-project

Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP)

The California Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP) is designed to offset about half of the incremental additional cost of acquiring eligible hybrid and battery-electric medium- and heavy-duty vehicles for both public and private vehicle fleets of any size. Vouchers are available on a first-come, first-served basis and range from $10,000 to $65,000 depending on truck weight and fleet size. The program is in its fourth year, and is slated to continue until 2023.

Website: http://www.californiahvip.org

High Occupancy Vehicle Lane (HOV)

One benefit of owning an alternative fuel vehicle in the state of California is eligibility for single passenger use of the High Occupancy Vehicle (HOV) lane. The California Department of Motor Vehicles distributes two kinds of decal stickers for AFVs, white and green. White clean air vehicle stickers are unlimited in quantity and are granted to qualifying Federal Inherently Low Emission Vehicles (ILEVs). ILEVs are typically 100% battery electric vehicles, hydrogen fuel cell vehicles, or CNG vehicles. Green clean air vehicle stickers are available to the first 55,000 applicants with transitional zero emission vehicles (TZEV), which typically refers to plug-in hybrids. The green decal limit was originally set at 40,000, but when these were completely exhausted in mid-2014, SB-853 increased the limit by 15,000. This incentive program is approved through January 1, 2019.

Website: http://www.arb.ca.gov/msprog/carpool/carpool.htm

Other

Advanced Technology Demonstration Projects

One of the programs funded by AB 118, the Advanced Technology Demonstration Projects program, serves to help accelerate the implementation of next generation advanced technology vehicles, equipment, or emission controls by funding pilot projects that demonstrate its feasibility. Some examples of previously funded projects include:

- $164,000 to the Bay Area Air Quality Management District for the testing of wind-assist marine demonstrations in San Francisco Bay ferry boats
- $1,000,000 for the purchase of zero-emission off-road equipment and vehicles by the ports of Los Angeles and Long Beach
- $1,000,000 for the purchase of electric school buses in San Diego County and Kings Canyon County
- $1,000,000 for the hybridization of an existing marine tugboat for the Port of Long Beach

Website: http://www.arb.ca.gov/msprog/aqip/demo.htm

Voluntary Accelerated Vehicle Retirement

The Voluntary Accelerated Vehicle Retirement program applies to owners of cars that failed their last smog check test. The California Bureau of Automotive Repair (BAR) offers $1,000 to $1,500 in cash (the latter applies only to low-income individuals) for the retirement of older and more polluting vehicles.

Website: http://www.arb.ca.gov/msprog/avrp/avrp.htm

Program Descriptions: Regional & Local

A number of programs exist at the regional or local level as well. The Bay Area Air Quality Monitoring District (BAAQMD) has been highly involved in developing climate change goals for the Bay Area, in collaboration with the Association of Bay Area Governments (ABAG) and the Metropolitan Planning Organization (MPO), responsible for the nine counties that comprise the Bay Area, which includes San Mateo County. BAAQMD has recently begun offering an expanded suite of grants and incentives for public and private fleets to switch to zero emission vehicles and to build supporting infrastructure.

Alternative Fuel Production and Use

PG&E EV Rate Plans

Pacific Gas and Electric Company (PG&E) has introduced two new rate plans specifically designed for customers who intend to charge their electric vehicles at home. The first plan incorporates the EV charging into their total household usage. In the second plan, the EV charging station is metered separately from the rest of the house. Installation of the second electric meter costs $100 but allows a user to distinguish between EV and household electricity usage, and is recommended for customers who will be charging at peak hours. Unlike the standard rates, neither EV rate plan is tiered; the price per kilowatt-hour (kWh) is based only on

the time of day you use electricity (PG&E, n.d.). This allows the utility company to charge low rates to EV chargers during off-peak times and high rates during peak hours so as to encourage EV charging at night when grid loads are lower. Further information about these rates is available in Appendix A.

Website:
http://www.pge.com/myhome/environment/whatyoucando/electricdrivevehicles/rateoptions/

AFV Infrastructure Development

BAAQMD Charge! Program

The Bay Area Air Quality Management District (BAAQMD offers grant funding for the installation of electric vehicle supply equipment (EVSE) or electric vehicle charging stations (EVCS) at Bay Area transportation corridors, workplaces, multi-family dwelling units (MDUs) and trip destination locations. Both public and non-public entities are eligible to apply for funding. The deadline for applications is typically in mid-December, unless funds are exhausted sooner. An initial allocation of $5 million is available for funding. These programs are summarized in Table 18.

- Awards are limited to 75% of eligible project costs incurred, up to the grant award amount limit, which varies by charging station/equipment, equipment ranging from $500 to $25,000.
- Higher funding limits are available for projects that offset grid demand through onsite power generation using zero-emission, renewable sources (i.e. solar, wind) and onsite battery storage.
- Minimum Grant Amount: $10,000 per application (and completed project).
- Maximum Grant Amount: $250,000 per applicant for projects that deploy Level 2 and Level 1 equipment.
- For applicants who proposed projects with DC Fast Chargers, the maximum funding limit is increased up to $600,000 per applicant; however, any additional funding requested above the $250,000 limit may only be used for the installation of DC Fast chargers.

Website: http://www.baaqmd.gov/grant-funding/public-agencies/charge

San Mateo County PACE Program

PACE, or Property Assessed Clean Energy, is an affordable, long-term financing option for energy, water, and renewable energy upgrades to residential and commercial buildings that is repaid on property taxes over a time period of up to 20 years. The tax bill remains with the property in the event of sale. Property owners receive 100% financing of improvement costs and projects can be cash-flow positive from day one. No up-front cash investment is required. Loan recipients can use the funds for solar panel or EVSE installation, both of which contribute to the generation and use of renewable electricity.

Website: https://green.smcgov.org/pace-financing

Vehicle Manufacturing and Purchase

Public Agency PEV Rebate Program

Government agencies may not be eligible for state and federal tax incentives since they do not pay taxes. In order to assist public agencies in the Bay Area with their efforts to green their vehicle fleets, BAAQMD has a PEV rebate program that is open exclusively to public agencies. It provides vouchers of $2,500 for each qualified BEV or FCEV, $1,000 for each PHEV, $500 per zero-emission neighborhood electric vehicle (NEV), and $2,500 per zero-emission motorcycle (ZEM) purchased or leased by a public entity. Each public agency is limited to a maximum of $90,000 in voucher awards per fiscal year.

Website: http://www.baaqmd.gov/grant-funding/public-agencies/pev-rebate

Table 18. BAAQMD EV Incentive Programs

Program	Description	Annual Budget
Light Duty Electric Vehicle (EV) Program	Grant funding is available for the purchase or lease of 3 or more new Light-Duty Zero- and Partial-Zero-Emissions Vehicles in fleets, including plug-in hybrid-electric, plug-in electric, and fuel cell vehicles.	$13 million is available for all EV-related programs
PEV Rebate for Public Agencies	Rebates available to public agencies for the purchase of PEVs. Maximum of $90,000 per fiscal year per agency. See below for rebate details.	$13 million is available for all EV-related programs
Heavy Duty Electric Vehicle (EV) Program	Grant funding is available for the purchase or lease of new Heavy-Duty Zero-Emissions Vehicles in fleets (electric and fuel cell technologies).	$13 million is available for all EV-related programs
Charge! Program	Grant funding is available for the installation of electric vehicle supply equipment (EVSE), or electric vehicle charging stations, at Bay Area transportation corridors, workplaces, multi-unit dwellings, and trip destination locations. Both public and non-public entities are eligible.	Initial allocation of $5 million. Min Grant Amount: $10,000 Max Grant Amount: $250,000 to $600,000

Website: http://www.baaqmd.gov/grant-funding

Plan Bay Area

The Sustainable Communities Strategy for the Bay Area was published in 2013 as part of its Regional Transportation Plan, referred to as Plan Bay Area (CARB, 2014c). Authored by the

ABAG, BAAQMD, Metropolitan Transportation Commission (MTC), and the Bay Conservation and Development Commission (BCDC), Plan Bay Area lays out the proposed programs and their corresponding funding. The Climate Initiatives portion of the budget was allocated $630 million for eight programs intended to support further reduction of GHG emissions in the region through the following initiatives (see Table 19):

Table 19. Plan Bay Area Climate Initiative Programs

Program	Description	Annual Budget
Clean Vehicles Feebate Program	Charges one-time fee on less efficient vehicles and provides up-front rebate to those purchasing more efficient vehicles.	$25 Million
Vehicle Buy-Back/Purchase Incentive Program for Plug-In Electric Vehicles	Consumers can trade in less efficient vehicles and receive cash incentive toward the purchase of a new PHEV or BEV	$120 Million
Regional Electric Vehicle Charger Network	Helps overcome some of the cost barriers to EVSE installation by providing financial assistance to employers, retailers, etc.	$80 Million
Smart Driving Strategy	Education campaign on driving styles to save fuel and rebates for real-time fuel efficiency gauges.	$160 Million
Car Sharing	Expands car sharing services allow people to rent cars by the hour.	$13 Million
Vanpool Incentives	Enhance the region's existing vanpool program, by reducing the cost of van rentals.	$6 Million
Commuter Benefit Ordinance	Requires employers with 50 or more employees to offer incentives for employees to use a commute mode other than driving alone.	N/A
Climate Initiatives Innovative Grants	Grant program to reduce GHG emissions from the transportation sector.	$226 Million

Source: (CARB, 2014c)

Program Descriptions: Private Sector

A number of private companies are also offering discounts or financing to support AFVs and AFV infrastructure locally.

ChargePoint® EVSE

ChargePoint® is a company that supports an expanding public charging network for electric vehicles by offering financing to retailers who want to install EV charging stations, and providing real-time station location and availability information to EV drivers. ChargePoint is currently the world's largest EV charging network, with over 18,000 DC charging stations, and the most open, meaning its network can operate any hardware, not just its own (chargepoint.com).

Auto Insurance Discounts

Many auto insurance providers give a discount to drivers of AFVs in the state of California. Farmer's Insurance offers 10% off to dedicated AFVs using ethanol, compressed natural gas, propane, or electricity, and HEVs (CARB, 2015b). AAA offers 5% off to drivers of factory-built hybrid vehicles, as well as automobiles that use ethanol (E85), natural gas or propane (calstate.aaa.com).

Propel Fuels

Propel® is a company that focuses on distribution of E85 (85% ethanol) and renewable diesel fuels. It also offers financing to retailers looking to incorporate capacity for providing these fuels at their new or existing retail locations. They assist retailers with permitting, construction, and marketing, and pass on grant based savings of up to 50% of the equipment and installations costs up to $100,000. Propel also offers a discount to fleet managers who purchase more than 500 gallons of biodiesel blends and E85 monthly. Fuel purchasers can qualify for a rebate of $0.03 per gallon for purchases of less than 1,000 gallons of biofuel per month, and $0.05 per gallon for purchases of 1,000 gallons or more per month (propelfuels.com).

Volta Charging Stations

Volta offers construction and management of level 2 EV charging stations in public retail locations at no cost to the host. The stations are funded by advertising, which is displayed on a screen on the charger itself. Volta's service is entirely turnkey; they install the station and take care of maintenance, technical support, and electricity costs (voltacharging.com).

Table 20. Summary of Government Offered AFV Incentives

	Federal	State	Regional/Local
Fuel	Excise tax credits	SB-1257 Utility User Tax Exemption for Public Transit Vehicles	PG&E EV Rate Plans
	Renewable Fuel Standard	LCFS	
		DGS Free Charging	
Infrastructure	Zero Emissions Airport Vehicles and Infrastructure Pilot Program	Alternative and Renewable Fuel and Vehicle Technology Program (ARFTVP)	BAAQMD *Charge!* Program
		EVCS Financing for Small Businesses	
		AB 8 and Hydrogen Fuel Cell Vehicles	Plan Bay Area EV Charger Network
		SB 1128 Sales Tax Exclusion	SMC PACE Loan Financing
Vehicle	Advanced Technology Vehicles Manufacturing Loan Program (ATVMLP)	Clean Vehicle Rebate Project (CVRP)	BAAQMD Public Agency PEV Rebate Program
	PEV Tax Credits	Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP)	BAAQMD Light- and Heavy-duty EV Fleet Funding
	MAP-21	SB 1128 Sales Tax Exclusion	MTC Feebate Program
	CAFE Standard	High Occupancy Vehicle Lane (HOV)	MTC PEV Buy-Back Program
Other	DOE Loan Guarantees	AB 118 Advanced Technology Demonstration Projects	One Bay Area Innovative Grants Program
	DOE Clean Cities Coalitions		
	DOE EV Everywhere Workplace Charger Challenge	Voluntary Accelerated Vehicle Retirement Program	
	DOE Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR)		

CHAPTER 4:
Challenges to Infrastructure Development and AFV Deployment

Alternative fuel vehicles are a crucial part of California's strategy to combat climate change and other transportation-related health and environmental impacts. The market for AFVs contains more options today than ever before. However, challenges to widespread adoption could slow or even derail their contribution to these important environmental goals. A thorough analysis of the challenges facing AFVs at a state and local level is needed to ensure that AFV markets succeed at this pivotal moment.

A variety of California workshops, documents, and initiatives have already been undertaken to identify and address these various challenges. Past initiatives have involved infrastructure site and density planning to ensure adequate refueling availability (e.g. the Hydrogen Highway Blueprint Plan), funding and grants to incentivize vehicle purchasing and infrastructure development (e.g. AB 118, BAAQMD's PEV Charger Deployment Program), and discussions and assessments of past efforts (e.g. ZEV Action Plan, Hydrogen Infrastructure NREL Workshop). A few examples of these initiatives are listed below:

- 2013 & 2015 ZEV Action Plans (Governor's Office)
- Hydrogen Highway Blueprint Plan (CARB)
- Refueling Infrastructure for Alternative Fuel Vehicles: Lessons Learned for Hydrogen Workshop (NREL)
- AB 118 Air Quality Improvement Investment Plan (CA State Assembly)
- State Alternative Fuels Plan AB1007 (CA State Assembly)
- Plug-in Electric Vehicle (PEV) Charging Station Deployment (BAAQMD)

Alternative fuel vehicles differ from gasoline and diesel vehicles on a variety of attributes. Table 21 displays a selection of conventional and alternative fuel vehicles from model years 2014 and 2015 and compares them on various attributes that are important to consumers. An attempt is made in this table to compare similar cars, but it should be kept in mind that none of the ICEVs is a direct substitute for the paired AFV. All vehicle costs may vary due not only to the AFV technology but also aspects such as brand, cargo capacity, interior trim, styling, and other luxury attributes. In some cases, no comparable vehicle exists, such as the Chevrolet Volt, the Nissan Leaf, and the Tesla Model S.

This table highlights many of the factors that consumers consider when purchasing an AFV, such as driving range, fuel economy, fueling time, vehicle cost, and fuel savings. Some of these attributes, such as driving range or fueling time, are more limited for AFVs than petroleum-based ICEVs. AFVs do offer other benefits, including lower and more predictable fuel costs and environmental benefits on both a local and global scale. The potential fuel savings shown in Table 21 are calculated relative to a gasoline vehicle that is driven 12,000 miles per year and has a fuel economy of 24 miles per gallon.

Table 21. Convenience Attributes of Popular Vehicles[1]

Year, Make, and Model	Typical Range (mi)	EPA Fuel Economy	Fueling Time (various sources)	Minimum Vehicle Cost pre-Incentives	Fuel Savings over 5 years (vs 24 MPG)[3]
2015 BMW 328d S8 (Dies)	555	37 MPG	5 min	$38,900	SAVE $3,186
2015 BMW 328i 2L 4cyl S8 (Gas)	427	27 MPG	5 min	$37,400	SAVE $908
2014 BMW i3 A1 BEV	81	124 MPGe	120V: 20 hr, 240V: 3.5 hr	$41,350	SAVE $6,247
2015 Toyota Prius PHEV	540 total (gas + elec)	95 MPGe (gas + elec)	120V: 3 hr 240V: 1.5 hr	$29,990	SAVE $5,839
2015 Toyota Camry (Gas)	476	28 MPG	5 min	$22,970	SAVE $1,168
2014 Ford Focus FWD FFV	372 gas/285 E85	30 gas/23 E85	5 min	$16,310	SPEND $355 (assumes E85 use only)
2014 Ford Focus A1 BEV	76	105 MPGe	120V: 18-20 hr 240V: 4 hr	$29,170	SAVE $5,898
2015 Hyundai Tucson FCEV[2]	265	50 MPGe	5 min	$499/month lease, 36 mo.	Fuel Included
2015 Hyundai Tucson 2WD A6 2L 4cyl (Gas)	376	24 MPG	5 min	$21,650	$0
2014 Honda Civic AV 1.8L 4cyl CNG	193	31 MPGe	Fast fill: 5 min Time fill: 8 hrs	$26,740	SAVE $3,829
2015 Honda Civic AV 1.8L 4cyl Gas	436	33 MPG	5 min	$18,290	SAVE $2,230
2015 Chevrolet Volt PHEV	380 total (gas + elec)	98 MPGe (gas + elec)	120V: 10-16 hr 240V: 4 hr	$34,170	SAVE $5,910
2015 Nissan Leaf S BEV	84	114 MPGe	DCFC: 30 min 240V: 8 hr	$29,010	SAVE $6,078
2014 Tesla Model S 85-kWh BEV	265	89 MPGe	Super: 30 min 240V: 40 min-2 hr	$79,900	SAVE $5,489

1. fueleconomy.gov, 2. hyundaiusa.com, 3. United States Energy Information Administration. (2014).

The experience of driving an AFV may require adjustments in expectations and behavior on the part of the driver. Nonetheless, in order to be competitive with the status quo, AFVs must:

- Offer beneficial attributes (fuel savings, air quality improvements, HOV lane access)
- Maintain or compensate for positive attributes of ICEVs (e.g. shorter range but ability to charge the vehicle at home)
- Have fueling costs that are the same as or less than conventional fuels
- Have life time vehicle costs that are comparable to petroleum-fueled ICEVs.

This chapter addresses the requirements of task 3 of C/CAG's agreement with the CEC and reviews the different challenges facing alternative fuel infrastructure development and AFV adoption. Chapter 4 identifies issues associated with:

- Zoning and parking policies
- Local building codes
- Permitting and inspection processes
- Training and education programs
- Public outreach.

Our research shows that the challenges facing AFV adoption, AFI development, and local readiness for AFVs falls into four main categories:

1. Economic challenges:
    - Vehicles and infrastructure have high up-front costs relative to gasoline and diesel.
    - Grants and incentives may be difficult or complicated to obtain.

2. Technical challenges:
    - Alternative fueling station density for most fuels is currently low.
    - Vehicle and fueling station hardware systems may be incompatible across technologies.
    - Most AFVs have a smaller driving range than ICEVs.
    - Recharging/refueling time for some AFVs takes much longer than for ICEVs.

3. Regulatory challenges:
    - Local rules and regulations may need to be updated to ensure that building and zoning codes apply to alternative fuels.
    - Permitting processes may move slowly due to unfamiliarity and caution on the part of government officials and building inspectors.

4. Educational challenges:
    - Consumers are wary of new and unfamiliar technology.
    - Consumers and investors are unaware of incentive programs.

- Consumers don't have full understanding of economic and environmental benefits of AFVs.
- Emergency responders need additional training on alternative fuels.

This chapter will review these economic, technical, regulatory, and educational challenges and Chapter 5 will propose potential policy solutions that can help to address them and ensure that San Mateo County is ready to handle the growing AFV population.

Economic Challenges

Most vehicle operators are accustomed to the costs of petroleum-fueled vehicle options. In contrast with gasoline and diesel internal combustion engine vehicles (ICEVs), AFVs have higher up-front costs but lower lifetime maintenance and fuel costs. This trade-off requires an adjustment in the way vehicle purchases are approached. Individuals must learn to view alternative fuel vehicle purchasing as an investment that pays off over time.

Alternative fuels are needed to power these new vehicles. However, infrastructure development is often costly and may not offer fast returns on investment (ROI), making it a relatively unappealing opportunity for traditional private investors. The infrastructure for most alternative fuels is still in the early stages of development.

Vehicle Cost

The cost of alternative fuel vehicles is an important concern for many potential buyers since AFVs cost more at the time of purchase than a conventional vehicle of comparable specifications. (See Table 21 for comparison of select vehicle models and Chapter 3 for a discussion of incremental vehicle costs). The cost of AFVs is expected to decrease over time due to economies of scale, but for the time being, their up-front cost is still expensive relative to that of conventional vehicles (Albert, 2014). Consumers may also have concerns about liquidity risk, since the resale value of a vehicle built with new technology is uncertain (Albert, 2014).

AFV buyers may be individuals or fleet managers. This distinction is important because purchasing priorities have been shown to differ between the two groups. Individual buyers have reported that the most important attributes for their purchasing decision are quality (90%) and safety (88%), followed by value (83%), performance (82%), and design (65%) (Consumer Reports, 2013). Fleet managers, on the other hand, are less concerned about design than about price, life cycle cost, and serviceability (Albert, 2014). Additionally, fleet managers may be limited by an inability to shift budget allocations or by rigid overhead restrictions that prevent them from accounting for the higher upfront price but lower lifetime fuel and maintenance costs (Albert, 2014).

Consumer priorities are also constrained by the amount they are able to spend on a vehicle. Luxury vehicle buyers may have different priorities than economy or second hand car buyers. Respondents in a 2013 Navigant survey on attitudes towards electric vehicles reported that 71% expected to pay $25,000 or less on their next vehicle after incentives, and 43% planned to spend less than $20,000 (Vyas, 2013). At those prices, many AFVs currently on the market are out of

reach for the average consumer. Luxury consumers, on the other hand, are not price sensitive and are more motivated by the performance attributes of a high-end vehicle like the Tesla Model S, which was rated as the number one large luxury vehicle of 2015 by US News and World Report based solely on its performance, beating out many ICEVs such as the Porsche Panamera and the Audi A7 (U.S. News, 2015). These are very different markets, but ultimately AFVs will have to appeal to both.

Drivers are aware of the incremental cost differential between AFVs and ICEVs, and respond positively to initiatives that neutralize it. In a 2013 survey of PEV owners, the state Clean Vehicle Rebate Project (CVRP) incentive was listed as a significant factor in their purchasing decision by 95% of respondents (CSE for ARB, 2013). The Center for Sustainable Energy collects data about the motivations of individuals who apply for rebates under the CVRP. In the Bay Area, over 80% of respondents said that federal tax incentives and state rebates were at least moderately important in their decision to buy a PEV.

The potential for cost savings from lower fuel prices is a major motivator for AFV consumers. In March of 2015, there were 5,680 total respondents from the Bay Area who had completed the Clean Vehicle Rebate Project (CVRP) survey, which is typically done at the time of purchasing an AFV. CVRP survey results from applicants who purchased their PEV between September 2012 and December 2014 found that economic issues were at the forefront of consumer motivation. Table 22 displays Bay Area respondents' primary motivations for getting a BEV or PHEV. The number one motivation was "saving money on fuel costs" (30%).

Table 22. CVRP Survey Respondent Motivations for Purchasing a PEV (% Total Respondents)

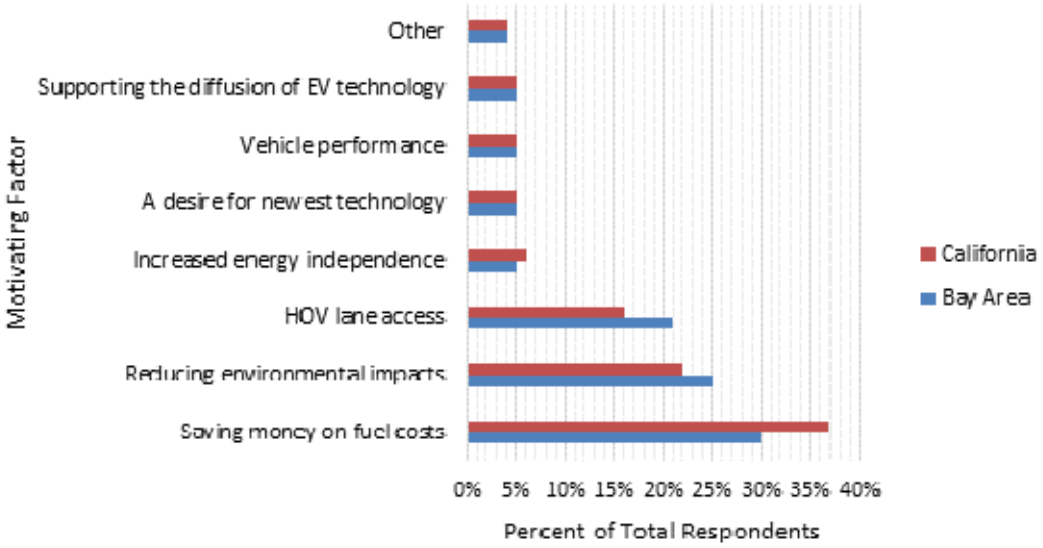
Primary Motivation	Bay Area	California
Saving Money on Fuel Costs	30%	37%
Reducing Environmental Impacts	25%	22%
HOV Lane Access	21%	16%
Increased Energy Independence	5%	6%
Desire for Newest Technology	5%	5%
Vehicle Performance	5%	5%
Supporting Diffusion of EV Technology	5%	5%
Other	4%	4%

Source: Center for Sustainable Energy (2015). California Air Resources Board Clean Vehicle Rebate Project, EV Consumer Survey Dashboard. Retrieved October 24, 2015 from http://cleanvehiclerebate.org/survey-dashboard.

Figure 21 shows the motivations of PEV buyers in the Bay Area, and compares them to the motivations of buyers statewide. The trends in the Bay Area reflect a greater concern for environmental benefits and HOV lane access than are present statewide but a lower concern for the potential for saving money on fuel costs. Survey data shows the average PEV buyer to date is well-educated, high-income (75% have an annual household income greater than or equal to $100,000), and lives in a detached single family home (Center for Sustainable Energy, 2015). As the PEV market matures, many of the early adopters will have already bought vehicles, and

manufacturers will need to interest less adventurous or less wealthy populations with their cars.

Figure 21. PEV Buyer Motivations in California versus Bay Area



Source: CSE for ARB. 2015. EV Consumer Survey Dashboard. http://cleanvehiclerebate.org/eng/survey-dashboard

The PEV data above shows that the future challenges of AFVs are:

- Current AFV buyers were high income early adopters, but expanding the AFV market will require a broader customer base.
- Apartment dwellers face unique hurdles when attempting to install home charging stations.
- New customers must be educated on the environmental and economic benefits of AFVs.

Fueling Infrastructure Cost

Developing and installing the infrastructure that is needed to provide alternative fuels to AFV owners is necessary but expensive. The cost of developing a refueling station varies widely based on the ground footprint, tank storage requirements, fuel and pipeline availability, and many other factors. EV charging stations are the least costly type of alternative fueling station to install since they have the smallest footprint and need only be connected to the existing electric grid network, whereas hydrogen and natural gas fueling stations, which require storage tanks and have a larger physical footprint, are much more expensive and may cost much more than the price of a conventional gasoline station to install. (See Table 10 in Chapter 2 for additional detail about infrastructure installation costs.)

The total cost of installing the 68 hydrogen stations currently planned for CA by the CEC and CaFCP is estimated to be about $65 million, funding which is designated for this purpose in AB 118 and AB 8. These 68 stations are expected to be capable of supporting 20,000 hydrogen vehicles (CaFCP, 2012). The CEC intends to continue funding infrastructure development until

100 hydrogen stations are installed across the state, which is expected to occur by 2018 (CaFCP, 2012).

In a mature market, the cost of developing a refueling site would be borne by private developers. However, the return on investment (ROI) time for AFV stations in most cases currently exceeds a timeframe that would attract traditional investors. It is difficult to generate quick profits with an alternative fueling station, or even to estimate the expected ROI. For one, it is very difficult to accurately predict the future market demand for alternative fuels. For another, it is hard to know which geographic areas will have the highest demand for a particular fuel. Construction loans may also be difficult to obtain from banks when requested for new technologies, because new technologies are considered a higher financial risk and banks have to comply with stricter liquidity rules (Sarah Dougherty, 2014). The interest rate for such a loan is high to compensate for this uncertainty, so investors may require additional incentives to engage in this market. An analysis of retail EV charging station development done by the Center for Climate and Energy Solutions (C2ES) showed that time to ROI under all scenarios modeled exceeded 5 years, making it an unappealing investment opportunity to most developers (Nigro, 2015). For this reason, alternative refueling and recharging sites are typically funded at least partially by public grants.

Technical Challenges

AFVs use new technologies and run on nonconventional fuel sources. They often require an adjustment in consumer habits and expectations due to their operational differences from ICEVs in terms of fueling time, range limitations, and home charging.

In addition, refueling or recharging infrastructure must be in place to support AFV populations, meaning that the two must develop at a comparable rate in each geographic area. Currently, station density for most alternative fuels is low. Manufacturers will not sell a vehicle to someone in a given area until the available supporting infrastructure reaches a density that allows the vehicle to function as intended, implying that infrastructure development should precede vehicle sales by at least a small increment of time. Table 23 summarizes the technical challenges inherent to AFVs, which are discussed in detail in the following section.

Table 23. AFV Technical Challenges

Issue	AFV Impacts	Local Challenge	Solutions (See Chapter 5)
Fuel Station Density	Driving time to fuel station is too long for customer convenience.	Public fueling infrastructure is less than what is needed for 2030 vehicle projections.	Support strategies to increase local infrastructure development.
EVSE Density	BEV drivers need public stations for emergency charging, long trips, and for owners with no home charging.	Free charging at businesses or public stations makes for inefficient use of resource. 12% of residents live in MUDs, which makes it harder to have home chargers.	Charge at least a nominal fee for EV charging. Support regulatory action that enables MUD dwellers to install home chargers.
Range Anxiety	Range anxiety is a limitation for BEV, NGV, LPGVs.	Limited AFI available.	Support strategies to increase local infrastructure development.
Vehicle & Station Coordination	Coordinating vehicle/station will support driver access and minimize station cost.	Ensure that public infrastructure is sufficient for demand and geographically strategic.	Endorse proper signage for AFI stations. Support strategies to increase local infrastructure development.
Alternative Fuel Supply	CA needs low CI fuels to achieve LCFS goals.	Fuel production resources in SM county are limited. These include waste for Bio CNG, solar for EV and hydrogen. Other fuel production technologies require further development.	Ensure availability of fuels produced in other parts of the county. Support development of local AFI.
Fueling/Charging Time	Long fueling time detracts from customer AFV experience. Primarily a problem for BEVs, and some kinds of CNG station.	Need rapid charge stations to achieve PEV alliance goals.	Implement streamlined permitting for EVSE.
Hardware Compatibility	Vehicle refueling hardware may not be compatible with all stations.	Need for AFV and AFI hardware compatibility in existing stations.	Support regulations to require refueling compatibility standards.
Fuel Station Layout	Codes require offset distances for fuel station layout and public garages.	Many cities have not yet adopted standards for alternative fuel stations.	Innovative station layouts can comply with codes and standards. Permit officials need to be aware.

Infrastructure Density Needs

Alternative fuel vehicles suffer from a chicken-and-egg problem: vehicles cannot be operated without fuel, but retailers have no reason to sell the fuel without consumer demand. Currently, both AFVs and alternative fuels are relatively scarce. PEV driver satisfaction with public charging infrastructure availability was only at 23% in 2012 (CSE for ARB, 2013). This is notable since the EV charging infrastructure is the best developed network of all the alternative fuels in California currently. That said, in the past three years, the availability of EVSE has increased substantially, and it very possible that PEV driver satisfaction has increased. The availability of hydrogen fuel, natural gas, biodiesel, and E85 is still quite limited throughout the Bay Area and the state. Table 24 shows the number of public stations of each fuel type operating in San Mateo County and California in 2015.

Table 24. Number of Public Alternative Fueling Stations in 2015

Fuel Type	San Mateo County	California
Biodiesel B20/RD	1	33
Compressed Natural Gas	4	152
Ethanol-85	1	74
EV Level 1*	22	718
EV Level 2*	253	5228
EV DC Fast*	22	469
Hydrogen	0 (4 Planned)	10
Liquefied Natural Gas	0	14
Liquefied Petroleum Gas	1	278

*Charging points, not retail stations.
(AFDC, 2015)

Table 24 shows that the public infrastructure for PEVs is the most abundant of the alternative fuels at this time. PEVs are the most prevalent type of light duty AFV operating in California, partially due to the relatively low price of EV supply equipment. Of the different alternative fueling stations, EVSE also takes up the least space and is the easiest to permit.

Hydrogen fueled vehicles are experiencing relatively rapid growth, and are currently receiving financial support from the state. However, FCEVs are still exceedingly rare, with the first commercially available passenger vehicles only reaching the market in 2015. There are no hydrogen stations operating in San Mateo County currently, but four are commissioned in the county and slated for development in 2015, with one out of the four scheduled to be operational in 2015 and the other three in 2016. Once these local fueling stations are operational, vehicle manufacturers will begin marketing FCEVs to the Bay Area.

Natural gas has become more appealing as a vehicle fuel in recent years due to its abundant domestic supply and low price compared to most other fuels. Public natural gas refueling infrastructure, on the other hand, is still quite scarce and expensive to install. As shown in Table

24, four public CNG stations are open in San Mateo County at this time. The high cost of CNG infrastructure is due to the compression technology and storage tanks required and because installation of a CNG station may require an additional pipeline to connect the fueling station to the utility's natural gas pipeline supply. LNG is typically delivered via truck but is more costly to produce than CNG (Hurst, 2013). As a result, NGVs are currently most prevalent among fleet owners who can afford to install a private NGV fueling station for their fleet, either connected to a pipeline or with an onsite tank. Navigant Research anticipates that 1,325 NGV stations will be added in the US between 2014 and 2022. The majority of these stations will be CNG and not LNG (Hurst, 2013).

Biodiesel and E85 dedicated pumps are also relatively rare. Only one station in San Mateo County, the Propel station in Redwood City, has pumps dedicated to biodiesel or renewable diesel and E85. However, both ethanol and renewable diesel are already being mixed in, to a small degree, with gasoline and diesel in conventional petroleum products. All the gasoline in the state contains 10% ethanol. Renewable diesel is indistinguishable from petroleum based diesel, and may be mixed into a diesel supply without notifying consumers.

Alternative Fuel Supply

In some cases, there may be concern about the availability of the alternative fuel itself, or the ability to transport it to the place where it is needed. This is primarily a concern with hydrogen and electricity, but could become a concern if supply of any alternative fuel falls.

While the United States electric grid as a whole has the capacity to support an increase in PEV charging, problems may arise at the local grid level (California ISO, 2014; Gerkensmeyer, 2010). Electric power is not evenly distributed nationwide, and it may not be possible to transmit enough energy to a specific location at a time of increased demand. Newer electric cars draw two to five times more energy than those made just a few years ago, and the faster they charge, the more power they draw at one time. PEVs are also more popular in certain areas than others, such as the Bay Area and Los Angeles, meaning the increase in load demand is likely to concentrate in specific locations in the grid.

Utility companies are already responding to the increased load demand in areas of dense PEV ownership. Utilities such as PG&E are upgrading the local transmission lines, starting with neighborhoods where people have bought PEVs that they will be charging at home (Bullis, 2013). PG&E has also created rate plans to incentivize off-peak EV charging, such as the PG&E EV-A and EV-B rate plans described in Appendix A. This more evenly distributes charging throughout the day.

Under SB 1505, hydrogen fuel used throughout the state must achieve an average 30% reduction of GHG emissions on a well to wheel basis as compared to gasoline and be produced from 33% renewable energy. The bill also requires a 50% reduction in well to tank NOx and hydrocarbon emissions and no increase in toxic air contaminants (Lowenthal, 2006). Fuel producers rely on electrolysis of water or steam reforming of natural gas to isolate hydrogen gas. Producing the needed supply of hydrogen with these renewability constraints may be challenging for non-electrolysis based hydrogen.

The current supply of natural gas is abundant in the United States due to recent advances in oil extraction and hydraulic fracturing techniques. However, hydraulic fracturing has received criticism due to the potential for water and environmental contamination. Alternatively, entities may choose to convert the organic wastes contained in landfills or wastewater into methane gas via biodigester technology. This methane, which would otherwise escape or be flared, can be cleaned and compressed into CNG. Some entities in San Mateo County, such as South San Francisco Scavenger Company and San Mateo City's Waste Water Treatment Facility, are already capturing their organic waste streams and using the biomethane they produce to fuel CNG vehicles.

LPG, biodiesel/renewable diesel, and ethanol are all produced outside of San Mateo County. Supply is not a major concern with these fuels, and the infrastructure to deliver them is well established.

Range Anxiety

A major concern with many AFV technologies is the fact that most vehicles have a shorter driving range than drivers are accustomed to with ICEVs. This means that the distance an AFV can go before a refuel or recharge is needed is shorter than that of an ICEV. This is of particular concern in areas where the public refueling infrastructure is limited. Trips to more remote areas may be difficult to undertake with an AFV, causing drivers to have legitimate hesitations about relying on an AFV for all their travel needs.

AFV driving ranges vary based on both the type of fuel used and the specific make and model of the vehicle. Table 21 displays the government reported range of a variety of vehicles. With a range of about 400 to 500 miles, plug-in hybrids have a range that is comparable to gasoline and diesel vehicles, and the gasoline they require is widely available. Natural gas fueled vehicles tend to have a relatively long range, around 200 - 250 miles, but have fewer options for refueling than hybrids. FCEVs have a similar range to that of gasoline or diesel powered vehicles, 250 to 400 miles for passenger cars and 16 hours of operation for busses, but the public station infrastructure is still in its beginning stages. FCEVs will likely be most convenient in urban areas for at least the next decade, and rely on strategically placed connecting stations to get between regional hubs (CaFCP, 2012).

BEVs vary widely in their range capacities. Early BEV models have a driving range of about 40-80 miles. However, Tesla has developed battery technology that allows the model S to have a stated range of 265 miles. While the technology that makes this possible was previously protected by patents, in 2014, Tesla made all of its patents open source in the hopes of advancing electric vehicle technology as a whole and encouraging other companies to invest in and develop electric cars (Musk, 2014). The driving range of a BEV can also vary based on driving conditions, such as speed, payload size, hills, temperature, and use of heating or air conditioning (ABAG, 2011).

Surveys of daily driving range have shown that the majority of people drive less than they may think in an average day. The State Department of Transportation (DOT) National Household Travel Survey found that people typically drive about 36 miles per day (Santos, 2011). A survey

of PEV owners conducted by the Center for Sustainable Energy found that 92% of respondents drove their PEV 45 miles a day or less, and that average daily driving range was only 28.9 miles, which coincides with the daily driving habits of non-PEV drivers with similar demographics (CSE for ARB, 2013). In spite of this fact, many drivers still consider the range limitations of AFVs to be problematic. As reported by the CSE in its survey results, "although an overwhelming majority of respondents expressed overall satisfaction with their vehicles, 40% were dissatisfied with their electric range and 57% indicated that a range of 150 miles or more would be needed for extreme satisfaction." (CSE for ARB, 2013). For this reason, many individuals will only consider a PEV as a second car. However, given projected BEV ranges of 150-200 miles for several 2017 models that will cost under $40 thousand, this complaint may soon become outdated (BACC, 2015).

Fueling Time

Another potential concern for drivers is the time required to refuel or recharge a vehicle. Consumers are accustomed to the 5 to 10 minutes it takes to refuel a diesel or gasoline vehicle, and may be reluctant to wait longer for their vehicles to become fully charged/refueled. (Examples of vehicle fueling times are listed in Table 21).

Refueling time depends both on the type of fuel and the type of fueling station. Hydrogen has a fueling time similar to that of gasoline and diesel, making it an easy transition for consumers in this respect. Natural gas fueling times vary based on the amount of compression that the natural gas is under. Fast fill CNG stations take only about 5 minutes, but slow fill stations take approximately 8 hours. The latter can work well in the case of a fleet of vehicles driven during the day and allowed to fuel passively overnight, such as a waste management company or bus fleet.

Electric vehicle charging time depends primarily on the charging level of a particular station, although the battery design plays an important role as well. Charging may be performed at home, work, or public stations. PEV owners who live in single family homes are able to install alternating current (AC) Level 1 or 2 charging stations at home, and can plug their vehicles in to charge them overnight, when electricity loads are low and rates are cheaper. AC Level 1 charging refers to plugging an adaptor into a typical household 120 volt outlet. This level of charging adds about 2 to 5 miles of range to a PEV per hour of charging time (DOE, 2013a). AC level 2 charging units require special installation, and use 240 volts of power in residential locations or 208 volts of power in commercial settings. AC Level 2 charging adds about 10 to 20 miles of range per hour of charging time (DOE, 2013a). Direct current (DC) fast charging outlets are typically located in heavily trafficked areas or along important routes. These stations can add 50 to 70 miles of range in about 20 minutes (DOE, 2013a). Tesla also has its own fast charging 120V DC network, with which only Tesla Model S vehicles are currently compatible. As of July, 2015, Tesla maintains 473 Supercharger stations with 2,660 Supercharger outlets and has plans to build more (teslamotors.com).

Technology Standardization

Electric vehicle charging highlights another potential obstacle to wide-spread adoption of AFVs: a lack of technological standardization can result in incompatibility between AFVs and the few fueling stations that are available. Once a manufacturer has begun using a certain technology, they are invested in it and may be slow to change if something new comes along. This has already occurred in the case of DC fast chargers for PEVs. The plug-in electric vehicle industry has developed several competing standards for Level 3 DC fast charger coupling equipment. The first to be heavily implemented was the CHAdeMO system, and as such it has a head start. The "West Coast Electric Highway" connects the 1,300 mile distance on I-5 between British Columbia to Baja California with a network of Level 3 DC fast chargers. The charging stations are compatible with the CHAdeMO coupler technology. This network runs through the states of California, Oregon and Washington. Each location also has Level 2 charging equipment that is compatible with most PEVs that do not use the CHAdeMO technology (WA DOT, 2014). Nissan has also donated 400 CHAdeMO fast chargers to be built throughout Europe (Nissan, 2012). The CHAdeMO system is used by many of the Japanese companies, such as Nissan, Mitsubishi, Honda, Mazda, Subaru, Kia and Toyota. CHAdeMO can also be used with Tesla Model S cars with an adaptor.

In October of 2012, the SAE published a revision to its J1772 standard for PEV charging. While the original standard had specified only conductive charge coupler and electrical interface requirements for AC Levels 1 and 2 charging, the revised version included DC Levels 1 and 2 fast charging as well, achieved by adding two high current contacts to the AC Level 1 and AC Level 2 charge coupler (SAE, 2012). Most American manufacturers support this technology, commonly referred to as the SAE Combined Charging System (DGS, 2014). However, the SAE Combined Charging System is incompatible with the older CHAdeMO technology, resulting in a contest between the two standards and a challenging situation for American EVSE retailers who wish to serve the whole PEV market.

A third approach to EV charging has been adopted by the company Tesla Motors, which has developed its own proprietary DC Level 3 supercharger. Tesla intends to install superchargers throughout the country that will be available only to Tesla owners. Lifetime charging is included in the price of the Tesla vehicle, and the charging stations will ultimately be solar powered, resulting in zero-emission refueling. Supercharging is available to owners of the 85 kWh and 60 kWh versions of the Model S, but not the 40 kWh version. Superchargers provide a half-charged battery in 20 minutes and an 80% charge in 40 minutes, and are available throughout California, with 473 total stations in the United States as of January, 2015 (Tesla, 2015). San Mateo County has one supercharger currently, located in downtown San Mateo City.

The distribution of EV charging station brands in California is shown in Figure 22 and the corresponding data in Table 25. The pie chart clearly shows that the ChargePoint brand of charger, which uses the CHAdeMo technology, has a large lead on all the other brands. Blink and Nissan, the next most prevalent charging station types, also use CHAdeMO, although Blink's website states that it has plans for its stations to become SAE J1772 compatible as well. SemaConnect stations use the SAE J1772 standard technology, and account for only 2% of the

public stations currently operating in California. Tesla stations, which only work for Tesla owners, account for less than 2%.

Figure 22. Public EV Charger Brands in California[23]

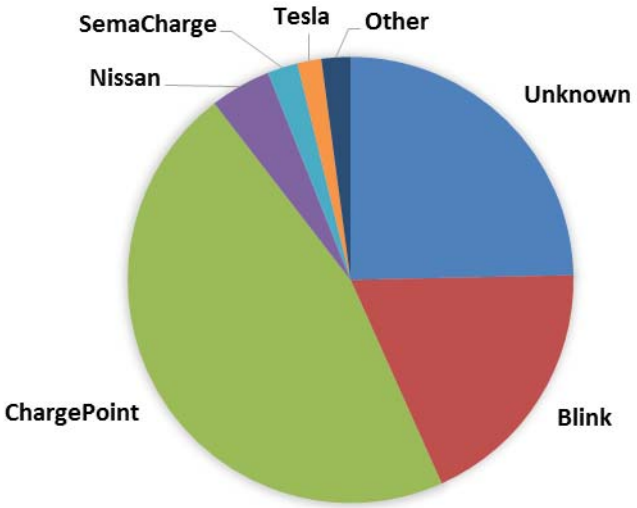


Table 25. EV Charging Outlets in California[11]

Unknown	1444
Blink	1091
ChargePoint	2707
Nissan	259
SemaCharge	129
Tesla	102
Other	123

Regulatory Challenges

Regulatory challenges include any aspect of alternative vehicle fueling and operation that must be regulated or permitted by the government, such as zoning laws, fire and safety codes, permitting, and parking regulations. Regulations around new technologies and alternative fuels are a challenge to both regulators and applicants. In some cases, regulations and codes have only been adopted for gasoline and diesel fuels. Permitting officials, inspectors, and developers

[11] United States Department of Energy, **Alternative Fuels Data Center**. October 21, 2014. http://energy.gov/eere/vehicles/fact-855-january-12-2015-electric-vehicle-chargers-network-and-state

may have a difficult time understanding how these rules apply to alternative fuels. Parking laws may also need to be revised to accommodate PEV charging spots or spots reserved for other types of AFVs, and new signs may be required for both AFV parking and AFI retail stations.

During a 2008 hydrogen workshop in Sacramento, breakout groups voted on the key issues that they believed need to be addressed in future infrastructure plans. Policy and regulatory issues received 29% of all participants' top 5 votes. At the local level, participants recommended that governments: "adopt local policies and codes to facilitate station siting, identify local champions, and build local communication and relationships" (Melaina, 2008).

BAAQMD conducted a survey of Bay Area government departments between March and August of 2012 regarding their level of PEV readiness (ICF International, 2013a). Participation in the survey was quite high, with 86% of all government agencies responding. The survey considered:

- Building Codes
- Permitting and Inspection
- Zoning, Parking, and Local Ordinances
- Stakeholder Training and Education
- Consumer Education and Outreach
- Incentives for Charging

Survey results showed a wide range of PEV readiness levels throughout the Bay Area. The survey found that:

- 1 in 6 Bay Area local governments surveyed have adopted EVSE specific requirements for permitting.
- 9 out of 20 cities in San Mateo County issue same day permits for EVSE.
- Permit fees in San Mateo County range from less than $100 (Brisbane, Redwood City, San Carlos, and Portola Valley) to more than $501 (Menlo Park and Woodside).
- Within San Mateo County, permitting readiness ranged from 21% (Woodside) to 65% (Burlingame).
- 11 out of 20 San Mateo County cities do not have building codes specific to EVSE.
- The majority of Bay Area agencies come close to meeting the BAAQMD PEV permit goal of 24-48 hour permitting at a cost of less than $250; however, approximately 25% reported taking longer than 6 days to issue permits and approximately 20% reported charging more than $250 across all property types (i.e., residential, commercial) (ICF International, 2013a).

Installation of EV home and public chargers is covered under existing local electric codes. However, as shown in BAAQMD's survey, many localities have not developed streamlined permitting for residential EV chargers.

Certain initiatives that are appropriate for PEVs, such as 24 hour permitting, may not be applicable to siting of liquid or gaseous fueling stations since they are more complicated structures. Hydrogen, CNG, and LPG are also relatively new technologies that may not be covered in existing building codes. Standards exist for fueling station layout and construction for hydrogen, CNG, and LPG fuels, but local authorities having jurisdiction (AHJs) may not have adopted these standards in their building code.

Biodiesel and ethanol are likely to be covered under local building codes, but may not fall under conditional use permitting language. Conditional use permits are issued when an existing petroleum station is being used to dispense alternative fuels. Modifying the station to dispense a different fuel than gasoline, such as E85 or biodiesel, may conflict with the conditional use permits even though modifications to the stations are limited.

Conversations with site developers that took place in the course of this project revealed that permitting issues were of primary concern for many developers, who reported that the cost and time involved with seeking approval for AFI construction was an important economic factor. In many cases, when applying for permits, planners will request developers engage in additional activities such as landscaping, beautification, or adapting surrounding areas for Americans with Disabilities Act (ADA) compliance. For developers working with very small profit margins and a long-term ROI, these added requirements may cause the entire project to be infeasibly costly. Streamlining the permitting process, ensuring that code and regulation language on AFVs and AFI is clear and well understood by government staff, and considering exemptions from add-ons like landscaping helps to remove obstacles to infrastructure development.

Zoning and Codes

Zoning laws are used to regulate the land use activities allowed in different areas (Rubin, 2013). Zoning rules in California are determined by the local AHJ, including both long-term general plans and specific questions of zoning and permitting (Rubin, 2013). As such, the rules may differ significantly from jurisdiction to jurisdiction, presenting a challenge to site developers since they will probably be planning fueling stations across jurisdictions. New or unconventional technologies may not have been considered in zoning laws as they are currently written, or the way the language applies to alternative fuels may be unclear. For example, some jurisdictions may have language specific to hydrogen fueling stations in industrial zones but not in commercial zones, while others may group all automotive fuels together, thereby implicitly allowing hydrogen in commercial zones (Rubin, 2013). This leaves the interpretation up to the individual and leads to confusion for both the site developers applying for permits and to the government officials who must approve them.

While zoning and land use decisions fall to local governments, building codes are primarily developed at the state level. Cities and counties in California are required to enforce Title 24 building standards. However, local governments can adopt local laws that modify state building standards “under limited circumstances to accommodate local climatic, geological or topographical conditions” (Rubin, 2013). Title 24 also include more stringent voluntary standards that local jurisdictions can choose to adopt.

Permitting

Construction of any kind of alternative fueling station will likely require several different government issued permits. Most permits fall into one of two categories: construction permits, or permits for operation, either of which could require onsite inspection first (Hewett, 2007). Station construction takes place in multiple stages, which guide the timeline for completing all of the required components and obtaining the necessary permits. The following list was developed specifically for hydrogen station construction, but the same steps are likely to be involved with construction of any liquid or gaseous fueling station.

1. Preliminary project scoping
2. Station design
3. Approval process
4. Station/dispenser construction
5. Station/dispenser startup
6. Station/dispenser operation
7. Station/dispenser maintenance

(Rivkin, 2012)

As shown in Table 26, many permits, obtained from a variety of agencies, may be required throughout the building process.

Table 26. Hydrogen Fueling Station Permitting Requirements

Permit	Agency	Permit Scope
Construction	Building Department	Permit to Construct General/ Address safety construction issues
Drainage	Engineering Department	Permit to Construct Drainage/ Modify sewer drainage
Site grading	Engineering Department	Permit to Construct Grading/ Modify site elevation
Electrical	Building/Electrical Dept.	Electrical Permit/ Modify electrical service
Demolition	Building Department	Construction Permit/Demolish structures required for dispenser construction
Food services	Health Department	Food sales
Air emissions	Bay Area Air Quality Management District	Air Quality Permit or No impact declaration
Fire safety	Fire Department	Fire Safety Permit/General fire code compliance
Water quality	Water Quality Mgmt Agency	Liquid discharge to environment

(Rivkin, 2012)

A California Environmental Quality Act (CEQA) review is required when a project "may cause either a direct physical change in the environment or a reasonably foreseeable indirect change

in the environment" (CA Natural Resources Agency, 2014). Depending on the scope and footprint of the project, some types of AFI development may require a CEQA review while others may not. For example, EV charging stations typically do not require a CEQA review, whereas a hydrogen refueling station typically does (Rubin, 2013). Authorities having jurisdiction may also have the power to exempt an AF station from a CEQA review based on its contribution to the public good.

Hydrogen fueling stations have rigorous setback requirements. For example, according to the National Fire Protection Association, a 7,000 psi liquid hydrogen system must be at least 50 feet from the next adjacent wall constructed with combustible material. These constraints, shown in Table 27, add an extra level of difficulty when siting and permitting hydrogen fueling stations as compared to other fuels with less stringent requirements.

Table 27. 2010 NFPA Setbacks for Hydrogen Fueling (7000 psi system)

Minimum Distance from Liquefied Hydrogen to Exposures		
NFPA 55	Nearest adjacent wall constructed of combustible materials	50 feet
Minimum Distance from Outdoor Gaseous Hydrogen to Exposures		
NFPA 55	Air intake openings	30 feet
	Lot lines	30 feet
	Wall openings	30 feet
	Parked vehicles	15 feet
	Buildings (with combustible walls)	10 feet
Separation Distances for Outdoor Gaseous Hydrogen Dispensers		
NFPA 52	Building, adjoining property, source of ignition	10 feet
	Nearest public street or sidewalk	10 feet
	Storage containers	3 feet

(DOE, 2013a)

Signage

Another challenge is the need for clear, affordable, and legal signs. One project developer reported that "the two most difficult permits to get were the permits for signage and for landscaping" (Hewett, 2007). A site developer that gave feedback for this Plan's task force reported that when alternative fuel sellers are leasing space for their machinery at a larger petroleum retail location, tension may develop between the larger and smaller retailer over which signs are displayed. Only a certain number of signs may legally be displayed, and retailers are often reluctant to take down a sign and replace it with the sign of a competing fuel seller. Their revenue from the alternative fuel comes only from the rent they collect from leasing space on their lot, and so the gasoline seller has no incentive to promote the alternative fuel. Cities have authority over street signage regulations, and thus have a large role to play in solving this problem.

Educational Challenges

Current understanding of AFVs and alternative fuels by the public is limited and may include mistaken or outdated beliefs. Educating the relevant stakeholder groups (consumers, government officials, and safety personnel) is essential for the acceptance and safe operation of alternative fuel vehicles. Stakeholders will benefit from learning more about the technology of AFVs, their environmental benefits, their life cycle costs, and the facts about safety requirements for the different fuels.

Consumers

The first stakeholder group that should be considered is consumers, including both individuals and fleet managers who are looking to buy new vehicles and might consider purchasing AFVs. Consumers may not be educated about all the types of AFVs available and will most likely have questions about the costs, technologies, and availability of refueling stations. Education about technological differences from gasoline vehicles can help consumers understand both the costs and benefits of using a given technology. Proper signage and updated online resources are an important part of this outreach since they allow consumers to see the locations and availability of refueling infrastructure for their vehicle.

Many consumers are not aware of the incentives that exist for alternative fuels. Recent surveys found that only one third of Californians are aware that AFV incentives exist and only 17% knew that the State of California offered its own set of incentives (Kurani, 2015). Outreach to consumers can help make them aware of incentives and rebates that will defray some of the vehicle costs.

Some consumers may have mistaken beliefs about the cost of alternative fuel vehicles. 60% of respondents in a 2013 Navigant study somewhat or completely agreed that electric vehicles are less costly to own in the long run than gasoline-powered vehicles (Vyas, 2013). For the remaining 40%, an increased awareness of the lifetime costs of an EV may change their position on purchasing one. Consumers may assume that alternative fuels are more expensive, when in fact, significant potential savings can result for AFV drivers due to lower costs to charge/fuel the vehicle and less required maintenance over time because AFVs do not have many of the internal components of traditional engines that require maintenance, repair, or replacement (Rubin, 2013).

Consumers may also have questions about the reliability of new technologies. According to a 2013 DOE study, “consumers faced with choices about unfamiliar features may question not only the value of the feature but also its potential impacts on vehicle reliability and maintenance costs” (Stephens, 2013). Consumers may also delay purchasing an AFV because they believe that earlier models are still prototypes and later models will be an improvement; or they may wait to learn from the experiences of others about performance, maintenance costs, and the availability of support (Stephens, 2013). Increased education about vehicle attributes and reliability can help to relieve those concerns about AFV technologies that are unwarranted. In 2013, 92% of PEV owners who replied to a CSE survey on plug-in vehicles reported overall satisfaction with their vehicle purchase and said they drive their PEVs an average of 910 miles

per month (CSE for ARB, 2013). A survey of AC Transit FCEV bus drivers also found high levels of satisfaction with handling, ride quality, and noise levels (T. Lipman, presentation at H2 workshop 5/21/2015). Making potential consumers aware of this high satisfaction rate may make them less skeptical of the relative newness of AFV technologies.

The Center for Sustainable Energy, which distributes CA's AFV rebates, collects survey data on information sources that were helpful to consumers researching their PEV purchase. The number one information source was manufacturer websites at 54%, followed by blogs, discussion forums, and friends, family, and colleagues. Government agencies were a key source of information for only 19% of respondents, indicating significant room for improvement in government outreach activities.

Local Government officials

The second group that should be targeted in educational outreach activities is government officials themselves. Government officials will be responsible for regulatory activities concerning AFVs and AFI and must be educated both on the technologies themselves and on the laws and codes that apply to them. Planning officials need to consider how land zoning rules apply to alternative fueling stations and parking areas. Permitting officials need to know what is required under the law when they receive permit requests for charging stations, fuel storage tanks, and liquid fueling infrastructure development sites. There are many training resources on this topic, many of which are covered in Chapter 7, which focuses on communication and outreach.

Safety officials

First responders and safety personnel need additional training to be fully prepared for emergencies involving alternative fuels in San Mateo County. The safety concerns around AFVs and AFI may be significantly different from those of gasoline and diesel. It is important for fire officials to understand what these concerns are when issuing permits for fuel generation or refueling equipment, and for first responders, such as fire fighters and EMTs, to understand how to safely handle alternative fuels in cases of emergency.

Alternative fuel training is not currently required for fire or other safety workers in California. A first responder safety training survey conducted by the California Center for Sustainable Energy (CCSE) found that out of 79 responding fire departments, 52% did not offer their staff training on AFVs (CSE, 2013). Respondents said the primary reasons for this were a lack of funding (63%) or lack of time (45%). However, with the expected growth in AFVs in California, this may soon pose a safety concern for both safety responders and the public at large. In fact, all kinds of first responders may need training on AFVs, not only fire officials. Over 60% of respondents believed that it was very important that paramedics and emergency technicians receive training in AFVs as well (CSE, 2013).

Over two thirds of fire departments reported that their fire fighters had received some level of training on AFVs (CSE, 2013). At the time of the survey, department trainings had covered the following fuels:

- hybrid and electric vehicles (over 50% of fire departments)
- natural gas (19%)
- hydrogen/fuel cell vehicles (13%)
- propane (11%)
- biofuels (9%).

Training rates of fire fighters on AFVs and AFI is highest for PEVs, but even 50% is still relatively low. Fire departments may need to give more priority to AFV training in future as the number of alternative vehicles increases throughout the state. The key obstacles appear to be time and funding. Training materials and resources are also included in this report. (See Chapter 6).

Most first responder trainings are conducted in house (41%), indicating a need for trainings that prepare the in-house trainer to properly disseminate this knowledge (CSE, 2013). That said, safety experts say that hands-on learning is critical to proper training on AFVs, and that this is best performed at a dedicated off-site training facility, which would likely require an increase in both time and funding allotted to trainings on this topic (CSE, 2013).

In San Mateo County, first responders report having had limited training on PEVs and little to no training on the other types of alternative fuels. As part of this project, fire and police marshals were contacted to assess the needs of first responders and provide support around gaining access to those resources. For additional information on emergency training in San Mateo County, see Chapter 6.

Technicians & Auto Dealers

While AFVs typically require less maintenance than ICEVs, technicians will need special new training to understand the mechanics of each vehicle type in order to fix any problems that arise as a result of accident or malfunction. Training courses are available at local colleges or online, and more information on these resources are described in Chapter 6.

Automotive dealerships are a key point of contact with potential AFV buyers. The more educated the dealers are regarding the trade-offs and benefits of AFV ownership, the better informed consumers will be when making vehicle purchase choices. In many cases, drivers will simply choose to bring their cars to the dealership for maintenance, and training for dealerships will be provided by the auto manufacturers themselves.

Local Factors for San Mateo County

In order to support C/CAG in developing effective local policies, it is important to highlight not only statewide and regional issues, but those factors that uniquely apply to San Mateo County.

Silicon Valley is a hotbed for technological innovation, and this extends to automotive research as well. Tesla Motors was founded in the Bay Area and is headquartered in Palo Alto. Many other car manufacturers are also setting up research divisions in Silicon Valley, including Ford, BMW, General Motors, Honda, Mercedes-Benz and Nissan-Renault (Baker, 2015).

San Mateo County and the Bay Area in general have shown exceptionally high rates of BEV purchases compared to the state and the nation. Cumulative BEV purchases outnumber PHEV purchases about 7 to 3 in 2015. In spite of this fact, only about half of the cities in San Mateo County issue same day permits for EVSE, permit fees range from under $100 to over $500, and 11 out of 20 cities have no building code specific to EVSE.

A variety of factors, including high income levels and local culture, has led to high ownership rates of BEVs in Silicon Valley, especially the luxury Model S from Tesla. A 2013 analysis of the 25 highest income zip codes in the United States found that in the 8 zip codes located in California, the Tesla Model S was the most registered vehicle in 2013, with purchase rates as high as 15.4% of all new cars registered in Atherton, 11.9% in Los Altos Hills, and 11.2% in Portola Valley (Caldwell, 2013).

Four new hydrogen stations are expected to open at locations through San Mateo County in 2015-2016, including stations in South San Francisco, Foster City, Redwood City, and Woodside. Six more hydrogen stations are in development throughout the peninsula and into San Jose. Toyota's fuel cell Mirai FCEV, listed at $57,500 before rebates, will become available at 8 dealerships nationwide in the Fall of 2015. Three of those dealerships, San Francisco Toyota, Stevens Creek Toyota in San Jose, and Toyota Sunnyvale, are in the Bay Area, indicating high confidence in demand for hydrogen vehicles here.

Government fleets and transit vehicles are seeing increased regulatory pressure to begin converting their fleets to zero emission vehicles. This would mean requiring a certain percentage of new vehicles purchased be either battery or hydrogen powered electric vehicles. The only public transit agency operating in San Mateo County is SamTrans, which has an annual ridership of 12.6 million people and operates 75 bus routes throughout San Mateo County and into parts of San Francisco and Palo Alto. Conversations with fleet managers at SamTrans revealed that they currently operate all their buses on clean diesel. In the past, they have experimented with hydrogen fueled buses and found them to be overly expensive to purchase and run. Given this experience, SamTrans anticipates converting its fleet to battery electric buses in the long term, which is possible for this agency since its bus routes typically do not exceed 80 miles in driving range.

Appendix B contains several case studies of entities in San Mateo County producing or selling alternative fuels, including:

- Propel Fuels, a company that sells biodiesel, renewable diesel and E85
- South San Francisco Scavenger, a waste management company that is producing CNG from municipal waste
- San Mateo Waste Water Treatment Facility, a regional waste water treatment plant that is producing CNG from waste water.

CHAPTER 5:
Increased Procurement Strategies for Alternative Fuel Vehicles

Chapter 4 describes the many challenges to widespread adoption of alternative fuel vehicles (AFVs). To summarize them, first, vehicle purchasing and infrastructure development require significant up-front investments. Second, the technological differences between AFVs and ICEVs involve an adjustment of behavior and expectations on the part of drivers. Third, in many cases, regulations around zoning and permitting of alternative fuel vehicles and infrastructure are often somewhat unclear. And fourth, the benefits of and funding opportunities for AFVs are not well understood by both the government and the public.

Existing policies and incentives are already having a large effect on the growth of alternative fuel vehicles in California and San Mateo County. Car manufacturers, fuel providers, and consumers are taking advantage of the state and federal incentives described in Chapter 3.

Local policies are another important piece of the puzzle. Local governments can work to connect local communities with state and federal opportunities and inform stakeholders of their existence. Local governments also have some power to incentivize AFVs and AFI in local communities. The local role has traditionally involved zoning and permitting of fuel stations and providing emergency response support. Local authorities collect a share of fuel tax, and have their own local vehicle fleets. These policy areas provide the primary tools for local jurisdictions to influence AFV adoption.

Chapter 5 fulfills elements of task 2, task 3, and task 5 of C/CAG's agreement with the CEC. The objectives of this chapter are to analyze potential policy options and feasible local strategies and best practices to incentivize AFV purchasing and increase alternative fuel availability. Chapter 5 discusses a variety of strategies to increase procurement of alternative fuel vehicles by considering:

- local zoning, parking, and permitting policies and incentives
- government fleet conversion to AFVs
- government impacts on alternative fuel infrastructure building
- alternative fuel price incentives

This chapter reviews the policy framework for vehicle and fuel regulation and explores options for local government and private entities to support AFV adoption. First, the framework for vehicle and fuel polices is reviewed to provide a context for opportunities at the local level. Next, the anticipated scope of policies is reviewed, particularly policy options available to local governments that could fit with the traditional role of local government and the expectations of participating with state GHG goals. Policy options and general strategies to address challenges to the AFV markets are presented throughout the chapter.

The authors of this report expect that the policy initiatives of greatest interest to C/CAG and its member cities are fuel and technology neutral. Fuel taxes, restrictions on driving, mandates for one particular type of fuel, and similarly prescriptive options are therefore not examined here. Table 28 shows the scope of traditional state, federal, and local policies, as well as the type of policy options not considered in this chapter. State and federal taxes provide existing policy support for alternative fuels as described in Chapter 3.

Table 28. Scope of Typical Local and Regional Policies

Traditional Local Role • Zoning, permitting, and land use planning • Education and outreach • Local fuel and vehicle sales taxes • Government fleet operation
State and Federal Role • Fuel taxes and tax incentives • Income tax and tax incentives • GHG and criteria pollutant regulations
Policy Options Not Considered • Fuel or vehicle specific mandates • Fuel or carbon tax • Vehicle driving restrictions

Policy Context

The patchwork of policies and incentives described in Chapter 3 includes state, federal, and local initiatives. These policies address all the stages of the alternative fuel vehicle's life cycle, including fuel production, fuel transport, infrastructure development, fuel retail, and vehicle sales.

Federal regulations provide several key incentives, such as the renewable fuel credits from the RFS2 and the incentive for car manufacturers to increase the fuel economy of their fleets because of CAFE standards. Updates to the CAFE standard in 2007 allowed for a credit trading provision. This was one of the primary motivations for manufacturers to increase production of FFVs, which brought down the fleet average of OEMs. The same incentive is now present for

other alternative fuel vehicles. However, the RFS2 expires in 2022. Federal tax credits are available for many AFVs, but these tax credits expire annually and must be readopted. State and federal policies need to be persistent and reliable in order to effect long-term change. These incentives are primarily the result of laws and executive orders, and their long term future is often under debate. For example, in 2014 the hydrogen fuel cell vehicle credit expired and was not extended into 2015, to the disappointment of FCEV manufacturers. Local input to legislators can provide support for the long-term persistence of these state and federal policies.

California has its own mix of vehicle and fuel policies including AB32, AB1493, the LCFS, and SB375. These policies provide support for incentives and encourage local entities to achieve GHG reduction goals. Some of the incentives target fuel producers and vehicle manufacturers to bring down the costs of AFVs and alternative fuels. Others are available to retail customers to bring down the up-front price of alternative fuel vehicles. Accessing these incentives may require education for local entities, including consumers, investors, and government agencies, that are not accustomed to developing fuel projects or purchasing AFVs.

Table 29 reviews the existing range of alternative fuel policies that apply to land use, vehicle regulations, and fuel production at the three main levels of government (federal, state, and local). For further detail on these policies, see Chapter 3.

To demonstrate how these policies apply throughout the life cycle of an alternative fuel vehicle, consider a fully electric BEV. Since the electricity is used to power a vehicle, that electricity is eligible for both LCFS credits and RFS2 RINs. We can imagine this electricity is dispensed from a public charging station, which was partially funded by the California ARFVTP or BAAQMD EV Charging Program. The electricity powers a BEV, the up-front cost of which was reduced by a $2,500 state rebate and a $7,500 federal tax credit. Its driver also benefits from HOV lane access in California. This is only one example of how the various policies play into the life cycle cost analysis of an AFV.

Table 29. Existing Alternative Fuel Policies

	Land Use	Vehicles	Fuels
Federal	• ATVMLP loans	• CAFE standards • Vehicle tax credits	• RFS2 • Excise tax credits
State	• SB-1128 sales tax exclusion • ARFTVP infrastructure funds • AFI tax credit • HOV lane access • AB 8 Hydrogen Infrastructure Funds	• Carl Moyer Program • ZEV mandate • CVRP rebates • AB 1493 • HVIP truck & bus vouchers • Accelerated vehicle retirement rebate	• AB32 • LCFS carbon credits • SB 375 • SB-1257 public transit tax exemption
Local	• BAAQMD PEV charging station deployment program • One Bay Area grant program • Reserved parking • Streamlined construction permitting • Develop AF friendly codes and zoning	• BAAQMD public agency PEV rebate program • BAAQMD vehicle buyback programs • Local government contracts can require AFV use by contractor	• Climate Action Plans • PG&E EV rate plans

Framework for Local AFV Policies

Fuel policies can be described as a three legged stool supported by the following three categories: fuel regulations, vehicle regulations, and land use and building codes. Policies within each of these categories can include governmental actions ranging from federal to state and local initiatives.

Local policy makers have many tools available to support AFV development, although some policy areas are out of the scope of local control. However, local decision makers do have authority over decisions about participation in regional GHG reduction plans, zoning and permitting, education, and local fuel and sales taxes. Table 30 summarizes the role that local jurisdictions can choose to play in the major policy categories that affect the AFV markets in California currently.

Table 30. Local Role in AFV Policies

Policy Category	Local Role
State and federal taxes and incentives	Support continuation of AFV friendly policies. Provide outreach and education to consumers, government officials, and manufacturers.
California State GHG Initiatives (e.g. AB32, LCFS, SB375 and SB471)	Coordinate local GHG plans to meet state GHG reduction targets.
Local zoning and permitting	Streamline AFI permitting process. Create AFV friendly zoning rules.
Local fuel and vehicle sales tax	Allow exemptions for fuels or vehicle sales taxes as appropriate.
K-12 Education & Public Outreach	Propose to school board that alternative fuel vehicles be covered in schools. Outreach to local communities to build AFV awareness.

This chapter provides a range of possible local policy options and reviews the role of existing state and federal policies. The rationale for considering different local policy options will be discussed in detail throughout this chapter. Each policy suggestion is intended to address at least one of the following four goals:

1. Promote financing strategies and incentive opportunities that reduce economic barriers to AFV purchasing and AFI development.
2. Support public-private partnerships and other innovative public and private solutions to the technical challenges of low fueling station density, range anxiety, fueling time, and hardware compatibility.
3. Implement policies to reduce regulatory friction around permitting, zoning, and codes as they apply to alternative fuel infrastructure development.
4. Expand education and training opportunities for government officials, fire and safety workers, and the general public on the use and benefits of AFVs.

Economic Strategies

Economic challenges are a key barrier to the increased use of AFVs. For one, the upfront cost of the alternative fuel vehicle is often significantly higher than that of a comparable gasoline or diesel vehicle. In many instances (PEV, diesel car, and CNG) the vehicle purchase price is higher than a conventional gasoline vehicle but the fuel price is lower. The vehicle operators may incur lower life cycle costs but the upfront cost remains an issue.

This intuitive conclusion is supported by several studies. Navigant Research (Vyas, 2013) found that 71% of survey respondents were unwilling to spend more than $25,000 for a new vehicle. A vehicle price modeling and market research study led by EPRI found that luxury car buyers were willing to pay about $5000 up-front for long-term fuel savings and environmental

attributes associated with PHEVs, but economy car buyers were only willing to pay $300 for the same attributes (EPRI, 2001). This analysis is consistent with the market segment that has purchased PEVs to date.

The refueling infrastructure needed to support AFVs also requires a large up-front investment. As described in Chapter 2, installation costs can range from as low as $500 for a home EV charging unit up to $1 million for a natural gas or hydrogen fueling station. In addition, initially low vehicle populations may not create the fuel demand necessary to generate fast payback times for investment cost. On the other hand, consumers will not purchase vehicles without knowing the supporting infrastructure is available. In many cases, the solution to this problem will involve building stations that are not fully utilized at their inception.

Vehicle Cost

In most cases, the up-front cost of purchasing an AFV is a primary barrier for drivers. However, consumers may be able to reduce those costs by taking advantage of incentives or innovative purchasing strategies that make AFVs more affordable for both individual consumers and fleet managers. The following strategies offer buyers a variety of ways to reduce the vehicle cost.

Incentives: As discussed in Chapter 3, many incentives exist at local, state, and federal levels to bring down the purchase price of AFVs. California's state Clean Vehicle Rebate Program rebates cover up to $5,000 for FCEVs and $2,500 for PEVs. This money is directly available at the time of purchase to both tax paying entities and government entities. Federal tax incentives may be worth as much as $7,500 for PEVs. The FCEV tax credit expired in 2014 and is currently being appealed by FCEV manufacturers, who are now heavily subsidizing their cars instead.

Consumers can already benefit from state and federal incentives when buying qualified AFVs. In addition, local governments have the ability to create tax incentives if they decide it is a good investment in the long-term. Exempting vehicle purchasers from sales taxes can generate further savings for consumers. To even the playing field between AFVs and ICEVs, local governments could exempt buyers from sales tax on the incremental price of the AFV as determined by the taxation authority. The sales tax for San Mateo County is 1.5%, and with city sales taxes added to that, the exemption would amount to around 2%. For an incremental EV price of $9000, the incremental sales tax would be $180.

Leasing: The immediate cost of alternative fuel vehicles may also be diminished by spreading that cost out over time. Vehicle leasing allows a consumer to pay for a vehicle slowly instead of having to make the full payment up-front. Consumers can lease a car to own, or, as with the Hyundai Tucson Fuel Cell Vehicle, obtain a temporary lease that includes maintenance and fuel. Leasing is also an important tool for government fleet managers who want to capture tax incentives like the federal plug-in electric drive motor vehicle tax credit, which can range from $2,500 to $7,500. Since governments have no tax liability, they may not see an obvious way to capture this value. However, partnering with local vehicle leasing agencies allows both governments and dealers to benefit. Lenders such as the Nissan Motor Acceptance Corporation and Ford Financing offer capital-leasing options that allow government fleets to buy vehicles at a cost that incorporates the tax credit (Rubin, 2013).

Aggregate purchasing: Aggregate purchase programs allow manufacturers to reduce costs because purchases are made in bulk. Volume discounts might be offered to group buyers who make use of "affinity group" distribution channels, such as employers, credit unions, or government coalitions (Schorske, 2011). With 7 million Bay Area residents, many of whom have already shown interest in being first movers in the AFV market, Bay Area EV Council members believe aggregate purchase programs have the potential to drive prices down by approximately 20% (Schorske, 2011). Transit fleet managers can also take advantage of this approach by pairing with other fleet managers that have similar needs. The number of vehicles needed for the combined fleets can bring down manufacturing costs due to economies of scale.

Car sharing programs allow multiple users to contribute toward the purchasing cost of AFVs. Zipcar, for example, has already purchased a large number of PHEVs. Members pay a monthly fee as low as $7 per month and are then able to reserve a car whenever they need one. Car sharing programs reduce the individual burden of vehicle ownership but allow individuals to have access to passenger vehicles when they need them, enabling the community as a whole to afford the relatively higher priced AFV. An EV car sharing program for low-income neighborhoods is currently being piloted in Los Angeles, which will allow higher need communities to experience the reduced air pollution, noise pollution, and convenience of electric vehicles (Sd24.senate.ca.gov, 2015).

Fleet managers may also encounter strict budgeting constraints that do not lend themselves to purchasing AFVs, which have a higher up-front cost but lower costs for fuel and maintenance. In this case, managers may need to restructure the budget allotted to vehicle purchases to account for the life cycle cost difference from ICEVs. For example, the cost of a PEV battery may need to be reconfigured as an operating expense and taken out of the fuel budget (Rubin, 2013). Multi-year fleet budgeting allows managers to offset up-front capital costs by incorporating the lower maintenance and fueling costs over time.

Alternative fuel carbon credits: Fleet operators and retailers can take advantage of credit payments through the low carbon fuel standard (LCFS) for the use of alternative fuels or electricity for vehicle operation. LCFS regulations for EV credit generation say that a fleet operator of a fleet of 3 or more EVs with installed EVSE is eligible to be a regulated party (CARB, 2012). LCFS credits are generated when alternative fuel vehicle fleets are fueled, and can then be sold to reduce the payback time on AFV investments.

Energy service financing: An innovative private sector solution to high up-front vehicle prices is to use an energy service financing approach, wherein the vehicle retailer sells the car for a lower up-front price with the understanding that the consumer will pay back the difference over time based on fuel savings (Sarah Dougherty, 2014). Retailers may offer a similar service-based lease with PEV batteries. The most expensive component of a PEV is its battery (Albert, 2014). Removing the cost of the battery from the initial payment could reduce up-front costs by $10,000 to $15,000. Financing that de-couples the cost of the battery from the purchase price of the car allows retailers and consumers to re-conceptualize vehicle costs. Retailers could potentially bundle battery payments with electricity in a consolidated "pay by the mile"

approach (Schorske, 2011). Decoupling the price of the battery from the price of the vehicle can most easily be achieved by encouraging secondary markets for PEV batteries that have reached the end of their useful life in vehicles, such as grid storage for intermittent renewable electricity (Melaina, 2014). At the point when they are retired, batteries retain the ability to charge up to 70 or 80%, which is insufficient for a vehicle but more than enough to be useful for grid storage purposes.

Summary

Governments can endorse a variety of financing and procurement strategies to make AFVs more affordable. Each strategy's pros and cons must be evaluated by the government agency, private fleet manager, or individual that considers purchasing an AFV. These strategies and their considerations are summarized in Table 31. Specific policies that could be implemented at the local level to encourage and guide AFV purchasing by all consumer groups are summarized below, in Exhibit 1.

Exhibit 1. Local Policy Options: Vehicle Cost & Fleet Procurement

R1	**Incentives:** Facilitate local government access to and education about state incentives, including the Carl Moyer Program, BAAQMD rebates, AB118 funding, and other opportunities. Raise awareness of federal or state tax credits available to individuals and fleet managers. Exempt vehicle buyers from sales tax on incremental price of AFVs as determined by the taxation authority.
R2	**Leasing:** Consider leasing vehicles to reduce up-front cost and allow government agencies to capture tax incentives through a third party.
R3	**Aggregate purchasing:** Engage with other jurisdictions to develop aggregate procurements for government fleets to reduce cost per unit.
R4	**Carbon credits:** Facilitate the sale of LCFS credits from locally owned alternative fuel production and use.
R5	**Energy service cost financing:** Decouple the price of the vehicle from the price of the battery or employ repayment based on fuel savings.
R6	**Budget restructuring:** Implement multi-year fleet budgeting that offsets up-front capital costs by incorporating lower maintenance and fueling costs over time.

Table 31. Alternative Fuel Vehicle Procurement Strategies

Procurement Approach	Description	Pros	Cons
Direct Purchase	Pay full cost of vehicle at time of purchase.	Lower total cost than leasing. No restrictions on resale. Non-complex purchase method.	Large up-front investment. Technology and value risks are assumed by purchaser.
Aggregate Purchase Program	Submit high volume purchase orders to manufacturers to bring down cost per vehicle.	Allows for lower total cost of vehicle.	Requires that purchasers have similar vehicle needs and specifications.
Loan Financing	Vehicle is paid for over a pre-negotiated time period with interest applying to balance of financed amount. Vehicle ownership is transferred after final payment.	Reduces up-front cost and distributes costs over time. A large down payment reduces monthly payments.	Loan interest and processing fees can result in higher total cost of ownership. Technology and value risks are assumed by purchaser.
Vehicle Lease	Vehicle is paid for through monthly payments over pre-negotiated lease term. Leasing company retains title after final payment, with option to purchase.	Allows government entities to capture tax credits. Reduces up-front cost and distributes costs over time. Allows for evaluation without ownership.	Loan interest and processing fees can result in higher total cost of ownership. Some government entities have no-lease policies.
Service Lease	Energy service cost financing allows consumer to pay back vehicle cost over time based on fuel savings. Car sharing programs allow use when needed. Battery service allows decoupling of battery from vehicle price.	Reduces up-front cost of purchase. Reduces risk of maintenance and resale value concerns.	May only be available to larger fleets. Places large onus on service providers.

(Harrigan, 2015; Nigro, 2015)

Fueling Infrastructure Cost

Along with an increasing number of alternative fuel vehicles, San Mateo County will need to accommodate an increase in the number of alternative fueling stations, both public and private. However, high station infrastructure costs and distant returns discourage investment. Local

governments can help to connect private developers with funding or create public-private partnerships. For instance, once funding has been identified, a site must be located and safety and construction permits and inspections will be required. Safety and regulatory concerns involved in constructing and installing alternative fueling infrastructure fall under the local purview as well.

Infrastructure Financing Models

About 100,000 PEVs are already in use in California, and approximately 3,300 of those are in San Mateo County (CVRP, 2015). A wide network of electric charging stations, both public and private, has been installed to support these vehicles. Electric chargers, hydrogen stations, and CNG stations all face the challenge of requiring expensive infrastructure that will be underutilized at its inception. In addition, EV charging takes half an hour at the very least to achieve any substantial charge.

Some of the solutions that have emerged for EVSE financing are also applicable to the financing of hydrogen and CNG fueling stations. Biodiesel, renewable diesel, and E85 will likely follow the same models as gasoline stations. Alternative fueling stations generate revenue for the fuel retailer and station host, although the return on investment time may be longer than is typically desirable for investors from a purely economic perspective. An analysis performed by the state of Washington found that the revenues from building an EV charging station are not sufficient to deliver a return on investment within a 5 year period, a typical maximum timeframe for private investors considering similar projects. However, with government incentives such as grants or low-interest loans, sufficient returns may be generated to merit private investment in alternative fuel infrastructure (Nigro, 2015). Installing an EV charging station in a building can also help station hosts towards attaining green building certification LEED status, an additional benefit for hosts.

Public refueling stations generate indirect revenue for a variety of stakeholders in addition to the station host or owner. Customers who are charging their electric vehicles at retail locations spend an average of 30 extra minutes in the store or surrounding shopping area, presumably resulting in more purchases while they await their vehicle (Rubin, 2013). Retail stations also present an opportunity to target green minded consumers with relevant advertising, which can help to pay for the cost of building the station. These combined stakeholders could be motivated by their indirect profit potential to help support infrastructure development in their area. For example, a group of local businesses could contribute to an annual fund to help subsidize AFI development in that area. This coalition could include:

- Owners of nearby businesses
- Tourism businesses enjoying an increase in visits by individuals traveling in AFVs
- AFV manufacturers and vehicle dealerships
- Advertisers targeting a green minded consumer
- Local businesses who want to be associated with a green brand.

(Nigro, 2015)

Car manufacturers have a direct interest in the construction of AFI. Manufacturers have been known to offer several years of fueling with the price of the vehicle. The lease for the Hyundai Tucson FCEV also includes unlimited hydrogen fueling for the first three years. In some cases, they also choose to build their own infrastructure. Tesla offers free charging with purchase of its BEVs, and has developed a proprietary fast charging technology that it plans to power with solar energy and make widely available for its customers nationwide.

Government entities also have an interest in funding alternative fuel infrastructure when this aligns with their greater climate change and air quality goals. California has very ambitious climate change targets, and a number of programs exist that are specifically focused on reducing emissions from transportation vehicles, such as the LCFS and the ZEV mandate. In order to achieve the goals of an 80% reduction in GHG emissions from 1990 levels by 2050 and a 50% reduction in petroleum use in cars and trucks by 2030, the state will need to convert to a largely alternative fuel vehicle fleet. Grants and incentives are being offered to build momentum around this change, some of which are targeted at increasing AFI development. Public assistance can also take the form of a public-private partnership where government funds the construction of a site and a private company runs and maintains it. Some government agencies, such as the DOE, have offered low-interest loans for alternative fuel infrastructure construction since it is considered a risky investment and therefore carries high interest rates from private banks.

Non-profit organizations have been known to help raise funding for AFI development. For example, the organization Adopt-a-Charger sponsors free EV chargers by collecting donations from corporations, organizations, and individuals (adoptacharger.org). Adopt a Charger matches a sponsor with a charging site and the sponsor agrees to pay for equipment, installation, maintenance, and administration fees for three years. Sites are typically located at popular public destinations like parks, colleges, museums, and beaches (adoptacharger.org).

Some government fleets are already running on alternative fuels and have their own refueling station. If these stations are made available for public fueling service as well as their own fleet needs, this increases the intensity of their use, reducing the return on investment time for infrastructure construction, and also helps meet the demand of alternative fuel drivers in the area. The following list summarizes some of the ways that stakeholders can collaborate to fund public AFI development:

- Engage in public/private partnerships where government funding covers the cost of construction but independent contractors complete construction and manage and maintain the refueling station.
- Take advantage of government grants and incentive programs offering money or other resources to support infrastructure development. (See Chapter 3 for specific programs).
- Create a coalition of stakeholders who stand to gain from the existence of AFI, such as government entities, local businesses, and car manufacturers.

AFI Ownership and Retail Models

Financing and ownership of alternative fuel infrastructure models are similar to those for vehicle purchasing, with some adjustment for the difference in cost and equipment needs. Aside from home EVSE charging, AFI development will be undertaken by private investors or government entities. Infrastructure financing and ownership by both has typically followed one of the following models:

- Outright purchase (cash or bank financed, or funded by government grants);
- Financing through local utility (capital investment by utility, paid back over time through the monthly utility bill);
- Ownership and operation of fueling station by the vehicle manufacturer;
- Capital equipment lease (usually equipment only-- financing with buyout at the end);
- Third party ownership— the alternative fueling site is hosted in an existing station, but the third party owns and operates the site for a fixed monthly price or a price per gallon gasoline equivalent.

(Clean Fuel Connection Inc., 2014; Schorske, 2011)

Public-Private Partnerships

Public-private partnerships generally refer to arrangements whereby a government agency arranges for a service or infrastructure to be provided or maintained by a private company. This is a highly useful concept when it comes to the development of alternative fueling infrastructure. AFI tends to be a low ROI endeavor for investors. However, the government has an interest in protecting public goods like air quality and safe GHG emission levels. Partnerships can take the form of initial funds for privately built stations, fuel subsidies, and others.

The State of California has engaged in a number of these types of partnerships. For example, FCEV manufacturers are partnering with the CEC to help fund the construction of hydrogen fueling stations in California. Honda has pledged $13.8 million to assist FirstElement Fuel in developing at least 12 additional hydrogen stations around the state, in conjunction with the $27 million FirstElement received from the CEC (Hard, 2014). In another case, PG&E, the public utility providing electricity and natural gas to the Bay Area, submitted a proposal to install 25,000 EV charging stations throughout Northern California. The majority of the stations will be Level 2 chargers, and 100 will be DC Fast Chargers installed at key locations. PG&E will install the chargers at no cost to the site manager, and will own the infrastructure but will contract out building and operation of the chargers (PG&E, 2015).

Summary

Local governments have an important role to play in increasing the amount of alternative fuels available in a certain geographic area and smoothing the path for AFI development. Exhibit 2 summarizes many of the policy options local governments can adopt to encourage AFI development in their region.

Exhibit 2. Local Policy Options: Infrastructure Cost

R7	**Open-access stations:** Locate government-owned alternative fueling stations in places where they can also be open to public-access. Charge public consumers to fuel at alternative fuel stations built for government fleets to increase the utilization of such stations and decrease ROI time.
R8	**Low-interest loans:** Obtain grant funding to create a local low-interest loan program. AFI loans may be considered risky by traditional loan entities. Longer loans or low-interest loans can change the balance of a project's viability.*
R9	**Increase vehicle sales:** Create incentives for increased AFV sales, which increases the demand for alternative fuels and improves the profit margin of alternative fuel retailers.

*One of three interventions shown by Washington analysis to be the most likely to increase the profitability of EV charging stations to the extent that they had an ROI of under 5 years (Nigro, 2015).

Fuel Payment Models

Fuel payment takes one of two main forms. Customers either pay as they go, or they can become members of a subscription service. For example, NRG Energy allows drivers to subscribe to its eVgo service for a flat monthly fee. Services vary with the subscription plan, but can include installation of a home charger and unlimited charging at public and home stations. Public station hosts also pay a flat monthly fee, and NRG handles the station installation and maintenance (Rubin, 2013). However, it is important that retailing companies have non-exclusive charging schemes, so that drivers can "locate, reserve, and be billed for charging regardless of memberships or subscriptions to a network of chargers" (Melaina, 2014). This was also called out by the Governor's office as an important goal in its ZEV Action Plans (Office of Governor E. G. Brown Jr., 2015, 2013).

EV charging presents an odd case because individuals with their own charging stations can choose to allow people to use them for free or at cost. A peer-to-peer EV charging model has developed, in which owners of EV charging units share privately owned "Angel chargers" with the EV community. The only example of this system thus far is PlugShare, which uses a web-based map to display whether a station is residential, public, or DCFC, as well as whether it is currently in use. (See www.plugshare.com).

Discussion: Is charging for EV charging a good or bad idea?

Free charging has anecdotally been shown to increase vehicle sales, and may prove to be a valuable tool for incentivizing AFV purchasing (Nicholas, 2013). However, offering free charging at work or public places may create an inefficient use of resources. Individuals may choose to charge at work instead of home to save on costs, and may overuse free chargers intended for individuals who need to charge in order to complete their commute home. This creates charger congestion and blocks those who place higher value on the ability to charge. It can also put unnecessary stress on the electric grid from cars that could be charged during off-peak hours overnight instead of during the day. Putting a price on the time spent charging,

even if it doesn't fully cover the cost of the electricity, infrastructure, and maintenance, usually ensures that chargers will be available to the drivers who have the highest need for them.

One example of how this might work comes from the Town of Portola Valley. Portola Valley's town center has 4 public EV charging stations. These used to be completely free, but the town found that this led to overuse of the chargers, and that individuals would leave their cars in the spots overnight. The Town of Portola Valley then changed the policy so that the chargers are free for the first hour, but subsequently cost $4 per hour. Since the majority of the charging stations' electricity is provided by solar panels, the cost mainly covers the cost of the software and long-term maintenance. Their current charging scheme has reportedly solved the over-usage problem (De Garmaux, personal communication, 2/17/2015).

In a study on work-place charging, Nicholas and Tal recommend offering free charging at Level 1 chargers but putting a fee on higher power Level 2 chargers, so that they will remain available for those in greater need of a charge. They suggest that the ideal price should be set below the equivalent amount of gasoline but above that of home charging (Nicholas, 2013) (Nicholas, 2013).

The hourly price for public EV charging can be complicated to determine. In one model, exemplified by the Charge Point network from Coulomb Technologies, the company installs the charging station and provides support services but allows the host to determine the cost of EV charging. Since site owners are barred from "re-selling" electricity, they can't charge on a per kWh basis but must rather set prices on a per-use basis, a time basis, or as part of a subscription package (Schorske, 2011).

Information about drivers' willingness to pay for charging shows that most drivers are willing to pay somewhere between $1 and $5 for charging when they truly need it. Surveys done by Navigant research found that of PEV users who expressed an interest in public charging stations, 23% said they would use such stations only if they were free. 29% said they would pay less than $1 for a 15 minute charge providing 6-7 miles of range, 29% would pay between $1 and $2, and 16% would pay between $2 and $5. The survey questions specifically focused on DC fast charging, and it should not be assumed that the rates mentioned would scale up for lower level charging hourly rates (Vyas, 2013).

The Center for Sustainable Energy (CSE) found that the three most important factors in determining when owners charge are cost, convenience, and range anxiety, which were rated as "extremely important" by 53%, 46% and 45% of participants, respectively. 43% of respondents were willing to pay $1 an hour for Level 2 charging on a daily basis, and 63% were willing to do so on an occasional basis (CSE for ARB, 2013).

Technical Solutions

The technical challenges mentioned in Chapter 3 include the need for coordination between infrastructure density and vehicle populations, range anxiety and other behavioral adjustments, and potential lack of technological standardization within the market. Government support of alternative fuels can help to solve many of these problems. Solutions may also arise through

private research and development of automotive technology and the increasing momentum of the AFV market.

Availability of Alternative Fuels and Refueling Infrastructure

Having an adequate number of refueling stations to support AFVs is an essential part of their integration. As previously discussed, there are many challenges to private investment in AFI. One solution to this problem is for the government to provide direct support for the development of alternative fuel infrastructure networks. This is particularly relevant in the case of fuel types that cannot be installed in the home. While many electric vehicle owners have been able to install charging stations in their homes, this will not hold true for most other fuels.

The State of California is currently playing a large role in the expansion of the hydrogen refueling network, ensuring that at least a limited network of refueling infrastructure will be available for individuals who purchase FCEVs. The California Energy Commission (CEC) provides up to $20 million dollars a year in grants for hydrogen infrastructure development.

The CEC has collaborated with the California Fuel Cell Partnership (CaFCP), a non-profit organization, to develop a siting plan that identifies strategic locations for a skeleton network of hydrogen stations. The CEC and CaFCP have identified regional hotspots where FCEVs are most likely to first be adopted, and will be placing intermediate stations near highways to connect the regions. The CEC is currently in the process of working to permit and develop 100 hydrogen fueling sites by 2020, 68 of which are expected to be operational by the end of 2016 (CaFCP, 2012). Four of these stations are located in San Mateo County: Redwood City, South San Francisco, Woodside, and Foster City. Statewide, the initial stations are primarily sited in the following California metropolitan areas:

- Santa Monica/West Los Angeles
- Coastal Southern Orange County
- Torrance and the surrounding area
- Berkeley
- San Francisco's South Bay region.

The number of FCEVs purchased is still small at this point, however. For the first few years that FCEVs are commercially available, hydrogen fueling stations may not operate at their full capacity. However, other innovative technologies may create new uses for the hydrogen, such as the Zero-SetV Generation 2 portable generators sold by Luxfer-GTM Technologies. They sell a zero emission generator that integrates high capacity hydrogen storage, battery storage, and a 110V power inverter into a portable, compact trailer that refuels at public hydrogen retail stations (luxfergtm.com).

FCEVs and PEVs are the only two types of vehicles considered to be zero or partial zero emission in California. PEVs are the most widely adopted passenger AFV to date. Since EVSE is cheaper and easier to install than hydrogen, many EV charging stations are installed in both public and residential settings, although the exact number of stations required to support the growing PEV fleet is a topic of much debate.

Natural gas and propane vehicles are primarily used in privately owned fleets with their own fueling station. Current trends indicate these fuels will mainly experience growth in the truck categories.

Biodiesel, renewable diesel, and ethanol are liquid fuels, and are compatible with the existing gasoline and diesel infrastructure. Renewable diesel and ethanol are already routinely blended in with gasoline and diesel. In the future, the percentage of renewable fuel in these blends may increase but should not require new infrastructure.

As mentioned in Chapter 3, the national electric grid is capable of supporting 150 million PEVs (Gerkensmeyer, 2010). However, at the local level, transformers may not be able to accommodate the sharp increase in demand created when a PEV is charged. PG&E, the local electric utility provider for San Mateo County, is working to upgrade their grid, and they use information about PEV ownership to prioritize areas with homes that contain EVSE.

Technological solutions may play an important role in solving the fuel availability problem. For example, smart grid technology allows two way communication between the grid and a PEV, which makes it possible to do things like stop PEV charging during high load times or only charge when time of use rates are low (ICF International, 2013a). This also helps to address the potential for overloading of the grid by excessive PEV charging in any one location.

Another way to ensure adequate alternative fuel supplies is to generate them locally. San Mateo County contains several potential feedstock sources such as organic wastes and other residues contained in municipal solid waste (MSW) or municipal waste water. Government entities operate waste water treatment facilities and coordinate MSW and greenwaste hauling. The organic matter collected by those services could be used to create natural gas, electricity, or liquid fuels. Potential fuel production technologies for converting organic residues include:

- anaerobic biodigestion, which produces methane as a potential feedstock for bio CNG or electric power generation;
- pyrolysis or gasification, thermochemical processes that produce liquid fuels.

Cities have several strategies available to them to support the use of these waste resources. Cities that own landfills or waste water treatment facilities can install technologies to capture and convert organic waste in one of the above processes. Cities can also make biofuel use a criteria for contract selection with waste haulers or make environmental stewardship a procurement criteria when considering partnerships with private entities.

Education about the opportunity for waste-to-energy solutions should be targeted at the following stakeholders:

- Municipal solid waste haulers
- Landfill managers, both privately and publicly managed
- Waste water treatment facilities, both privately and publicly managed;

Cities may not be ready to directly involve themselves in building fuel production infrastructure or stations, but they can support the development of alternative fuel infrastructure by endorsing legislative action and encouraging action at the local and community level. Exhibit 3 summarizes four local policies and government actions that may increase alternative fuel availability.

Exhibit 3. Local Policy Options: Fuel Availability

R10 **Provide political momentum:** Support state legislative moves to fund alternative fuel infrastructure.

R11 **Raise awareness:** Implement outreach and community education programs to raise consumer awareness of the alternative fuels that are available in San Mateo County.

R12 **Support R&D:** Create business friendly policies to support research and development and other types of technological innovation in the alternative fuel vehicle sector.

R13 **Assess supply:** Emphasize the need for public utilities to assess local electric grid for capacity constraints and assess other fuel supplies for potential vulnerabilities.

Multi-Unit Dwellings (MUDs)

Multi-unit dwellings (MUDs) present a special case when it comes to EV charging access. As the popularity of PEVs grows, PEV owners are more likely to be renters instead of home-owners, or to live in multi-unit dwellings (MUDs). In San Mateo County, about 12% of the population currently lives in MUDs (See Table 32). A number of unique challenges face MUD residents who want to install charging stations in their building that would allow them to access the convenience and cheaper rates of off-peak home charging.

Table 32. 2012 San Mateo County Housing Characteristics

Dwelling Type	Number of Residents
Single Family Housing	231,334 (85% of total)
Multi-Unit Dwelling	32,658 (12% of total)
Total Housing Units	272,158

Source: San Mateo County 2014-2022 Draft Housing Element.

A recent California law, Assembly Bill (AB) 2565, confirms the legal right of renters to install EVSE in rental properties, ensuring that they will be able to charge at home even if they do not own their home. The law is primarily aimed at renters in MUDs and includes a number of restrictions; the law does not apply to residential properties with less than five parking spaces, properties that are subject to rent control, residential leases where no parking is provided as part of the lease, or residential properties where EV charging stations already account for at least 10% of available parking spaces.

However, MUD charging presents several technical challenges. For one, most existing lots were not designed with EV charging in mind. The distance between utility meters, parking spots, and electric panels may require installation of another electric panel closer to the parking lot. If an additional meter is required to capture off-peak rates, there may not be enough space in centralized locations, and any upgrade in electrical capacity could trigger a review of the whole building. Installing EVSE in multi-car garages also raises logistical concerns. MUDs must coordinate the desires of multiple residents. If more than one PEV owner resides in the building but it has only one EV charging unit, this may necessitate the shuffling of cars to accommodate everyone's needs.

In addition, the costs of installation may be contentious for residents and building managers to negotiate. Disagreements can arise between residents and management about who should be responsible for electrical upgrades, maintenance, and decommissioning of EVSE. Full use of a charging spot may require switching or rotating of parking spaces, a request that may encounter resistance from both management and residents. Federal and state subsidies may have inflexible requirements, such as the federal requirement that EVSE include wireless internet, which is sometimes challenging to install underground. In Los Angeles County, subsidies are only available to the owner of the vehicle and not to Homeowner's Associations (HOAs) (Balmin, 2012). As shown in Table 32, 12% of the residents in San Mateo County currently live in MUDs, a number that is likely to increase over time given the housing demands in the Bay Area. Developing workable solutions to this problem will greatly increase the ability of these residents to consider PEVs as an option.

Local governments, property managers, and residents can employ different strategies to overcome logistical challenges such as parking space location and infrastructure cost. The question of electricity payment is often a sensitive one. Ideally, a separate meter allows the electricity used by PEVs to be directly charged to the PEV driver. In the case of multiple users, MUDs can select a charging unit with a flexible billing system so that PEV drivers can pay-as-they-go. Government policies can further encourage MUD PEV charging by requiring the installation of EVSE in new buildings or giving preferential permitting to buildings that have EVSE installed. Providing residents with access to an impartial mediator who is informed about legal considerations, codes and standards, billing arrangements, and other common solutions can also be very helpful. A public registry of PEV ready buildings can also help drivers to easily identify buildings that will make charging easy, and incentivizes MUD EVSE readiness. The policies shown in Exhibit 4 offer a variety of ways in which local governments can support MUD residents who are considering purchasing a PEV.

Exhibit 4. Local Policy Options: MUD EV Charging

R14	**Adopt voluntary Green Building codes:** Adopt and publicize building code enhancements that mandate pre-wiring for MUD chargers in new and remodeled buildings (See www.ReadySetCharge.org).
R15	**Educate property managers:** Reach out to HOAs and property managers to educate them about MUD EVSE solutions (See www.sdge.com/training and

http://innovation.luskin.ucla.edu/ for suggestions).

R16 **Employ a mediator:** Designate an informed mediator to assist with negotiations between residents and property managers.

R17 **Offer preferential permitting:** Offer preferential permitting for buildings that have EV charging infrastructure.

R18 **Create a registry of PEV buildings:** A publically accessible registry of buildings with EVSE capacity will serve as an incentive to MUDs to include EVSE in their plans.

Range Anxiety & Fueling Time

Range anxiety refers to the fear AFV drivers have of not being able to go as far as they would like without refueling. This means potentially being stranded in a place where there are not any alternative fuel stations. Range anxiety will remain a concern until the infrastructure for each fuel is more pervasive.

Driving range varies widely between different alternative fuels and specific vehicle models. Gasoline and diesel vehicles typically have a driving range of about 450 miles. The average BEV currently has a range of about 70 miles, although Teslas and those with backup gasoline tanks can go much farther, up to 250 miles. PHEVs have a much greater range when the backup gasoline engine is considered. Depending on the size of the gasoline tank, this can extend the range to as much as 450 miles. The FCEVs that are currently on the market have a range of about 300 miles. NGVs have a range of about 250 miles, and LPGVs about 350 miles or more.

Ideally, with a full spectrum of vehicles available, drivers could choose a vehicle based on the expected distance of a given trip and time available for refueling. This may not be possible for individuals who have access to only one vehicle, in which case they may either choose to purchase a vehicle that serves their typical daily needs, or they may choose a longer range vehicle like a PHEV so that their longest possible trips will also be accommodated by the existing infrastructure. FCEVs and LPGVs, while technically capable of driving long distances, may not be supported by refueling infrastructure in all parts of the state. BEVs are more limited in range than most AFVs. BEV drivers may need to have either a second car in the home or access to a car sharing network that allows them to use an ICEV or PHEV with longer range for longer trips. Once refueling infrastructure is more widespread, this will alleviate many range anxiety concerns, although charging times may remain relatively long for PEVs.

BEVs have the shortest range of all the AFVs at this time, but this range has been increasing quickly. Manufacturers expect that in 2017 we will see 3 BEV models with driving ranges of 150-200 miles for under 40 thousand dollars; the Chevy Bolt, the Tesla Model 3, and the Nissan Leaf v2 (BACC, 2015). BEVs may be available later in the decade that have ranges of up to 350 miles (Schorske, 2011). In the meantime, government can help to alleviate this concern by encouraging the increased development of refueling networks. For example, the Association of

Bay Area Governments has a goal of installing at least 100 DCFC chargers in the Bay Area to help combat BEV range anxiety (ABAG, 2011).

An area of development that may help alleviate range anxiety is mobile charging and refueling units, which have already been developed for several different AFV types. Luxfer-GMT Technologies sells portable cylinder packs (referred to as the G-PAK) that are filled with hydrogen or CNG and used for emergency refilling or roadside assistance. The G-PAK carries enough hydrogen to fuel several cars (luxfergtm.com). Envision Solar's EV ARC™ units are portable EV chargers fueled with solar panels that can be located anywhere. An EV ARC™ can fully charge one typical EV per day or offer partial charges to multiple EVs. The non-profit Charge Across Town conducted a demonstration of these charging units, three of which were located in convenient locations around San Francisco from April-December of 2015 (chargeacrosstown.com).

Local governments can help address range anxiety by increasing access to alternative fuels. At the local level, this primarily involves creating policies that are friendly to businesses that are seeking to solve range anxiety issues with longer driving ranges or car sharing programs. At the larger scale, state and federal governments can provide funding for alternative fuel infrastructure. Exhibit 5 displays strategies that local governments can undertake to combat range anxiety concerns.

Exhibit 5. Local Policy Options: Range Anxiety

R19	**Provide political momentum:** Support state legislative moves to fund alternative fuel infrastructure.
R20	**Support R&D:** Create business friendly policies to support research and development and other types of technological innovation in the alternative fuel vehicle sector.
R21	**Endorse vehicle flexibility:** Support car sharing organizations that allow members to use different vehicles for different types and lengths of trips.
R22	**Plan regionally:** Coordinate AFI site planning and locations with other cities in the region.

Lack of Technology Standardization

The CEC has already recognized the need for "universal access to ZEV infrastructure for California drivers," and is working to develop interoperability standards for EV charging stations that ensure compatibility of technology between stations (Office of Governor E. G. Brown Jr., 2013). In the case of DC fast charging EVSE, this could mean requiring that stations offer both types of chargers, CHaDEMO and SAE J1772. (See Chapter 4 for a review of the differences between these charging systems). The Governor's Office Draft 2015 ZEV Action Plan also recommends the development and implementation of a uniform standard for hydrogen refueling technology, the Hydrogen Station Equipment Performance (HyStEP) device, to ensure

hydrogen fueling pumps follow industry standard protocols in SAE J2601 (Office of Governor E. G. Brown Jr., 2015).

Technological developments may also play a role in solving the hardware standardization problem. Wireless charging technologies, such as those available from Plugless Power or Qualcomm Halo, would be compatible with all vehicles. While wireless charging has the potential for efficiency losses, Qualcomm Halo says that its product "actually benefits from its lack of physical connection, with efficiency that increases the higher the power level—think >90%" (qualcomm.com).

The actual harmonization of different product technologies will be done by private auto manufacturers. However, local governments can encourage the private sector to solve these problems in a way that is efficient and has the least negative impacts on drivers by supporting policies that require inter-operability standards.

Exhibit 6. Local Policy Options: Technology Standardization

R23	**Require interoperability:** Support legislation and policies that require stations to have fueling or charging hardware that is technologically compatible with all vehicles of that fuel type.

Regulatory Strategies

Cities and counties are responsible for setting a large portion of local regulations, which presents an opportunity to craft regulations such that they encourage the use of alternative fuels. The highest growth rates for technology market share are associated with the presence of clear standards. Local governments have jurisdiction over zoning, permitting, and building regulations. The next most important factors are the price of gasoline and government subsidies for the purchase of green vehicles (Plotkin, 2013; Zoepf, 2011). The latter are areas of regulation that will be implemented at the state level, but cities and counties can advocate for policies they believe benefit their communities. The areas of AFV policy that city and county governments have the most direct jurisdiction over are:

- zoning laws and building codes
- parking allowances and space requirements
- permitting requirements and fees
- local signage requirements and placement.

Higher Level Policies

A number of higher level decisions can help to pave the way for AFV and AFI friendly policies. Simply stating the desire to increase access to AFVs and AFI in a city's general plan can open the door to future initiatives. Having a dedicated Director of Sustainability is another important move towards increasing access to alternative fuels. The available grants and incentives are constantly changing. A Sustainability Director assumes the responsibility of organizing local

outreach programs and finding out about grants and other resources, tasks which are likely to fall through the cracks if not explicitly assigned to at least one individual. Another solution is to require that municipal contractors meet certain environmental standards, such as the use of alternative fuels in their fleets. Including sustainability and environmental performance in evaluation criteria provides significant economic motivation for companies to be environmentally responsible.

Setting specific goals and targets for local city and county procurements is a targeted way to encourage the transformation to a lower emission vehicle population. In San Mateo County, Portola Valley has an environmentally preferable purchase plan, which could influence fleet purchasing decisions. The County of San Mateo established a 30MPG target for the County sedan fleet, which has prompted the purchase of many hybrid vehicles over the last few years (Kema Services Inc., 2012). The County of San Mateo currently has 189 hybrid vehicles in its agency fleets, which makes up 25% of its total government vehicles. The County installed one electric vehicle charging station in Redwood City in 2013, and has plans to install 7 more throughout the county so that their fleets can expand their use of BEVs. AC Transit in the Alameda-Contra Costa District currently has 12 Fuel Cell Electric Buses in operation (see Figure 23).

Figure 23. AC Transit Fuel Cell Electric Bus

Zoning & Building Codes

Cities and counties may want to consider revising zoning and building codes to accommodate or encourage the installation of PEV charging units and the construction of AFI. Building codes in California are divided into codes for residential and nonresidential buildings. Residential buildings may be either single family homes or multi-unit dwellings. Nonresidential buildings include business, industrial, institutional, and retail uses (Rubin, 2013). Cities and counties are obligated by law to enforce the building codes outlined in California's Codes and Regulations,

Title 24, Chapter 3. However, local governments can elect to modify them under limited circumstances to accommodate local climatic, geological or topographical conditions.

The mandatory residential Cal Green Building standards dictate that in newly constructed multi-family dwellings with 17 or more units, "3 % of the total number of parking spaces provided for all types of parking facilities, but in no case less than one, shall be electric vehicle charging stations (EVCS) capable of supporting future electric vehicle supply equipment (EVSE)" (Title 24: Part 11 Supplement, 2015). Nonresidential mandatory standards include a requirement that businesses designate a certain percentage of parking spaces for low-emitting vehicles or have wiring capable of supporting EVSE as dictated by Table 33.

Table 33. Nonresidential Mandatory EV Parking Standard

Total Number of Parking Spaces	Mandatory Number of Required EV Charging Spaces
0 to 50	0
51 to 75	1
76 to 100	2
101 to 200	3
201 and over	3%*

*Number of spaces rounded up to the nearest whole number.
(California Building Standards Commission, 2015)

However, cities and counties can elect to adopt the more stringent voluntary residential and nonresidential standards for EVs and AFVs laid out in the Cal Green Building Standards Code for 2013, thereby making them mandatory for that jurisdiction. If adopted, these voluntary residential standards require that in new multi-family dwellings with 17 or more units, 5 % of the total number of parking spaces provided for all types of parking facilities, but in no case less than one, shall be electric vehicle charging stations capable of supporting future EVSE. Nonresidential voluntary standards are divided into two tiers based on the desired level of compliance. Table 34 and Table 35 show the number of spaces required for each tier.

Table 34. Nonresidential Voluntary Tier 1 EV Parking Standard

Total Number of Parking Spaces	Tier 1 Number of Required EV Charging Spaces
0 to 50	1
51 to 75	2
76 to 100	3
101 to 200	5
201 and over	4%*

*Number of spaces rounded up to the nearest whole number.
(California Building Standards Commission, 2015)

Table 35. Nonresidential Voluntary Tier 2 EV Parking Standard

Total Number of Parking Spaces	Tier 2 Number of Required EV Charging Spaces
0 to 50	2
51 to 75	3
76 to 100	4
101 to 200	7
201 and over	6%*

*Number of spaces rounded up to the nearest whole number.
(California Building Standards Commission, 2015)

Building codes provide guidance to all the stakeholders involved (government personnel, construction companies, and residents) on a number of issues that can arise during the installation of infrastructure. For example, codes related to PEVs may provide guidance on the following issues:

- The number of circuits and conduits needed and service panel requirements;
- Placement of electric meters;
- Sourcing of electricity for on-street and lot parking;
- The impact of charging infrastructure on building electrical loads and local electrical distribution;
- Allocation and sizing of parking spaces to accommodate charging infrastructure;
- Compliance with the Americans with Disabilities Act (ADA) (Rubin, 2013).

The Americans with Disabilities Act (ADA) of 1990 is a federal law that ensures accessibility of all public structures to people with disabilities. All stations and parking lots must comply with the ADA. Current ADA standards for California parking lots are provided in the 2013 California Code of Regulations Building Codes, but CA DGS has recently proposed updated standards for facilities with electric vehicle charging stations (EVCS). If adopted, these would be included in the 2016 CA Building Codes. The proposed EVCS ADA requirements are displayed below in Table 36.

Table 36. Proposed EVCS ADA Requirements

Total number of EVCS at facility	Minimum Number of EVCS required to be ADA compliant		
	Van Accessible	Standard Accessible	Ambulatory
1 to 4	1	0	0
5 to 25	1	1	0
26 to 50	1	1	1
51 to 75	1	2	2
76 to 100	1	3	3
101 and over	1, plus 1 for each 300, or fraction thereof, over 100	3, plus 1 for each 60, or fraction thereof, over 100	3, plus 1 for each 50, or fraction thereof, over 100

Source: CA Building Standards Commission. August 3, 2015. 45-Day express terms for proposed building standards of the division of the state of architecture. Regarding proposed changes to the CA Building Code, CCR, Title 24, Part 2. http://www.documents.dgs.ca.gov/dsa/access/2016-Pt2_45-Day-Express-Terms_08-03-15.pdf

Building codes and standards exist for all of the different alternative fuels. However, only some are mandatory and many local jurisdictions have not adopted them all. Official standards provide guidance to how to handle each alternative fuel. Ensuring that building and construction codes and standards have been adopted for all alternative fuels and are well-understood is a very helpful step towards creating an AFI friendly culture. Table 37 displays the primary codes and standards that apply to each alternative fuel and describes typical fueling station conditions. For additional information about codes and standards, see Chapter 6.

Table 37. Key Codes and Standards for Alternative Fuels

Fuel	Example Public Fuel Station	Key Codes & Standards	Local Regulatory Factors
PEV	Fast charge along highway Level II in shopping mall	NEC, Cal Green Building Code	Multiple sites are needed. Parking, ADA, and other constraints affect station planning.
Hydrogen	Integrate hydrogen production, storage, and compression with existing gasoline station.	NFPA 2, 55	Standards for station installation may not be incorporated in local codes. Equipment requires larger standoff distances to buildings and adjacent properties. Sites larger than conventional gasoline stations may be necessary to accommodate these fuels.
CNG	Integrate CNG compression, storage, and dispensing with existing gasoline station.	NFPA 52	
LPG	Integrate separate dispenser with local gasoline/diesel station.	NFPA 58	Conditional use permit. Local rules on signage.
E85		NFPA 30, 30A	
Biodiesel			
RD			

Exhibit 7 summarizes the local policy options for increasing accessibility to alternative fueling station construction and development.

Exhibit 7. Local Policy Options: Zoning and Building Codes

R24 **Adopt voluntary standards:** Adopt the voluntary residential and nonresidential standards for EVs as laid out in the Cal Green Building Standards Code for 2013. Adopt voluntary standards for building and construction codes and zoning designations of all alternative fuels as listed in Table 37. Require that new buildings include conduits and capacity for future EVSE demands.

Parking requirements

Like most counties, the cities of San Mateo County mandate the number of off-street parking spaces required for all residential and non-residential buildings. A common recommendation in PEV readiness planning is that "charging spaces designated for PEVs should count toward meeting minimum parking requirements for business owners and developers" (Rubin, 2013). This recommendation is particularly relevant to PEVs because charging stations are frequently located in general parking areas where a car may be parked for extended periods of time while charging. This is not likely to be the case for most other AFVs.

Municipalities can set aside parking that is designated for alternative fuel vehicles in order to incentivize their purchase. However, it is important that governments be able to enforce this regulation if a non-AFV is found parked in an AFV spot. Assembly Bill 475 authorizes local government to require that cars located in a parking space with PEV charging equipment must be plugged into the charger in order to ensure that the space is being used for PEV charging. Similar enforcement policies could be developed for parking reserved for AFVs.

Free or reserved parking has been offered as an incentive for AFV purchasing in a few California cities. San Jose, Hermosa Beach, and Santa Monica all offer free metered parking to electric vehicles with a white or green clean vehicle decal. (In order to be eligible in San Jose, vehicles must also be purchased from and registered in San Jose). Sacramento offers free parking in designated lots to operators of 100% electric cars certified by the city's Office of Small Business Development.

Governments have the option of incentivizing AFV purchasing through local parking policies. Regulations around parking space requirements and parking laws are an important part of ensuring that the use of AFVs is pleasant for all drivers. Exhibit 8 displays some of the local policy options that municipalities may consider.

Exhibit 8. Local Policy Options: AFV Parking

R25	**Provide and enforce PEV parking:** Allow PEV charging spots to count toward minimum parking requirements. Designate reserved public parking spots for AFVs. Create policies that allow for enforcement of AFV parking violations.

Permitting

The permitting process can impose large costs on a developer if it invites delays or involves high or unpredictable fees. Therefore, permitting for AFI development should be streamlined to the greatest extent possible. The streamlining mechanism itself will vary by fuel since the nature of the infrastructure and construction process varies greatly. However, it is important for developers and consumers to be able to account for the monetary cost of permitting and the time required to obtain a construction permit.

Residential EVSE permitting usually consists of several steps. First, developers must get a permit from the local authority having jurisdiction (AHJ). An inspection is often required once the work has been finished, followed by another inspection if any issues with the installation are found. An additional logistical constraint is that inspection times must be coordinated between homeowner, installer, and utility (Schorske, 2011).

Efficient permit processing reduces the costs incurred by delays. Cities and counties can set goals for how long it should take to obtain a certain type of permit. For example, the City of Los Angeles has a seven-day approval process for installation of EVSE, assuming the existing wiring is sufficient to handle the increased charge (Rubin, 2013). San Francisco offers same-day permitting for Level-2 electric vehicle chargers in single-family homes, and applicants can

obtain this permit on the internet or over-the-counter. This is partly because San Francisco requires only a standard electrical permit for installation of Level 2 chargers (Rubin, 2013). In fact, as of 2012, more than half of Bay Area governments issued same-day permits for electric vehicle supply equipment in single-family residences, and 80% charged applicants under $250 for these permits. (Rubin, 2013)

It's also useful to develop a checklist or guidance document that can help people looking to install different types of AFI to navigate the permitting and development process. The guidance document should include information about which permits are required and when, permit application requirements, inspection requirements, and the applicable codes for a given type of station. An example of this sort of checklist is provided in California's Zero Emission Vehicles Community Readiness Guidebook (Rubin, 2013).

The planning and permitting process is a crucial step in alternative infrastructure development at the local level. In general, both planners and developers benefit from good communication before and during the permitting process. Exhibit 9 lists specific suggestions to make permitting smoother and more successful for both parties.

Exhibit 9. Local Policy Options: Permitting

R26 **Have a presubmittal review:** Recommend permit applicant meet with permitting officials for a presubmittal review, which provides an opportunity to avert potential issues that may delay the permitting process or lead to the denial of an application.

R27 **Streamline permitting:** Streamline permitting process to greatest extent possible, including:

- Permitting time (for EVSE, ideally 24 to 48 hours)
- Permitting cost (for EVSE, ideally less than $150 for Level 1 or 2 chargers)
- Inspection requirements (for EVSE, ideally one final inspection if at all)
- Develop templates and guidelines for AFI permitting
- Allow online submission of permit applications

R28 **Educate applicants**: Authorities Having Jurisdiction (AHJ) are encouraged to make the applicant aware of:

- any special concerns relating to the proposed station's local zoning codes and amendments that may have not been considered in the draft application
- history of issues with similar projects in the jurisdiction and other key insights for a successful project plan during the pre-submittal review

And officials: Applicants are encouraged to provide AHJs with information about:

- station technology
- all codes, standards and regulations related to station development used for other projects
- how codes have been interpreted or amended in other jurisdictions
- any deviations in their design from code requirements and standards of record, rationale for these deviations, and how deviations are being addressed.

(Hewett, 2007; Rubin, 2013)

Signage

Cities are responsible for approving the signs posted on city streets. Caltrans is the lead agency tasked with installing signs "along highway corridors and local roads to provide directions to PEV charging and hydrogen stations" within 3 miles of highways and other major roadways

(Melaina, 2014). It is up to local agencies whether or not they choose to install street signs indicating the location of alternative fueling stations. ZEV signage requirements are laid out in the CA Department Of Transit Traffic Operations Policy Directive 13-01 (CA DOT, 2013). Retail stations are required to display signs showing the types of fuel available. However, sign limits may prevent alternative fuels from being represented when all the signs are already being used by the station host.

AFV signs serve two primary purposes: first, to assist drivers in locating a fueling station when they need one, and second, to clearly demarcate any regulatory ordinances that apply to road or parking usage rules (America, 2012). Signs for fueling stations have the secondary benefit of making the general public aware of the availability of alternative fuels in their area. In addition, it's worth noting that E85 stations with visible price sign marquees have been shown to experience higher E85 sales volumes than those without signs (Bromiley, 2008). Cities and counties should ensure that signage is clear for all fueling stations, and that in the case of retail stations selling multiple fuels, all fuels are represented.

Signs can also be used to designate a parking spot only for AFVs. ECOtality recommends the use of regulatory signs that permit the stall to be used only for the purpose of EV charging (America, 2012). In order for the regulatory signs to be enforceable, they must also be supported by local ordinances.

Local signage recommendations are shown in Exhibit 10. Further information on approved signs and signage requirements is contained in the Training chapter of this plan, Chapter 6.

Exhibit 10. Local Policy Options: Signage

R29	**Station signage:** Institute a policy requiring that all the fuels sold at a retail location are represented by visible signs.
R30	**Street signage:** Post the maximum number of allowable signs indicating the location of all types of alternative fuels available on local streets.
R31	**Parking signage:** Demarcate AFV parking spots and parking policies with clear signs.

Education and Outreach

In order for AFVs to succeed in San Mateo County, all of the potential stakeholders must be informed and involved. Therefore, it is important to ensure that educational opportunities exist for consumers, investors, government officials, safety personnel, and support staff like technicians and mechanics.

Government officials in planning and permitting departments have an important role to play in AFI development. As alternative fuel infrastructure permit applications become more common, officials will have to interpret local codes and zoning rules as they apply to alternative fuels. Education and outreach efforts should include building inspectors, planning department employees, and council members, who have the power to support alternative fuels from the top

down. These individuals are particularly key and will benefit greatly from guidance about how local laws apply to new technologies and alternative fuels.

Fire and emergency response training about alternative fuels is also needed in San Mateo County. Conversations with local fire and police marshals showed that the availability of AFV training resources, including teaching materials, time, and money, was very limited. Training topics and resources are also covered in the Plan, and further details on this are available in Chapter 6.

City and county outreach to consumers and investors will help to spread knowledge about the costs, benefits, and incentives available for alternative fuel vehicles and infrastructure. As part of this Alternative Fuel Readiness Plan, C/CAG has developed a strategy for outreach to community stakeholders regarding AFVs, found in Chapter 7.

The CEC has provided funding for workforce development and safety training on AFVs. As of October, 2013, the CEC had provided $23.25 million in funds for trainings through agencies such as the Employment Development Department, California Community Colleges Chancellor's Office, and the Employment Training Panel (CSE, 2013).

Additional education should also target potential sources of biomethane and local fuel production. Local agencies and businesses may consider turning organic waste from municipal collections or waste water treatment into biomethane once they are aware of the potential savings and environmental benefits. Several entities in San Mateo County are already demonstrating the feasibility of turning organic waste products into energy. South San Francisco Scavenger Company at the Blue Line Transfer Station has installed a biodigester that converts food waste into natural gas, which they use to fuel half of their waste collection trucks (see Figure 24). The City of San Mateo is capturing the biomethane produced from its waste water treatment facility and scrubbing it to produce natural gas to fuel city fleets. Other companies and agencies in San Mateo County that generate significant amounts of organic waste could consider taking this approach to fuel production. Further education about the costs and benefits of this type of technology will help those entities to decide if they are interested in waste-to-energy solutions.

Figure 24. SSF Scavenger Company CNG Fueling Infrastructure

Education and outreach are essential to the successful adoption of alternative fuels in San Mateo County. These efforts should be specially targeted to each stakeholder group, including government staff, individual consumers, emergency responders, local technicians, and entities with the potential for alternative fuel production. These policy options are summarized in Exhibit 11.

Exhibit 11. Local Policy Options: Education and Outreach

R32 **Perform outreach and training to:**

- Planning and permitting staff regarding the application of codes and regulations to AFVs and AFI.
- Potential consumers regarding benefits, costs, and available incentives.
- Police and fire departments regarding first responder training on AFVs.
- Businesses and technicians regarding the existence of training programs and available funding for education.
- Waste management entities and cities with landfills or waste water treatment plants about the opportunity for waste-to-energy fuel generation.

Inclusivity and Openness in Policy Development

Increasing the use of AFVs and their supporting infrastructure requires the coordination of many activities, including importing fuels, developing siting plans, permitting, funding, and building alternative fueling stations in a way that will best serve the community. In order to achieve these goals, planning must be open and inclusive of all stakeholders, including:

- Government officials of SMC and surrounding counties
- Planning staff and building inspectors
- Fuel retailers and wholesalers
- Vehicle manufacturers
- Developers and construction companies
- AFV drivers
- Public and private fleet managers
- Private companies interested in providing AFI at the workplace

One way to engage with the surrounding community on the topic of alternative fuels is to join a local coalition focused on related issues. San Mateo County's cities are eligible to become members of the Silicon Valley Clean Cities Coalition or San Francisco Clean Cities Coalition, depending on the location of the city. The Clean Cities program is sponsored by the DOE, which provides members with a variety of resources to reduce their use of petroleum. Communities can leverage these resources to create networks of local stakeholders and provide customized technical assistance to fleets implementing clean vehicle strategies like alternative and renewable fuels, idle-reduction measures, fuel economy improvements, and new transportation technologies. Member coalitions are also eligible for special funding opportunities through the Clean Cities program from the DOE. Membership in a Clean Cities Coalition would allow the cities of San Mateo County access to educational opportunities, increased legislative influence, financing and funding resources, and create a forum for increased communication across the region.

Coordination between towns and inclusiveness of all stakeholders are both important for ensuring that stations are distributed in a way that ensures full and sufficient coverage across the region for all drivers, including San Mateo County residents, commuters, and tourists. Site planning and infrastructure development require the cooperation of County officials, who must sign off on permits, and developers, who must comply with local regulations while trying to maintain the profitability of their investments. Local governments will have the most success in developing alternative fuel readiness if they engage with all stakeholders during planning and drafting of regulations. A transparent process will allow immediate feedback from those who have the most to gain or lose from a proposed regulation. Exhibit 12 displays options for creating a transparent and inclusive approach to all aspects of local policy development regarding alternative fuels.

Exhibit 12. Local Policy Options: Open and Transparent Policy Planning

R33 **Engage in open and transparent policy planning through:**

- Joining a Clean Cities Coalition to better coordinate with surrounding governments.
- Inviting local advocacy groups to provide input on policy needs and draft regulations, such as the Bay Area Climate Collaborate, Silicon Valley Joint Venture, Silicon Valley Leadership Group, Prospect Silicon Valley, and many more.
- Sending follow-up surveys to drivers regarding purchasing experience and developers regarding permitting and construction process.
- Creating a website with resources (permitting template, installation checklist, etc.) up-to-date information about incentives, and draft regulations.

Policy Options Overview

San Mateo County will benefit from many of the state and federal policies and initiatives described in Chapter 3. However, San Mateo County also has the option of instituting its own policies and education programs to smooth the transition of AFVs into its community. Each policy option must be evaluated on an individual basis to assess the costs and benefits to a particular community, and education and training should be targeted to local needs.

Before considering new policies, it is useful to consider those policies that already exist and currently apply in San Mateo County. Many of these policies have already been discussed throughout this report, but they are summarized in Table 38, which lists the major categories of incentives that already exist and whether they currently apply to each type of AFV or alternative fuel in San Mateo County.

Table 38. AFV Incentives Currently Available for AFVs in San Mateo County

Incentive	CNG	LNG	BEV	LPG	FCEV	E85	BD	PHEV
HOV Lane	X		X		X			X*
Federal Tax Credit			X		X			X
State Rebate			X ($2,500)		X ($5,000)			X ($900-$1,500)
BAAQMD Rebate			X**		X**			X**
LCFS Credit	X	X	X		X	X	X	X
RFS2 RIN	X	X	X			X	X	X
Insurance Discount	X		X	X	X	X		X

*Only first 55,000 applicants.
**Only for government fleets.

AFVs and AFI development face both monetary and non-monetary barriers. These are shown in Table 39 and Table 40 and are ranked according to the effective cost burden as it is perceived by consumers. Local government has a part to play in solving these issues. Table 41 shows a summary of all the policy options available at the local level.

Table 39. Local Policies to Address Monetary Barriers

Monetary Barriers	Possible Local Policies	Policy Effectiveness	Policy Challenges
High up-front price of alternative fuel vehicles	Lease AFVs for government fleets through a third party retailer	Effective; allows governments to capture tax incentives	Requires coordination between government and retailer
	Aggregate purchasing and bulk orders	Effective; creates economies of scale	Requires agreement on specifications
	Energy service cost financing	Effective; captures lower cost of fuel	Requires delayed payment of retailer
Need for alternative fuel infrastructure	Create coalitions between government agencies and other organizations	Somewhat effective	May not generate sufficient funding
	Ensure predictable permitting times and costs	Effective; reduces cost of delays	Bureaucratic hurdles
	Public-Private partnerships	Effective; both entities can benefit	May still be difficult to find funding
	Ensure compatibility of infrastructure and charging systems	Somewhat effective; helps post AFV purchase	Possible technical challenges with vehicles and stations
	Offer low-interest loans	Effective; reduces up front cost	Funds must be obtained to cover loans

Table 40. Local Policies to Address Non-Monetary Barriers

Non-Monetary Barriers	Possible Local Policies	Policy Effectiveness	Policy Challenges
Limited driving range; fueling/charging availability; long fueling time	Incentivize infrastructure building Pilot programs Station maps	Effective if enough stations are built Somewhat Somewhat	Costly Tailoring policy to driver needs
Unfamiliarity; lack of awareness about benefits and incentives	Labeling Information Outreach programs	Effective	Tailoring policies to evolving market needs
Perceived differences in or prejudices against AFVs	Information Outreach programs	Probably effective	Tailoring policies to evolving market needs
Lack of technology standardization	Testing, standards development	Effective	Complexity of technologies and future business models
Limited availability and diversity of vehicle	Research & Development	Limited	Little role for public policy

Adapted from: Stephens, T., 2013. Non-cost barriers to consumer adoption of new light-duty vehicle technologies, in: Light Duty Vehicles. p. 47.

In summary, the strategies and policy approaches shown in Table 41 could be considered by C/CAG and its members if their goal is to increase the use of AFVs and the availability of supporting refueling infrastructure in San Mateo County.

Table 41. Summary of Local Policy Options

	Fuel	Vehicles	Infrastructure
Economics	• Sell LCFS credits and RINs from fuel production. • Offer reduced price PEV charging in public locations.	• Take advantage of and advertise state and local rebate opportunities. • Lease instead of purchase vehicles to defray cost and capture federal tax credits. • Aggregate AFV purchase orders with other agencies to reduce cost of manufacturing. • Restructure fleet vehicle budgets to account for lower fuel costs over time. • Join Silicon Valley Clean Cities Coalition	• Apply for grants and educate investors about available incentives. • Obtain funds for low-interest loan programs. • Make city fueling stations open-access. • Engage in public-private AFI partnerships. • Identify pre-permitted sites that can be easily converted for AFI retail. • Require new buildings have EVSE ready wiring.
Technology	• Encourage utilities to upgrade grid capacity. • Support hardware compatibility standards.	• Create supportive business environment for AFV/I R&D.	• Support legislation that creates government funded skeleton AFI networks.
Regulation	• Require fuel retail signage to represent all fuels available at a site.	• Include AFV/I goals in General Plan. • Create public fleet AFV goals or emissions targets.	• Have dedicated Sustainability official • Adopt AFI friendly building codes. • Include PEV spots in parking requirements.
Education	• Outreach to local agencies about waste-to-energy fuel production options.	• Outreach to consumers and fleet managers about AFV incentives and benefits. • Outreach to technicians about training options.	• Educate indirect AFI beneficiaries. • Include AFVs in first responder emergency training curricula.

Sample Implementation Plan for AFI Construction

1. Determine type of infrastructure needed (e.g. Level 1 vs. 2 for EVSE, onsite H2 generation vs. liquid H2 delivery, CNG vs. LNG).
2. Choose ideal locations for AFI site. (e.g. commercial location vs. highway, distance from similar stations).
3. Establish contracting agreement with site host or property owner.
4. Engage with engineering and construction to create site installation plan drawings.
5. Check local regulations and codes to determine what permits and reviews are required.
6. Meet with local permitting officials to discuss site plans.
7. Accept bids and award contracts for station equipment and installation.
8. Apply for all permits.
9. Begin site construction and equipment installation.
10. Comply with site inspection requirements as necessary.
11. Install all recommended signs, bollards, and parking lot striping.
12. Receive approval, sign-off on all permits.
13. Begin station operations.

Useful website links:

The California Department of General Services' (DGS) offers state procurement contracts for local governments to purchase vehicles. DGS sells a variety of alternative fuel vehicles, including some ZEVs, at negotiated prices. See the DGS website for more information: http://www.dgs.ca.gov/buyinggreen/Home/BuyersMain/Transportation/Cars.aspx.

The Department of Energy has a helpful handbook that can serve as a resource to fleet managers, its Plug-In Electric Vehicle Handbook for Fleet Managers, which can be found at: http://www.afdc.energy.gov/pdfs/pev_handbook.pdf.

EVSE financial analysis tool can be found here: http://www.c2es.org/publications/business-models-financially-sustainable-ev-charging-networks.

The California Governor's Office of Planning and Research has published a Guidebook on Zero Emission Vehicle Community Readiness that can be found here:

http://www.opr.ca.gov/s_zero-emissionvehicles.php.

The Bay Area PEV Readiness Plan, commissioned by BAAQMD, offers comprehensive information about incentives and guidelines for local readiness for EVs in the Bay Area: http://www.bayareapevready.org/participate/pev-readiness-plan/.

Permitting template for electric vehicle charging infrastructure developed by the DOE available here: http://www.afdc.energy.gov/pdfs/EV_charging_template.pdf

Hydrogen readiness safety checklist: http://h2readiness.com/safety_checklist and permit template: http://h2readiness.com/permit_template.

CHAPTER 6:
Training Materials and Resources

Alternative fuels such as biodiesel, compressed natural gas (CNG), liquefied natural gas (LNG), liquefied petroleum gases (LPG), hydrogen, and electric vehicle (EV) technology are currently in use, or expected to be in the near future, across San Mateo County. Unlike conventional diesel and gasoline fuel, some aspects of alternative fuel handling and use are not yet covered by regulations, standards, or even accepted practice. Many stakeholders and obligated parties, such as operators, first responders, and government officials remain unfamiliar with the specific techniques and practices needed for safe vehicle operation, maintenance, and refueling.

This chapter addresses the following aspects of alternative fuels and handling practices by identifying and educating stakeholders in San Mateo County on:

- Alternative Fuel Safety,
- Codes Standards and Signage,
- Infrastructure and Facility Requirements,
- Safety and Permitting,
- Environmental and Health considerations,
- First Responder Training Considerations and Resources,
- Non First Responder Training Resources

Chapter 6 fulfills Task 4 of C/CAG's agreement with the CEC to develop training materials for stakeholder education on alternative fuels, alternative fuel vehicle operation, and supporting infrastructure. This training chapter was prepared in coordination with representatives from the County of San Mateo's Office of Emergency Services (OES). The work and resources contained within have been developed for use within San Mateo County; following successful dissemination of training materials sourced for this chapter, OES and County representatives will present the San Mateo County efforts as a template for first responder AFV training and readiness in the Bay Area Urban Areas Security Initiative (Bay Area UASI) region. USAI consists of 14 regions within the Bay Area and surrounds (USAI, 2015). The alternative fuel sources and some of the vehicle attributes considered in this study are shown in Table 42.

Table 42: Alternative Fuel Sources Considered in this Study

Alternative Fuel Source	Vehicle Attributes
Electric	Electric vehicles use electricity from a power source to charge EV batteries and can travel from 40 to 120 miles on a single battery charge. Hybrid electric vehicles combine an electric motor with a separate gasoline or diesel engine.
Bio- / Renewable-diesel	Biodiesel is a drop in replacement fuel for conventional diesel. The use and safety considerations are essentially the same as those for conventional diesel engines.
CNG	CNG vehicle fuel tanks are maintained at pressures of 2900 to 3600 psi. CNG fuel is used in either OEM or retrofit gasoline/internal combustion engine automobiles.
LNG	LNG vehicle fuel tanks are insulated and maintained at Cryogenic (-26°F) temperatures and pressures of up to 150 psi. LNG fuel is used in either OEM or retrofit gasoline/internal combustion engine automobiles.
LPG	LPG fuel is used in either dedicated or bi-fuel vehicles. LPG tanks are maintained at moderate pressure of up to 375 psi.
Hydrogen	Hydrogen is used to power fuel cells vehicles or modified internal combustion vehicles. Hydrogen fuel is stored either as a compressed gas, in cryogenic conditions or stored in advanced materials such as zeolites.
Ethanol	Ethanol is also available as E85, or high-level ethanol blends. This fuel can be used in flexible fuel vehicles, which can run on high-level ethanol blends, gasoline, or any blend of these. Another blend, E15, has been approved for use in newer vehicles, and is slowing becoming available.

Conventional and alternative combustion fuels, by their very nature, must be energy dense and flammable. Therefore, stakeholders need to be educated on the fire, explosion, and ignition properties and risks of each fuel and technology combination (Astbury, 2008). Table 43 shows the some of the relevant fuel properties of each alternative fuel compared to conventional gasoline and diesel and the specific fire hazards associates with that fuel.

Table 43: Fuel Properties Table

	Gasoline	Diesel	CNG	LNG	Propane	Hydrogen	Ethanol
Formula	$C_8 H_{18}$	$C_{12}H_{26}$	CH_4	CH_4	C_3H_8	H_2	C_2H_5OH
Boiling Point (°C)	27 to 240	180 to 40	-162	-162	-42	-252.7	75
Auto-ignition Temperature (°C)	257	316	540	450	482	574	423
Peak Flame Temperature (°C)	1977	2054	1790	1790	1990	2045	1,920
Flammability Limits (vol %)	1 to 7.6	0.6 to 5.5	5.3 to 15	5.3 to 15	2.2 to 9.6	4 to 75	3.3 to 19
Flash Point (°C)	- 43	241	- 184	- 188	- 73 to – 101	- 101	13
Special Fire Hazards	Yellow luminous flame visible in daylight; flame flashes from ignition source to leak point; accumulated vapor may explode if ignited in confined area	Yellow luminous flame visible in daylight; dense black smoke	Yellow luminous flame visible in daylight; flame flashes from ignition source to leak point; accumulated vapor may explode if ignited in confined area			Blue flame invisible in daylight; flame flashes from ignition source to leak point; accumulated vapor may explode if ignited in confined	Blue flame invisible in daylight; flame flashes from ignition source to leak point; accumulated vapor may explode if ignited in confined area

Source: National Alternative Fuels Training Center, http://assets.slate.wvu.edu/resources/527/1287595763.pdf, accessed 5/11/2015

Training Scope and Deliverables

The scope of this chapter is to provide information and resources on informational courses and classes with associated training materials for Stakeholders within San Mateo County regarding processes, mechanisms, impediments, and issues involved in AF development.

As part of this effort, the project team has reviewed and compiled existing training materials for stakeholder training and education on electric vehicle operation and installation in San Mateo County. The team has also complied analogous training materials for CNG, LNG, LPG, and hydrogen vehicle operation and Alternative Fuel Infrastructure (AFI) installation. The training materials are included as attachments to this chapter.

Stakeholders in San Mateo County

Alternative fuel vehicle (AFV) stakeholders within the San Mateo County region were identified based on the likelihood and criticality of exposure to AF's and AFV's. The stakeholders and obligated parties are defined as "persons, companies, and/or regional entities including fleet operators, planners, first responders, and government decision-makers". The list of potential stakeholder agencies in San Mateo County are listed in Table 44 and Table 45.

Table 44 : List of Government and First Responder Stakeholders

Stakeholder	San Mateo County Agencies
Government Stakeholders	County Office of Emergency Services Departments of Public Works Planning and Building Departments
Airports	• San Francisco • Half Moon Bay Airport • San Carlos Airport
Ports	Redwood City
First Responders	
Firefighters	• North County • Central County • Woodside • Colma • Menlo Park • Redwood City • San Mateo City • Daly City • Belmont • Foster City
Law Enforcement	• Police Departments - Atherton - BART - Belmont - Brisbane - Broadmoor - Burlingame - Colma - Daly City - East Palo Alto - Foster City - Hillsborough - Menlo Park - Millbrae - Pacifica - Redwood City - San Bruno - San Mateo City • San Mateo County Sheriff's Office • California Highway Patrol
Ambulance Services	• SMCo Transport Paramedics • San Mateo County Health System • Bayshore Ambulance • AMR Ambulance

Table 45 : List of Non-First Responder Stakeholders

Non First Responder Stakeholder	San Mateo County Organizations
AF Fueling Stations Owners and Operators	Electric [a] Biodiesel [b] CNG [c] LNG [d] LPG [e] Hydrogen [f]
Fleet Owners	• Cal Trans • Sam Trans • County of San Mateo • City Fleets [g] • School District Bus Fleets [h] • Car rental companies [i] • Charter Coaches
Roadside Assistance	• Towing Companies [j] • Breakdown Assistance [k]
Auto-repair shops	• Collision Damage [k,l] • Automotive Servicing [k,l]
Dealerships [l]	• New car dealerships [m] • Used Car retail [m]

[a] There over 200 public EV charging stations in San Mateo County. For a detailed map, click the link here: http://www.afdc.energy.gov/fuels/electricity_locations.html

[b] There are no dedicated biodiesel stations in San Mateo County, but there is one renewable diesel station.

[c] There are 10 natural public CNG fueling stations in San Mateo County. For a detailed map, click the link here: http://www.afdc.energy.gov/fuels/natural_gas_locations.html

[d] There are no dedicated LNG fueling stations in San Mateo County.

[e] There is 1 public LPG fueling station in San Mateo County, located in Belmont. For a detailed map, click the link here: http://www.afdc.energy.gov/fuels/electricity_locations.html

[f] Hydrogen Fueling Stations in San Mateo County are in development. For a list of planned stations and addresses, click the link here: http://www.cafcp.org/stationmap

[g] Each city within the county maintains a city bus fleet. The cities of Belmont, Brisbane, Burlingame, Milbrae, Portola, Redwood City, San Bruno, San Carlos, South San Francisco currently use AF municipal fleets.

[h] More information on the school districts can be found at http://www.smcoe.org/about-smcoe/districts-and-schools/

[i] There are 288 car rental companies listed in San Mateo County, for a comprehensive list please click the link here: http://www.yellowbook.com/s/car-rental/san-mateo-county-ca/

[j] There are 197 roadside assistance and towing companies listed in San Mateo County, for a comprehensive list please click the link here: http://www.yellowbook.com/s/towing-companies/san-mateo-county-ca/

[k] There are 783 auto-repair shops listed in San Mateo County, for a comprehensive list please click the link here: http://www.yellowbook.com/s/auto-repair/san-mateo-county-ca/

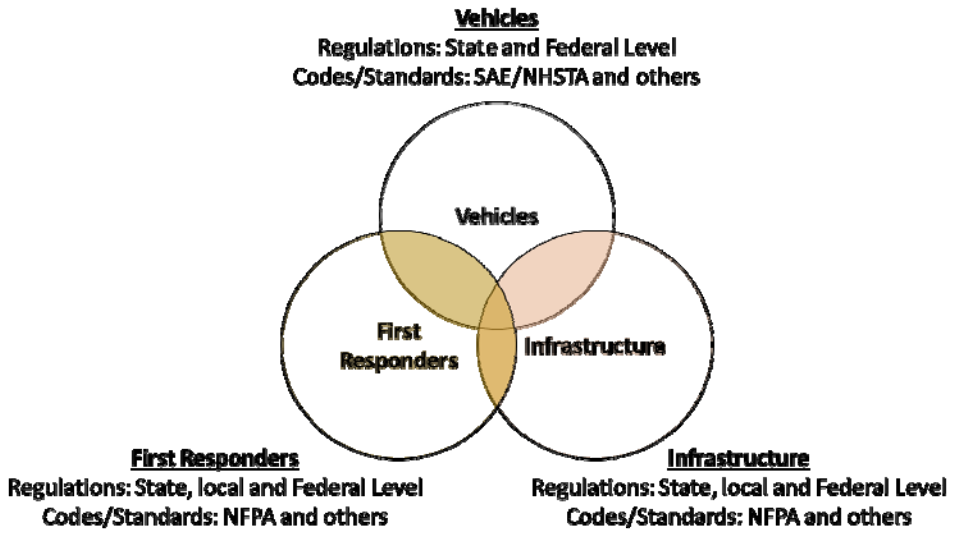
[l] All auto repair shops contacted do not specialize in AFVs repairs or services. For comprehensive repairs, stakeholders are advised to contact the dealership.

[m] There are 640 listed automotive dealerships listed in San Mateo County, for a comprehensive list please click the link here: http://www.yellowbook.com/s/car-dealership/san-mateo-county-ca/

Alternative Fuels Regulations

Aspects of AF use and storage are addressed in a standardized manner in the range of federal, State and Local safety and hazard regulations. Three basic groupings for codes and standards envelop all aspects of AF and AFV use and deployment. These are: (1) vehicles; (2) built infrastructure; and (3) emergency responders. Each of these three groupings have different regulatory and consensus codes and standards. This is illustrated in Figure 25 (Blake, 2010; Durso, 2010; Farr, 2010; Grant, 2010).

Figure 25: Basic Groups of AFV Related Codes and Standards



Source: Adapted from United States National Electric Vehicle Safety Standards Summit Summary Report (Grant, 2010)

Vehicles

Vehicle safety concerns relating to vehicle and all its components are regulated on a federal level, and are addressed by NHSTA and other vehicle oriented codes and standards such as those outlined by SAE (Grant, 2010).

Infrastructure

Infrastructure, including buildings, roadways and zoning requirements are regulated on the State, Local and Federal level. Regulations are based on numerous model consensus codes and standards from NFPA and other organizations. Enforcing these requirements are the state and local fire marshals, fire inspectors, building officials, electrical inspectors, public health officials, and others with similar official enforcement duties (Grant, 2010).

First Responders

The concerns and interests of emergency responders are self-regulated, following model codes and standards provided by NFPA and other standards developers.

Fuel Codes and Standards

Regulating the vehicle, infrastructure, and safety aspects of alternative fuels is challenging because new fuels are emerging and best practices are constantly revised. In many cases, the most thorough guidelines for the requirements of implementing alternative fuels are found in the NFPA codes and standards.

The Uniform Fire Code, (UFC), Uniform Building Code (UBC), Uniform Plumbing Code (UPC), Uniform Mechanical Code (UMC), Code of Federal Regulations (CFR) and the National Fire Protection Agency (NFPA) are designed and written to address all aspects of AFs. Many jurisdictions choose to adopt the NFPA codes and standards for standard best practices on the use, storage, and transport of alternative fuels. The NFPA also uses a system of identification symbols and signs to quickly and clearly inform first responders and obligated parties of the environmental, health, and safety risks associated with a fuel (Hemsley, 1993; NFPA, 2015a). Table 46 and Table 47 list some of the relevant NFPA codes for storage, use, and dispensing of flammable liquids, compressed gases, and liquefied gases.

These codes are typically in revision cycles, resulting in new and/or updated editions on a regular basis (NFPA, 2015a). The revisions present a challenge when equipment manufacturers and fuel stations designers are involved in the development of new facilities and the standards are still under review and have not been adopted. This situation is particularly challenging for hydrogen where the NFPA standards are under revision and new fueling station designs and protocols may be the safer and better solution.

Where current regulations and codes do not provide guidance, engineering judgement and use of codes for comparable fuels are applied. In the case of codes that are in constant revision cycles or that deal with emerging technologies, such as NFPA 2, The Hydrogen Technologies Code, developers work with local officials to ensure the infrastructure and technology safety requirements are met. Ultimate authority for approval or disapproval of implementing an alternative fuel rests with the local authority having jurisdiction, usually the fire prevention official.

Table 46: Some Relevant National Codes and Standards for Alternative Fuel Implementation

Standards/Code	Description
NFPA 2	Hydrogen Technologies Code
NFPA 30	Flammable and Combustible Liquids Code
NFPA 30A	Automotive and Marine Service Station Code
NFPA 30B	Code for the Manufacture and Storage of Aerosol Products
NFPA 50A	Standard for Gaseous Hydrogen Systems at Consumer Sites
NFPA 50B	Standard for Liquefied Hydrogen Systems at Consumer Sites
NFPA 52	Standard for Compressed Natural Gas Vehicular Fuel Systems
NFPA 58	Standard for Storage and Handling of Liquefied Petroleum Gases (LPG)
NFPA 54	National Fuel Gas Code
NFPA 55	Compressed Gases and Cryogenic Fluids Code
NFPA 56	Standard for Fire and Explosion Prevention During Cleaning and Purging of Flammable Gas Piping Systems
NFPA 57	Liquefied Natural Gas (LNG) Vehicular Fuel Systems Code
NFPA 58	Liquefied Petroleum Gas Code
NFPA 59	Utility LP-Gas Plant Code
NFPA 59A	Standard for Production, Storage, and Handling of Liquefied Natural Gas (LNG)
NFPA 67	Guide on Explosion Protection for Gaseous Mixtures in Pipe Systems
NFPA 68	Standard on Explosion Protection by Deflagration Venting
NFPA 69	Standard on Explosion Prevention Systems
NFPA 70	National Electrical Code
NFPA 70A	National Electrical Code Requirements for One- and Two-Family Dwellings
NFPA 70B	Recommended Practice for Electrical Equipment Maintenance
NFPA 73	Standard for Electrical Inspections for Existing Dwellings
NFPA 88B	Standard for Repair Garages
NFPA 88A	Standard for Parking Structures
NFPA 88B	Standard for Repair Garages
NFPA 90A	Standard for the Installation of Air-Conditioning and Ventilating Systems
NFPA 90B	Standard for the Installation of Warm Air Heating and Air-Conditioning Systems
NFPA 91	Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Particulate Solids
NFPA 101	Code for Safety to Life from Fire in Buildings and Structures
NFPA 289	Standard Method of Fire Test for Individual Fuel Packages
NFPA 321	Standard on Basic Classification of Flammable Liquids, Gases and Volatile Solids
NFPA 325M	Fire Hazard Properties of Flammable Liquids, Gases and Volatile Solids

Source: National Fire Protection Association, Codes & Standards, http://www.nfpa.org/codes-and-standards, accessed 4/10/2015.

Table 47: Some Relevant National Codes and Standards for Alternative Fuel Implementation Continued.

Standards/Code	Description
NFPA 385	Standard for Tank Vehicles for Flammable and Combustible Liquids
NFPA 386	Standard for Portable Shipping Tanks for Flammable and Combustible Liquids
NFPA 395	Standard for the Storage of Flammable and Combustible Liquids at Farms and Isolated Sites
NFPA 400	Hazardous Materials Code
NFPA 402	Guide for Aircraft Rescue and Fire-Fighting Operations
NFPA 403	Standard for Aircraft Rescue and Fire-Fighting Services at Airports
NFPA 405	Standard for the Recurring Proficiency of Airport Fire Fighters
NFPA 407	Standard for Aircraft Fuel Servicing
NFPA 408	Standard for Aircraft Hand Portable Fire Extinguishers
NFPA 409	Standard on Aircraft Hangars
NFPA 410	Standard on Aircraft Maintenance
NFPA 412	Standard for Evaluating Aircraft Rescue and Fire-Fighting Foam Equipment
NFPA 414	Standard for Aircraft Rescue and Fire-Fighting Vehicles
NFPA 415	Standard on Airport Terminal Buildings, Fueling Ramp Drainage, and Loading Walkways
NFPA 496	Standard for Purged and Pressurized Enclosures for Electrical Equipment
NFPA 497M	Manual for Classification of Gases, Vapors, and Dusts for Electrical Equipment in Hazardous (Classified) Locations
NFPA 551	Guide for the Evaluation of Fire Risk Assessments
NFPA 555	Guide on Methods for Evaluating Potential for Room Flashover
NFPA 556	Guide on Methods for Evaluating Fire Hazard to Occupants of Passenger Road Vehicles
NFPA 557	Standard for Determination of Fire Loads for Use in Structural Fire Protection Design
NFPA 791	Recommended Practice and Procedures for Unlabeled Electrical Equipment Evaluation
NFPA 853	Standard for the Installation of Stationary Fuel Cell Power Systems
NFPA 900	Building Energy Code
UFC	Uniform Fire Code
UBC	Uniform Building Code
UPC	Uniform Plumbing Code
UMC	Uniform Mechanical Code
CFR	Code of Federal Regulations

Source: National Fire Protection Association, Codes & Standards, http://www.nfpa.org/codes-and-standards, accessed 4/10/2015.

Additional sources of published information containing guidance on equipment and facility safe design practices are:

- Society of Automotive Engineers (SAE, 2015),
- National Highway Traffic Safety Authority (NHTSA, 2015),
- Petroleum Equipment Institute (PEI, 2015),
- American Petroleum Institute (API, 2015)
- Underwriters Laboratories (UL, 2015), and
- American Society for Testing and Materials (ASTM, 2015).

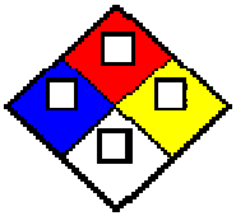
Stakeholders are encouraged to periodically review the published information and update to the most current standards and practices as they become available.

Alternative Fuel Signage and Identification Symbols

Most jurisdictions have adopted the NFPA 704 for identification of the hazards of materials for emergency response (NFPA, 2012). NFPA 704 defines the colloquial "fire diamond" used by emergency response personnel to quickly and easily identify the risks posed by hazardous materials. The fire diamond is used to determine what, if any, special equipment should be used, procedures followed, or precautions taken during the initial stages of an emergency response.

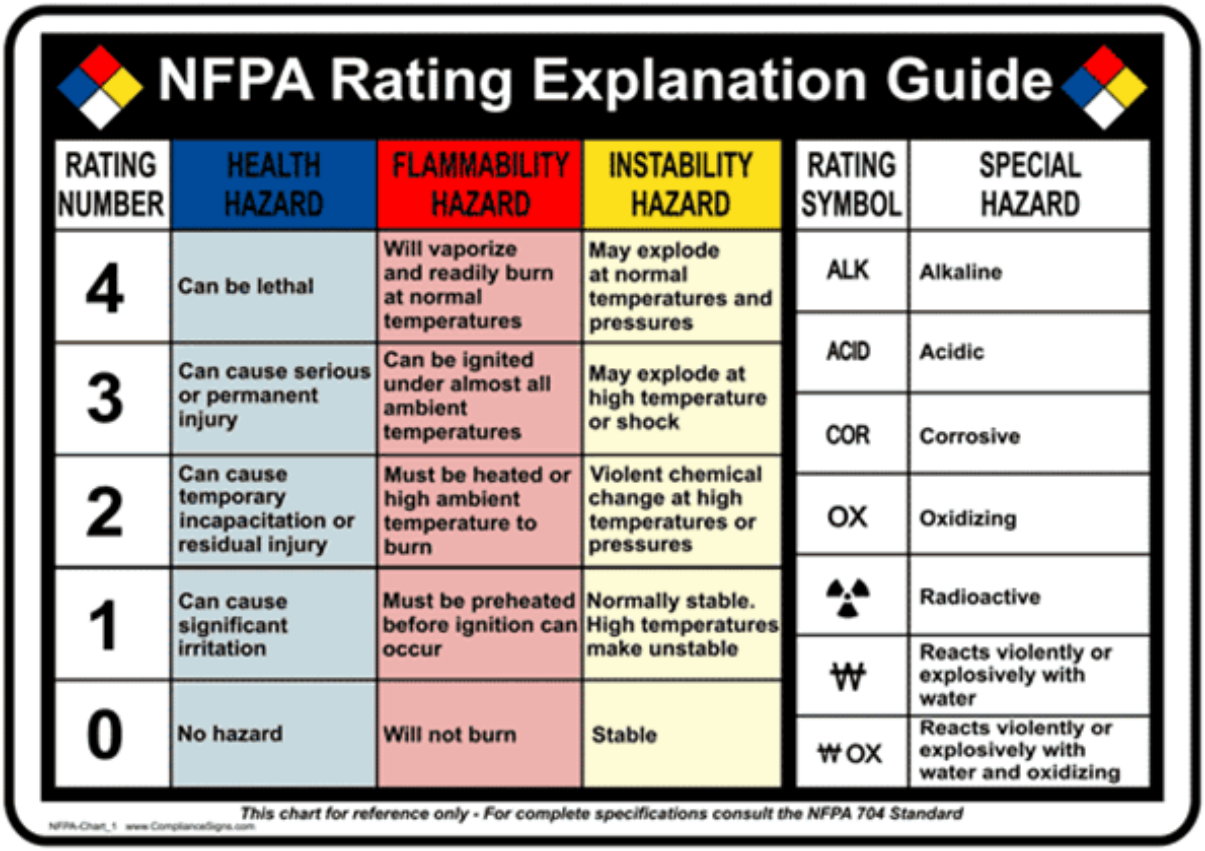
Obligated parties, such as AFV and fuel tanker owners, fueling and maintenance stations, etc., are required to display identification markers classifying the type of alternative fuel in use and the level of risk/hazard associated with the alternative fuel (NFPA, 2012). Figure 26 shows the NFPA diamond classification system.

Figure 26: NFPA Diamond Classification System



The four divisions are typically color-coded with red indicating flammability, blue indicating level of health hazard, yellow for chemical reactivity, and white containing codes for special hazards. Each category is divided in five levels of hazard potential with zero (0) used to indicate no special hazards and four (4) for severe or extreme hazard potential. Figure 27 shows the NFPA rating explanation guide.

Figure 27: NFPA Rating Explanation Guide



NFPA Rating Explanation Guide

RATING NUMBER	HEALTH HAZARD	FLAMMABILITY HAZARD	INSTABILITY HAZARD
4	Can be lethal	Will vaporize and readily burn at normal temperatures	May explode at normal temperatures and pressures
3	Can cause serious or permanent injury	Can be ignited under almost all ambient temperatures	May explode at high temperature or shock
2	Can cause temporary incapacitation or residual injury	Must be heated or high ambient temperature to burn	Violent chemical change at high temperatures or pressures
1	Can cause significant irritation	Must be preheated before ignition can occur	Normally stable. High temperatures make unstable
0	No hazard	Will not burn	Stable

RATING SYMBOL	SPECIAL HAZARD
ALK	Alkaline
ACID	Acidic
COR	Corrosive
OX	Oxidizing
☢	Radioactive
₩	Reacts violently or explosively with water
₩ OX	Reacts violently or explosively with water and oxidizing

This chart for reference only - For complete specifications consult the NFPA 704 Standard

Source: http://www.compliancesigns.com/nfpadiamonds.shtml accessed 5/1/2015.

The degrees of hazard in each of these categories are given as follows:

- **A rating of 1** is for **slightly hazardous (toxic) material** which require only minimal protection.
- **A rating of 2** is for **moderately toxic or hazardous material** which require additional Personal Protective Equipment (PPE) or equipment.
- **A rating of 3 or 4** is for **highly to extremely toxic (deadly) material (and any carcinogen, mutagen, or teratogen)**. These materials will require specialized equipment (e.g. respirator (or exhaust hood), full face shield, rubber apron, specialized glove, handling tongs, etc.) beyond that required for moderately toxic material.

The numeric values designated in the standard by "Degree of Hazard" using Arabic numerals (1, 2, 3, 4), not to be confused with other classification systems, such as that in the NFPA 30 Flammable and Combustible Liquids Code, where flammable and combustible liquid categories are designated by "Class", using Roman numerals (I, II, III).

Classifications of Flammable and Combustible Liquids

Most jurisdictions have adopted NFPA 30 for classification of flammable and combustible liquids (NFPA, 2015b). NFPA 30 includes a system for categorizing liquids as being flammable or combustible. These classifications are used for determining the various fire protection requirements for the storage and use of flammable and combustible liquids.

Flammable liquids are classified as Class I, which are further sub-classified, based upon additional criteria that affects fire risk, as Class IA, Class IB and Class IC - these liquids have flash points below 100 °F (37.8 °C).

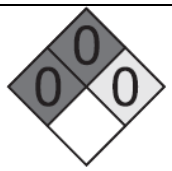
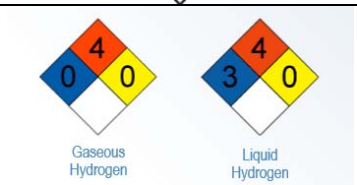
- Class IA liquids are liquids that have flash points below 73 °F (22.8 °C) and boiling points below 100 °F (37.8 °C). Unstable flammable liquids are treated as Class IA liquids.
- Class IB liquids are liquids that have flash points below 73 °F (22.8 °C) and boiling points at or above 100 °F (37.8 °C).
- Class IC liquids are have flash points at or above 73 °F (22.8 °C), but below 100 °F (37.8 °C).

Combustible liquids are classified as Class II and Class III, which are further sub classified, based upon additional criteria that affect ire risk, as Class IIIA and Class IIIB - these liquids have flash points of 100 °F (37.8 °C) or more. Class I liquids are the most hazardous from a fire safety standpoint, while Class IIIB liquids are the least hazardous.

- Class II liquids are combustible liquids that have a flash point at or above 100 °F (37.8 °C) and below 140 °F (60 °C).
- Class IIIA liquids are combustible liquids that have a flash point at or above 140°F (60 °C), but below 200 °F (93 °C).
- Class IIIB liquids are combustible liquids that have a flash point at or above 200 °F (93 °C).

Table 48 shows the alternative fuel source and the NFPA signage and hazard classification codes.

Table 48: NFPA Signage and Hazard Classification Codes.

Alternative Fuel Source	Classification Diamond
Gasoline	
Electric	
Hybrid electric	
Biodiesel	
CNG	
LNG	
LPG	
Hydrogen	

In most cases, AFV's are also adorned with additional markers and identification symbols, such as badges, decals and placards that indicate the type of fuel and engine technology. Table 49 shows typical examples of additional AF markers.

Table 49: Some Typical AF Identification Markers.

Alternative Fuel Source	AF Identification Marker	Identification Requirements
Electric	 	Optional Optional
Biodiesel		Optional
CNG	 	Mandatory Optional
LNG	 	Mandatory Optional
LPG		Mandatory
Hydrogen		Mandatory

Role of Stakeholders in San Mateo County

This section provides information on the stakeholders and their respective roles in AF permitting, deployment, use, and response situations. This section also provides information on levels of AF training by each stakeholder group.

Government Decision Makers/Leaders

County Emergency Disaster Response

Role

The county emergency disaster response teams are planned and coordinated by the Office of Emergency Services (OES) in San Mateo County. AF and AFV response are the responsibility of the local fire department.

AF Training

OES staff have received no dedicated training on alternative fuels, vehicles, and infrastructure requirements from centralized source. Staff attend online webinars, review guidance documents issued by DOE, CEC and other relevant parties. OES Staff are required to comply with all applicable local, state and federal laws relating to alternative fuels. These generally are dealt with on a case-by-case basis.

Department of Public Works

Role

The Department of Public Works plans, designs, constructs, operates, and maintains facilities and equipment that are safe and accessible to the clients of County agencies, the general public and county employees. The Department advises the Board of Supervisors on all public works issues, including rates and charges for services for both the users and service providers. A similar role is played by public works departments in every city and town in San Mateo County for their citizens and employees.

AF Training

Public Works staff have received no specific training on alternative fuels, vehicles, and Infrastructure requirements from centralized source. Staff are required to comply with all applicable local, state and federal laws relating to alternative fuels. These generally are dealt with on a case-by-case basis, in consultation with AF project stakeholders.

Planning and Building Department

Role

The building department is responsible for planning and regulating land use and development within the unincorporated areas of the County. The department is organized into three Sections:

1) Long Range Planning, which prepares and updates land use plans and studies, ensures zoning ordinance compliance through code enforcement, develops and manages the Geographic Information System for the Department, and prepares land use planning maps;

2) Current Planning, which conducts project reviews and environmental impact analyses; and
3) Building Permits and Inspections, which protects life and property by issuing building permits and conducting inspections.

A similar role is played by planning and building departments in every city and town in San Mateo County for their citizens and employees.

AF Training
Building Department staff have received no specific training on alternative fuels, vehicles, and Infrastructure requirements from centralized source. Staff are required to comply with all applicable local, state and federal laws relating to alternative fuels. These are generally dealt with on a case-by-case basis, in consultation with project stakeholders and fire prevention officials.

Redwood City Port Authority

Role
The Port of Redwood City, located 18 nautical miles south of San Francisco, is the only deep-water port in South San Francisco Bay. The port is located between San Francisco and the Silicon Valley/San Jose region, and provides inland transportation access via United States Highway 101 and Union Pacific Railroad. The Port of Redwood City specializes in bulk, neo-bulk and liquid cargoes. The port authority serves as a landlord and provides oversight activities on the transport of cargoes through the facility.

AF Training
Port authority staff have received no specific training on alternative fuels (or conventional fuels) and rely on individual users of the facility to comply with all applicable local, State and Federal regulations.

Fire Officials

Firefighters and Fire Prevention Officials

Role
Fire officials and fighters are the first responders on-site in the event of an accident involving AFI or AFVs. Fire prevention officials are responsible for ensuring that facilities housing alternative fuel and infrastructure comply with all local, state and federal safety regulations.

AF Training
The levels of training on specific types of AF varies from station to station. Firefighters from across San Mateo County have received sporadic training on AFs and AFVs. Most of the trainings already received related to AFVs were focused on extrication from electric and hybrid vehicles. Sourcing of training materials is often centralized, through the Office of Emergency Services. Additionally, each department may independently find materials, conduct trainings, or hire private trainers. The types and sources of materials varies greatly from symposiums, online videos and resources, private companies, and state fire agencies.

Emergency Responders

Law Enforcement

Role

The role of law enforcement agencies in AFI and AFV planning is limited to maintaining public safety in the event of an incident and enforcement of State and Federal laws governing AF use and deployment.

AF Training

Emergency response is typically within the remit of the fire fighters. Law enforcement agencies receive many of their trainings from a centralized source: The Commission on Police Officers Standards and Training (POST). There are no current POST trainings regarding AF or AFV emergency response. Most accidents in the area are dealt with by California Highway Patrol in the region, not the local sheriffs or police departments. CHP has received some exposure and training around electric vehicles and hybrids.

Ambulance Services

Role

The role of ambulance services and Emergency Medical Technicians, (EMT) is to provide emergency on site medical assistance and to transport injured parties to a facility for treatment.

AF Training

Most often in the case of an accident, the fire department is responsible for extrication of injured parties. Ambulance service employees do not receive any specific training on vehicle accidents or safety in general, nor with regard to AFs or AFVs.

Non-First Responder Stakeholders

Fueling Station Owners

Role

Fueling station owners are responsible for informing themselves on and adhering to the relevant local, state, and federal regulations regarding fuel they sell. Fueling infrastructure is constructed and inspected in consultation with local officials in the Building and Fire departments. Fueling station owners are required to prominently display all relevant fuel and hazard identification symbols, and list the contact details of emergency services.

AF Training

New employees hired at fueling stations receive training on emergencies, such as how to shut off pumps. Internal postings inform staff about who the emergency contacts are. Typically, a staff member conducts training internally. Occasionally propane distributors provide training on use of their equipment.

Wholesale Fuel Distributors

Role

Wholesale fuel distributors, similar to fueling station owners, are responsible for informing themselves on and adhering to the relevant local, state, and federal regulations regard the fuel

they distribute. Any infrastructure is constructed in consultation with local officials, and distributors are required to display all relevant fire and hazard identification symbols, as well as the emergency contacts. Distributors are also responsible for ensuring that distribution vehicles adhere to all relevant codes and regulations and are fit for purpose.

AF Training

Employees who directly handle fuels receive training from trade associations on safety protocols for dealing with the fuels. Internal postings inform staff about who the emergency contacts are and provide information on the immediate fire and safety risks of the fuels.

Fleet Owners, School Fleets, and Charter Companies

Role

Fleet owners and charter companies are responsible for informing themselves on and adhering to the relevant local, state and federal regulations regarding the fuel and vehicles they use. Transit hubs are constructed in consultation with local officials and are inspected regularly. In some cases, onsite supervisors are responsible for finding and providing safety training related to internal operations and servicing vehicles.

AF Training

Trainings come in several forms including video, in person exercises, presentations, websites, and pamphlets.

Roadside Assistance/ Towing Services

Role

Roadside services provide assistance in the case of a breakdown or minor accident.

AF Training

Several towing service employees have received training by coordinating with local fire departments and dealerships. Primarily, however, they rely on the California Tow Truck Association and independent research. Training is sporadic and inconsistent from one company to another.

Auto-Repair Shops and Garages

Role

Auto-repair shops provide mechanic services to AFV's and AF fleets. Typically, auto-repair shops that deal with alternative fuels are specialized and are heavily promoted by dealerships.

AF Training

Trainings on AFs vary between auto shops. Most employee trainings cover servicing and maintaining vehicles. These trainings include some safety components as well. A few employees received training from equipment salesman, vehicle manufacturers and trade associations.

Dealerships

Role

Dealerships sell and provide information to consumers on AFs, AFV's and AF fleets.

AF Training
Technicians at dealerships receive extensive training if they are selling AFVs on their lot. The manufacturer hosts specialized trainings that certify technicians to work on each of their vehicles. Current training comes from trade associations and vehicle manufacturers.

Alternative Fuel Infrastructure Permitting

The State of California and DOE have heavily invested in a range of fueling and infrastructure plans and best practices guidebooks. This section of the report provides information on infrastructure permitting by fuel type and provides the reader with information on the relevant guidebooks and other resources for infrastructure permitting. The permitting processes consists of seven stages, which help define the overall process and the timeline for completing all of the required components (Blake, 2010; Rivkin, 2012). Briefly, these are:

1. Preliminary project scoping
2. Station design
3. Approval process
4. Station/dispenser construction
5. Station/dispenser startup
6. Station/dispenser operation
7. Station/dispenser maintenance
8. Some fueling infrastructure installation may require California Environmental Quality Act (CEQA) approval, e.g. adding a piece of equipment that requires a new permit from the relevant Air Quality Management District (AQMD).

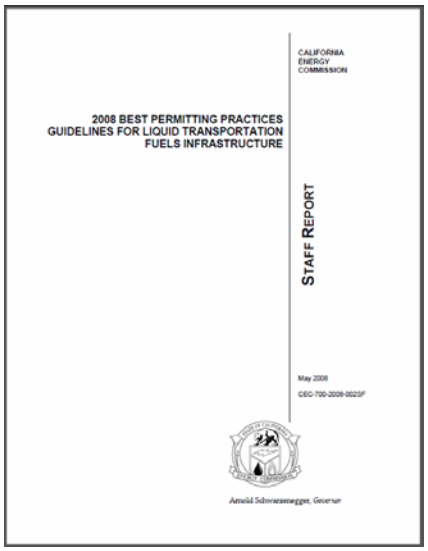
Local fire prevention officials often have jurisdiction and final approval authority over refueling facilities, for example, and the requirements imposed by such local authorities in the absence of NFPA or other guidelines may differ substantially from one locale to another. This makes planning and engineering more complicated for stakeholders considering alternative fuels (Rivkin, 2012).

Bio-/Renewable Diesel, and Ethanol

The permitting and infrastructure requirements for bio- / renewable- diesel and ethanol are essentially the same as for conventional gasoline and diesel fuels. Ethanol has been in use in the United States as a transportation fuel and blending component for many years and the infrastructure requirements are well defined. The CEC 2008 Best Permitting Practices Guidelines for Liquid Transportation Fuel Infrastructure shown in Figure 28 provides recommendations to local, state, and federal agencies, as well project proponents, on approaches and tools to streamline and coordinate the permitting process for petroleum and other liquid transportation fuel infrastructure projects (CEC, 2008). The guidelines do not recommend changes to laws, regulations, or agency jurisdictions or responsibilities. These

guidelines apply to the permitting process for bio- and Renewable diesel infrastructure projects as well as ethanol infrastructure projects.

Figure 28: 2008 Best Permitting Practices Guidelines for Liquid Transportation Fuels Infrastructure



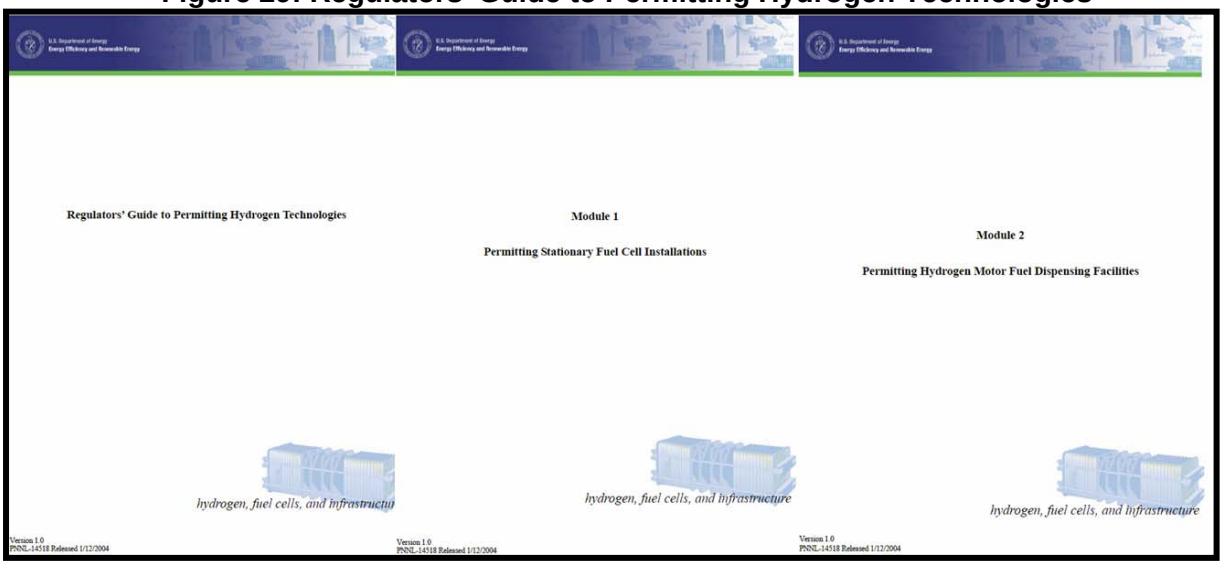
Hydrogen and EV Infrastructure Permitting

Standardized procedures for permitting hydrogen technologies and systems are not well established. As a first step, DOE sponsored the development of a new guide designed to help regulators sort through the multitude of codes and standards that apply when permitting hydrogen facilities.

The Regulators' Guide to Permitting Hydrogen Technologies (DOE, 2004a), shown in Figure 29, was developed through a collaborative effort involving the National Fire Protection Association (NFPA), the International Code Council (ICC), Pacific Northwest National Laboratory (PNNL), and the National Renewable Energy Laboratory (NREL). It provides basic information about hydrogen's use as a fuel, information on the regulatory process, and relevant codes and standards for stationary fuel cell technologies for commercial buildings and hydrogen motor fuel dispensing facilities. The guide is included as an Attachment to this report and consists of:

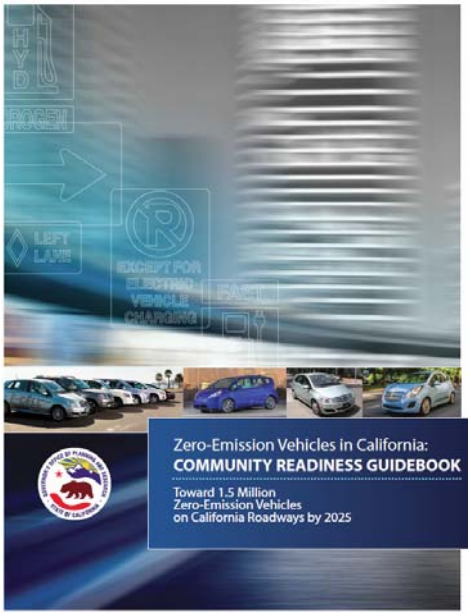
- Regulators' Guide to Permitting Hydrogen Technologies (DOE, 2004a),
- Module 1—Permitting Stationary Fuel Cell Installations (DOE, 2004b)
- Module 2—Permitting Hydrogen Motor Fuel Dispensing Facilities (EERE, 2004)

Figure 29: Regulators' Guide to Permitting Hydrogen Technologies



Additionally, California State government has made it their priority to help communities become "ZEV ready". As part of this effort, the Office of Planning and Research (OPR) developed a guidebook to develop infrastructure plans, improve permitting, and complete other actions to accommodate ZEVs by 2015 (OPR, 2013). The ZEV Guidebook shown in Figure 30 is a resource for cities and counties where hydrogen stations and electric chargers will be installed.

Figure 30: Zero Emissions Vehicles Community Readiness Guidebook



The guidebook highlights many aspects of ZEV readiness, including necessary infrastructure, planning, zoning, permitting guidelines, greening local fleet,s and encouraging consumers through incentives and outreach. Although much of the book focuses charging, CaFCP staff

were instrumental in putting together the hydrogen section with background information, recommended actions for local communities, and practical tools and templates.

For hydrogen specific resources, the Bay Area Air Quality Management District (BAAQMD) has compiled a H2 guidance document that provides individuals and agencies involved with planning or permitting a hydrogen station with guides, resources, and best practices learned from constructing hydrogen stations in California (BAAQMD, 2014). The guidebook focuses on:

- Characteristics of hydrogen as a fuel
- Layout and design of hydrogen stations
- Recommended actions to prepare for hydrogen stations and fuel cell electric vehicles
- Building and fire codes that apply to hydrogen stations
- An example permitting process for a hydrogen station

The guidebook is shown in Figure 31 and is included as an Attachment to this report.
CEC has also published resources for anyone considering the installation of a hydrogen fueling station (CEC, 2004). The resource shown in Figure 32 provides guidance for planning, designing, siting, permitting, and procuring facilities to refuel hydrogen-fueled vehicles.

Figure 31: H2 Readiness: Best Practices Guidebook

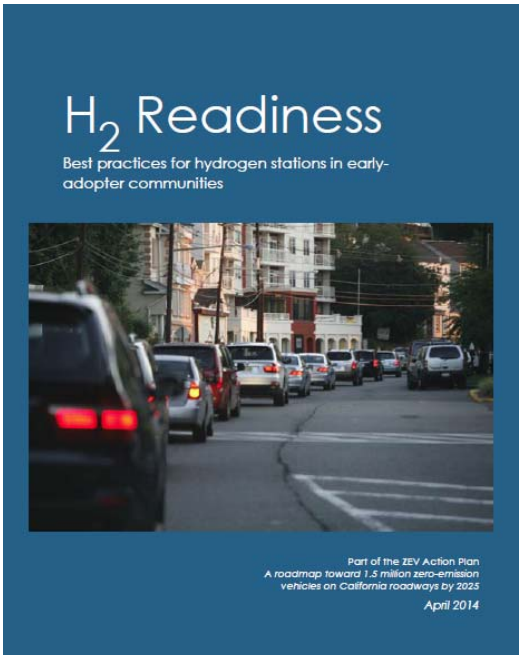
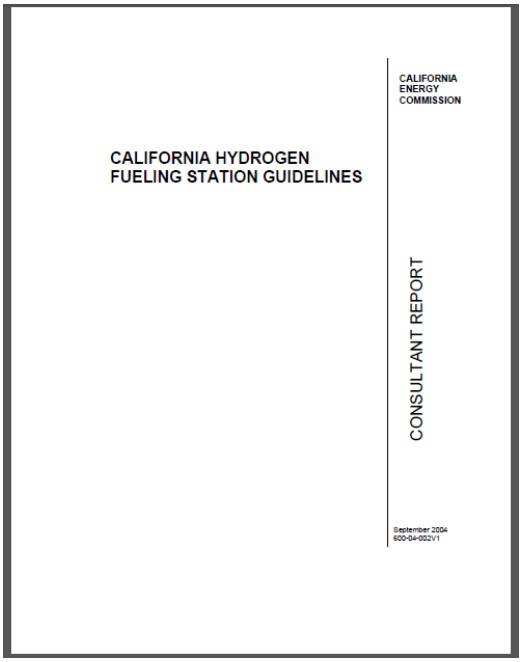


Figure 32: California Hydrogen Fueling Station Guidelines



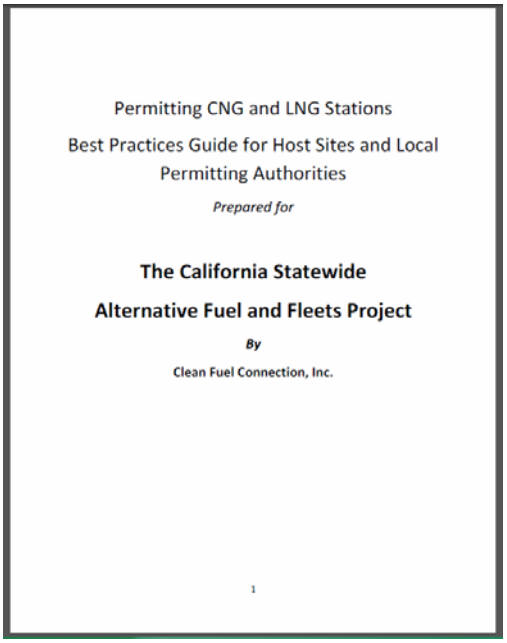
CNG/LNG and LPG Infrastructure Permitting

CNG and LNG are established alternative transportation fuels in California. DOE, Bay Area Air Quality Management District (BAAQMD) and Fire Prevention Officials have sponsored the development of guides designed to help regulators sort through the

multitude of codes and standards that apply when permitting CNG and LNG facilities. Permitting requirements for LPG infrastructure are similar to those for CNG.

Figure 33 shows the CNG and LNG station permitting best practices guide developed by Clean Fuels Connection, Inc., for DOE and BAAQMD (Clean Fuel Connection Inc., 2014). This guide focuses on the permitting of new compressed/liquefied natural gas stations and the effort to streamline permitting practices without sacrificing details governing safety. It is intended for use by municipal and state officials entrusted with fire protection and the safety of the people within their jurisdictions. Fire departments that heretofore have had limited exposure to the use and safety of compressed natural gas (CNG) as a fuel for motor vehicles should find these recommendations valuable. Figure 34 shows the CNG station-permitting guide developed by the northeastern regional fire safety officials (NRFCO, 2000).

Figure 33: Permitting CNG and LNG Stations Best Practices Guide


Permitting CNG and LNG Stations

Best Practices Guide for Host Sites and Local Permitting Authorities

Prepared for

The California Statewide

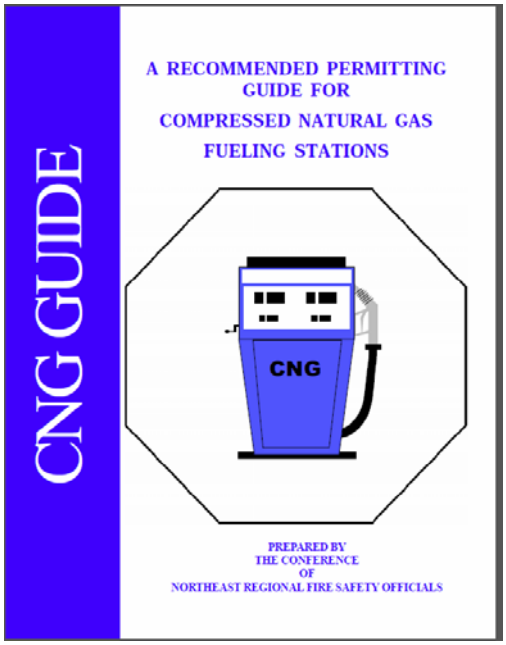
Alternative Fuel and Fleets Project

By

Clean Fuel Connection, Inc.

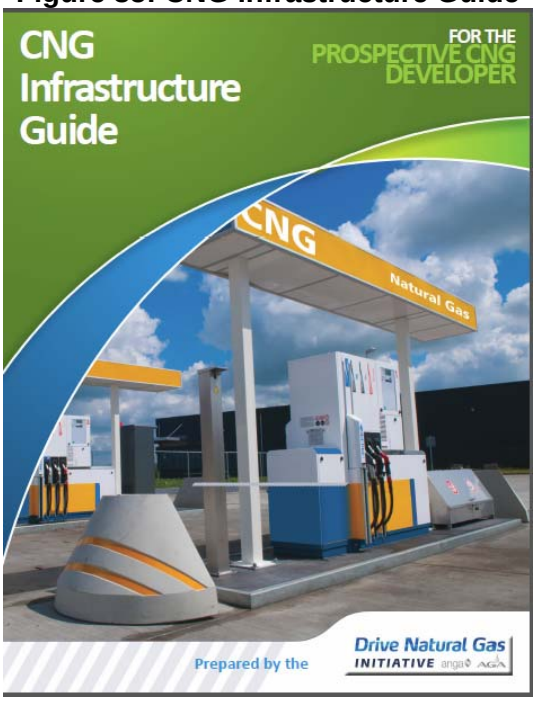
1

Figure 34: CNG Station Permitting Guide



The Drive Natural Gas Initiatives Infrastructure Committee developed a CNG infrastructure guide to help those interested in pursuing CNG development (DNGI, 2014). The guide is a resource for prospective station owner/operators, fleet managers, and those involved in the conversion and maintenance of natural gas vehicles. The guide also includes examples of CNG station siting plans. (See Figure 35).

Figure 35: CNG Infrastructure Guide



Alternative Fuel Safety

Safety Considerations

Training materials and first responder experience do not encompass all of the risks and hazards associated with alternative fuels. Training materials need to address potential hazards, labelling concerns, operating practices, and other factors (DOE, 2015a, 2015b, 2013a; U.S. DOT, 1999). Some examples of the safety, fire, health, and environmental considerations for each alternative fuel are:

- Flammability
- Corrosivity
- Health impacts
    - Asphyxiation
    - Acute toxicity
    - Chronic toxicity
- High pressure
- Cryogenic temperature
- Mechanical energy (includes energy stored as potential or kinetic energy)
- Electrical energy

Source: United States DOT, 1999. Clean Air Program: Summary of the Safety, Health, environmental and System Risks of Alternative Fuels. Report Number: FTA-MA-90-7007-95-1 and DOT-VNTSC-FTA-95-5. Cambridge, MA.

The more significant safety considerations for each fuel are discussed below.

Bio-/Renewable Diesel

Important safety considerations for the biodiesel component of biodiesel fuel blends include:

- Corrosivity - elastomer or polymer component failure due to the composition difference between biodiesel fuel and gasoline or conventional diesel fuel is a type of corrosivity hazard.
- Toxicity hazard - ingestion of a fuel which has been billed as non-toxic, but which is generally an ester of a fatty acid and methanol.

Electricity

Important safety considerations for electricity include:

- Flammability - fires caused by electrical malfunctions, such as short circuits.
- Corrosivity, toxicity, or high temperatures - can occur from direct contact with battery electrolyte.
- Electrical energy hazard - electric shock.

CNG

Important safety considerations for CNG include:

- Flammability - fires or explosions caused by ignition of gas leaks. Gas leaks can occur from fuel dispenser or fuel system damage, use of improper components, or poor overall design and maintenance.
- Toxicity - natural gas can accumulate in enclosed spaces causing asphyxiation. The odorant may not provide sufficient warning of the actual gas concentration.
- High-pressure hazard - fuel tank explosion, missile damage from failure or improper assembly or disassembly of fuel system components.

LNG

Important safety considerations for LNG include:

- Flammability - fires or explosions can occur from ignition of leaks of fuel. Non-odorized fuel gas increases the hazard.
- Toxicity - asphyxiation from exposure to non-odorized fuel gas.
- Cryogenic hazards - LNG presents several hazards associated with the cryogenic property of the fuel: Personal injury may occur from exposure to cold fuel or fuel vapors. Structural failure can occur due to stress from contraction of structural members exposed to cold fuel or fuel vapors. Structural failure can also occur due to embrittlement of materials exposed to cold fuel or fuel vapors.

LPG

Important safety considerations for propane include:

- Flammability - propane gas can collect in low spaces; large propane vapor clouds can detonate.
- Toxicity hazard - propane gas can collect in low spaces, displacing air and may cause asphyxiation.

Hydrogen

Important safety considerations for hydrogen include:

- Flammability - fire or explosion from ignition (especially static ignition) of gas releases or gas leaks. Note that hydrogen fuel is a non-odorized flammable gas.
- High pressure hazard – hydrogen gas is stored at high pressures (2,400 to 3,600 psi), fuel tank explosion, missile damage from failure or improper assembly or disassembly of hydrogen fuel system parts.

Ethanol and Ethanol Blends

Important safety considerations for ethanol and ethanol blends include:

- Flammability - vapors in fuel tanks are within the flammable range for typical ambient temperatures.
- Corrosivity – ethanol is slightly acidic and can corrode some active metals.
- Toxicity hazard – fuel ethanol is denatured with natural gas or gasoline.

Safety Practices

Safety practices for alternative fuels are similar to those for a conventional petroleum fueling station. They include posting safety signs and keeping ignition sources away from the fuel. Every fuel station must include emergency telephone numbers for the fire department, police, maintenance, and medical providers. Regular inspection of fueling nozzles, dispensers, and receptacles is required. Use of cell phones, matches, and the smoking of cigarettes should be strictly prohibited at the premises of the fueling stations. If an emergency fire occurs, attempts should not be made to disconnect the nozzle from the vehicle. Evacuate the immediate area of fire, trigger the emergency safety device, and contact the fire department (Townes, 1998).

Current safety codes and standards do not fully cover all aspects of alternative fuel use, although consideration has been given to certain fuels in some arenas. For example, the NFPA has developed codes for electric vehicle technologies, and for CNG, LNG, LPG, and H_2 fuel storage and dispensing, but these requirements do not specifically apply to maintenance facilities unless the refueling and maintenance occur in the same area (NFPA, 2015a). Where current regulations and codes do not provide guidance, engineering judgement and use of codes for comparable fuels must be applied to such issues as fuel leaks, flammability, flame luminosity, toxicity, and other potential concerns (Hemsley, 1993). Table 50 summarizes alternative fuel properties and practices.

Table 50: Summary of Alternative Fuel Safety Considerations and Practices

Parameter	Electric	Biodiesel	CNG	LNG	LPG	Hydrogen
Storage	EV charging stations	As for conventional liquid fuels	High pressure cylinders (up to 5000 PSI)	Cryogenic (-26°F) moderate pressure (up to 150 PSI) in insulated tanks	Moderate pressure tanks (up to 375 PSI)	Compressed H_2 gas in high pressure tanks (up to 10,200 PSI) Cryogenic H_2 (cooled to -425°F, at pressures of 5,000 PSI) in insulated tanks Storage in advanced materials — within the structure or on the surface of certain materials, as well as in the form of chemical compounds that undergo a chemical reaction to release hydrogen
Dispensing	EV charging stations	As for conventional liquid fuels	Specialized high-pressure fueling connector	Specialized cryogenic fueling connector	Specialized fueling connector	Specialized high-pressure fueling connector Specialized cryogenic fueling connector
Dispensing Vapor recovery	Not applicable	Desirable	Not applicable	Desirable	Required	Required
Exposure Hazards	High voltage electric shock; corrosive liquid can cause tissue injury	Toxic via ingestion, vapor inhalation or skin contact	Physical hazard due to high pressure, can cause injury or embolism	Serious physical hazard due to cryogenic temperature; contact with fuel or equipment cooled by fuel can cause severe frostbite	Physical hazard due to high pressure, can cause injury or embolism; latent heat of vaporization can freeze tissue	Serious physical hazard due to cryogenic temperature and high pressures; contact with fuel or equipment cooled by fuel can cause severe frostbite
Fire Hazards	Battery overheating risk	As for conventional liquid fuels	Released gas is lighter than air; ignites more readily than conventional liquid fuels	Vapor lighter than air; ignites more readily than conventional liquid fuels	Vapor heavier than air; ignites more readily than conventional liquid fuels	Vapor lighter than air; ignites more readily than conventional liquid fuels
Fire prevention for facilities	Ventilation and/or explosion proof equipment at floor level and pits	As for conventional liquid fuels	Ventilation and/or explosion proof equipment at floor level and pits	Ventilation and/or explosion proof equipment at floor level and pits; methane detectors desirable as fuel is not odorized	Ventilation and/or explosion proof equipment at floor level and pits	Ventilation and/or explosion proof equipment at floor level and pits; hydrogen detectors desirable as fuel is not odorized
Vehicle Issues	Significant range and/or weight penalty	As for conventional liquid fuels	Significant range and/or weight penalty	Slight range and/or weight penalty	Slight range and/or weight penalty	Significant range and/or weight penalty

Source: Adapted from HEMSLEY, G. V., 1993. TCRP Synthesis 1 Safe Operating Procedures for Alternative Fuel Buses: A Synthesis of Transit Practice. Acurex Environmental Corporation; DOE, 2013. Fuel Cell Technologies Program: Hydrogen Storage.

Vehicle Accident Safety

Alternative Fuel Vehicles (AFVs) such as electric vehicles, hybrids, fuel cells, hydrogen compressed and liquid natural gas, LPG, and hydrogen are increasing in popularity and use within San Mateo County. As these vehicles are deployed in fleets or used by private individuals, their safety during refueling, recharging, and in crashes, become an issue of paramount concern. All AFV's undergo rigorous safety testing and meet the Federal Motor Vehicle Safety Standards. Additionally, the National Highway Transportation Safety Authority (NHTSA) has performed tests of the crashworthiness of prototype hydrogen vehicles and electric vehicles (DOT, 2015).

In the event of an accident, first responders, typically fire fighters are responsible for extrication and making the area safe for evacuation.

Fueling Stations

Safety concerns and considerations regarding fueling stations are examined in detail in the material provided in the alternative fueling infrastructure permitting section of this report. This section briefly describes some concerns of fueling stations. The NFPA codes present minimum ventilation rates required to prevent flammable vapor accumulation in fueling facilities. The ventilation rates are directly related to the electrical classification requirements. Operators of maintenance facilities requiring electrical system avoid the cost of replacing the electrical system. For systems with indoor fuel dispensing, this option is not available.

Bio-/Renewable Diesel, and Ethanol

Bio-/renewable diesel, and ethanol fueling stations operate in the same manner as conventional gasoline and diesel stations. As a liquid fuel, bio-/renewable diesel, and ethanol are dispensed like conventional gasoline and diesel. A nozzle lockout system can be used to prevent fueling gasoline vehicles with ethanol (DOE, 2013a).

EV Charging

EVs are recharged primarily at private home base locations, such as residential or company garages. Likely locations for opportunity charging include parking facilities at shopping centers, the workplace, park and ride lots, and airports. Fleet or commercial users may also need access to public charging facilities away from their home base. The voltage required for charging EV batteries depends on the battery type. Stakeholders should consult the vehicle's manufacturer for this information (DOE, 2013a; Grant, 2010).

The energy levels for EV charging are:

- **Level 1:** Charging from a standard, grounded 120-volt, 3- pronged outlet available at all homes.
- **Level 2:** Charging at home or public stations functioning at 240-volt/40-amp service with special consumer features to make it easy and convenient to plug in and charge EVs at home or at an EV charging station on a daily basis.

- **Level 3:** A high-powered charging technology currently under development that will provide a charge in 5 to 10 minutes, making it analogous to filling the tank of an internal combustion engine at a local gasoline station

CNG

CNG fueling facilities generally consist of one or more gas compressors, compressed gas storage tanks, and gas dispensing equipment. Compressed natural gas can be dispensed by either "fast-fill" or "time-fill" systems at both public and private access stations. Fast-fill systems can fuel a vehicle in about the same time as a conventional liquid-fuel dispenser. These systems compress and store the gas until needed (Blake, 2010; DOE, 2013a; Durso, 2010; Farr, 2010; Grant, 2010).

Time-fill systems compress the natural gas and dispense it directly into NGVs, eliminating the need for storage vessels. These systems require six to eight hours to fuel an NGV and are commonly used by fleets with vehicles that return to a central location and park overnight. The number of vehicles that a time-fill station can service depends on the size of the compressor, the gas storage capacity of the vehicles, and the desired fill time. (Durso, 2010; Farr, 2010).

LNG

LNG stations generally consist of one or more gas compressors, liquefaction equipment, liquefied gas storage tanks, and gas dispensing equipment. LNG stations are structurally similar to gasoline and diesel stations because they both deliver a liquid fuel. LNG dispensers deliver fuel to vehicles at pressures of 30 to 120 psi. Because LNG is stored and dispensed as a super-cooled, liquefied gas, protective clothing, face shield, and gloves are required when fueling a vehicle (DOE, 2013a) .

There are three options for LNG fueling: mobile, containerized, and customized large stations. In mobile fueling, LNG is delivered by a tanker truck that has on-board metering and dispensing equipment. A starter station, or containerized station, includes a storage tank, dispensing equipment, metering and required containment. A custom station has greater storage capacity and is tailored to meet fleets' needs (DOE, 2013a).

LPG

LPG stations generally consist of one or more gas compressors, gas storage tanks, and gas dispensing equipment. LPG vehicle fueling stations are operated directly by LPG supply companies or by traditional gasoline station owners. Propane dispensing is as fast as gasoline dispensing because the fuel is handled in a liquid state (DOE, 2013a; Grant, 2010).

Most refueling systems employ 500 to 1,000 gallon storage tanks, but storage of up to 30,000 gallons is not uncommon. LPG is typically stored in above-ground tanks. Choice of storage capacity is influenced by local zoning ordinances and codes, with smaller capacity tanks being used in more congested commercial areas and larger tanks being used in less congested industrial sites (DOE, 2013a).

Hydrogen

Hydrogen stations generally consist of one or more gas compressors, liquefaction equipment, liquefied gas storage tanks, and gas dispensing equipment. Most of the hydrogen fueling stations available today have been constructed to support demonstration projects that will help address transition barriers, as well as provide valuable data as hydrogen vehicles begin to penetrate the market. As the market expands, fueling infrastructure will need to grow to match demand. These facilities may be stand alone operations or offer hydrogen pumps in addition to gasoline or natural gas dispensers (DOE, 2013a, 2013b, 2004b).

Many of the hydrogen safety, codes, and standards today are based on practices from the chemical and aerospace industries. The United States Department of Energy (DOE) is coordinating the efforts of codes and standards organizations to develop better codes and standards that ensure the safe use of hydrogen for transportation and stationary applications. One of the outputs of this effort is NFPA 2, a harmonized national standard for hydrogen infrastructure (DOE, 2013a, 2013b, 2004b).

Road Tunnels, Bridges, and Other Limited Access Highways

In recent years, road tunnel fires and subsequent international research projects have suggested that vehicle fires within tunnels are likely to develop more rapidly than expected, degrade the tenability of an environment more quickly than originally calculated, burn for longer periods of time and at higher temperatures, and resist intervention of fire-fighting operations (Connell, 2008).

The NFPA standard 502: Standard for Road Tunnels, Bridges, and Other Limited Access Highways, provides fire protection and fire life safety requirements for limited access highways, road tunnels, bridges, elevated highways, depressed highways, and roadways that are located beneath air-right structures (NFPA, 2014). The guidelines cover construction, operation, maintenance, and fire protection of road tunnels, bridges, and other limited access highways to mitigate hazards, maintain structural integrity, and protect lives. Other topics include standpipe and water supply, control of hazardous materials, emergency ventilation, electrical systems, and emergency response.

Garages and Parking Structures

Public parking

Parking a gaseous-fueled vehicle in an enclosed structure is a serious safety concern as it can lead to a buildup of the gas if a leak occurs. The building department permits public parking structures according to Local, State and Federal codes and standards regarding building ventilation and fire safety. For example, NFPA code 88A applies to parking garages and structures. This standard covers the construction and protection of, as well as the control of hazards in, open and enclosed parking structures, including automated-type parking structures, other than those within one and two family dwellings. The standard requirements address means of egress; construction types; building service and fire protection systems, including lighting, heating, ventilation, and sprinkler systems; special hazard protection, and housekeeping.

For flammable gaseous fuels such as natural gas, LPG and hydrogen, fuel storage and delivery systems are governed by NFPA codes. For example NFPA 52, the Vehicular Gaseous Fuel Systems Code, spells out specific safety requirements for NGVs and their fueling facilities. In addition NFPA 30A applies to facilities that perform maintenance and repair of NGVs. NFPA 2, the Hydrogen Technologies Code, addresses specific safety requirements for vehicles and infrastructure that use hydrogen. A detailed list of the applicable NFPA codes is shown Table 46 and Table 47.

Home garages

The safety considerations for AFV parking in home garages are essentially the same as for any enclosed spaces, individuals parking an alternative fuel vehicle in a private home garage must ensure that adequate ventilation is in place to avoid the build-up of gasses in the event of a leak. In the case of EVs, private individuals are required to have permit for home charging. As part of the permitting process, a building department inspector will inspect the garage/parking structure to ensure that it meets all applicable codes and standards.

Alternative Fuel Properties

Conventional and alternative combustion fuels are energy dense and highly flammable. Therefore, stakeholders need to be educated on the fire, explosion, and ignition properties and risks of each fuel and technology combination (Astbury, 2008). This section discusses the types of alternative fuels available in San Mateo County and their ignition and explosion hazards with reference to existing commonly used fuels. In conjunction with the OES we have focused on providing training resources for First Responders and other Emergency Services staff. Table 51 shows the some of the relevant fuel properties of each alternative fuel compared to conventional gasoline and diesel.

Table 51: Detailed Fuel Properties Table

	Gasoline	Diesel	CNG	LNG	Propane	Hydrogen	Ethanol
Formula	C_8H_{18}	$C_{12}H_{26}$	CH_4	CH_4	C_3H_8	H_2	C_2H_5OH
Motor Octane Number	83 to 90	N.A	130	130	97	N.A	92
Cetane Number	8 to 14	40 to 65	10	10	5 to 10	N.A	8
Density of Liquid Fuel(kg/L)	0.75	0.81	N.A	0.421	0.51	0.071	0.78
Density of Gas (kg/m^3)	2.75	4.13	0.65	0.65	0.51	0.084	1.61
Boiling Point (^{o}C)	27 to 240	180 to 40	- 162	- 162	- 42	- 253	75
Heat of Vaporization (kJ/kg)	355	286	507	507	423	N.A	842
Auto-ignition Temperature (^{o}C)	257	316	540	450	482	574	423
Peak Flame Temperature (^{o}C)	1977	2054	1790	1790	1990	2045	1,920
Spark Ignition Energy (MJ)	0.24	0.24	0.29	0.29	0.305	0.02	0.23
Flammability Limits (vol %)	1 to 7.6	0.6 to 5.5	5.3 to 15	5.3 to 15	2.2 to 9.6	4 to 75	3.3 to 19
Storage Pressure (psi)	ambient	ambient	2,900 to 3,600	150	100 to 375	5,000 to 10,000	ambient
Flash Point (^{o}C)	- 43	241	- 184	- 188	- 73 to – 101	- 101	13

Source: National Alternative Fuels Training Center, http://assets.slate.wvu.edu/resources/527/1287595763.pdf, accessed 5/11/2015.

A brief summary of selected liquid fuels ignition and combustion fuel properties shown in Table 51 is discussed below. These are the fuel properties which First Responders should be readily aware of in the event of an accident.

Motor Octane Number

The octane number is a measure of the tendency for the fuel to pre-detonate during the combustion process in internal combustion engines running on the Otto cycle (spark ignition or petrol engines). In this type of engine, the air–fuel mixture is pre-compressed typically to 7 to 10 bar prior to ignition. The explosion pressure reaches seven to eight times the pressure at ignition, reaching peak cylinder pressures of 50 to 70 bar. The higher the octane number, the less prone the fuel is to detonate (Astbury, 2008).

Cetane Number

This is an indication of the ignition quality of diesel fuel. It is a measure of a fuel's ignition delay between the start of injection and start of combustion of the fuel. In a particular diesel engine,

higher cetane fuels will have shorter ignition delay periods than lower cetane fuels (Astbury, 2008).

Boiling Point

The boiling point is an important parameter as it is directly related to the volatility of a fuel. Fuels which have low boiling points will readily evaporate, thus spillages do not persist for long periods. Cryogenic fuels such as LNG and Hydrogen boil at very low temperatures and hence any spillage will tend to vaporize. However, as the liquid is very cold, rapid boil-off occurs until the ground has been cooled to the atmospheric boiling point, when evaporation reduces significantly (Astbury, 2008; DOE, 2013a).

Flash Point

The flash point of a liquid is the temperature at which the vapor pressure is sufficient to form a flammable concentration with air. Spillages of liquid fuels at a temperature above their flash point will form flammable vapors, which are likely to explode if ignited. Conversely, spillages of liquid fuels below their flash point do not form flammable concentrations of vapors (Astbury, 2008).

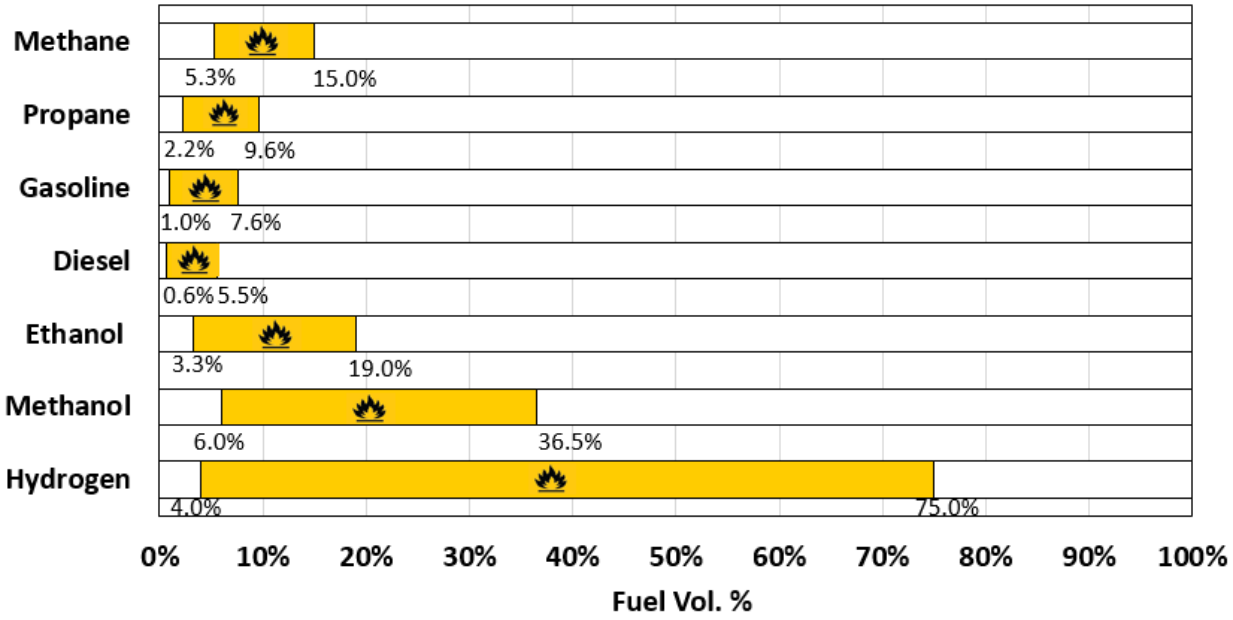
Auto-ignition Temperature

The auto-ignition temperature is the lowest temperature at which combustible vapors ignite spontaneously (i.e. without an external source of ignition) in a confined space. This temperature is required to supply the activation energy needed for combustion (Astbury, 2008).

Flammability Limits

The flammability limit represents the range where a combustible mixture forms. The lower and upper limit correspond to the minimum or maximum percentage of fuel needed in an air-fuel mixture to support combustion. Combustion occurs when the correct ration of air-fuel is ignited by the introduction of heat, including spark ignition and compression. The upper limit is the maximum concentration or percentage of fuel (richest air-fuel mixture) that will support combustion. Mixtures above the upper limit will not burn because there is too much fuel and not enough air. The lower limit is the minimum concentration of fuel (leanest air-fuel mixture) that will support combustion. Air-fuel mixtures below the lower limit will not burn because there is too much air and not enough fuel (DOE, 2015b).

Figure 36: Flammable range for fuel-air mixtures at 1 atm. 25°C.



Source: United States DOE Alternative Fuels Data Center, Fuels Properties Table, http://www.afdc.energy.gov/afdc/pdfs/fueltable.pdf., accessed, 5/15/2015.

Health and Environmental Considerations

Many environmental considerations relating to the use and handling of alternative fuels are the same as those for conventional fuels. For example, vapors of gasoline, diesel, methanol, ethanol, and LPG, if accidentally released, tend to accumulate at ground level, or in low-lying regions such as maintenance pits. As a result, the use of these fuels in areas with pits requires stringent electrical classifications, i.e. explosion-proof equipment in the pits and below 18 in. (0.46 meters) above grade level (Hemsley, 1993).

Electrical classification requirements are based on the composition of gas, and the likelihood of the gas being present. This links the electrical classification to the building ventilation rates: if the ventilation disperses the gas quickly, the likelihood of a flammable concentration accumulating is decreased. Unlike gasoline, methanol, ethanol, and LPG, natural gas is lighter than air and natural gas vapors near room temperature will rise and accumulate at ceiling level in enclosed areas. The NFPA codes do not specifically identify electrical classification requirements for indoor maintenance areas where CNG or LNG vehicles are serviced. Ventilation at ceiling level ensures that no areas exist in which flammable pockets of gas might accumulate (DOE, 2015c, 2013a; Hemsley, 1993).

The spill or leak of an AF is not likely to result in any long-term environmental damage. A United States Department of Transport review of the potential environmental hazards for each AF that is not gaseous at normal temperatures and pressures shows that all of the liquid AFs are biodegradable over a reasonably short period of time (i.e., a period of several months or less) (United States DOT, 1999). The main concern is that a liquid AF should be prevented from

entering into any waterway or drainage system. Aside from any consideration of aquatic toxicity, there is actually a potential fire/explosion safety hazard situation created when a flammable or combustible liquid enters a waterway where there are covered sections where vapors can accumulate. This problem is particularly acute for the alcohols since they are soluble in water (DOE, 2013a, 2013c; U.S. DOT, 1999).

Health Hazards

In addition to fire hazards, the use of alternative fuels can present health hazards. For most fuel health effects, inhalation of fuel vapors is the most likely exposure route. The threshold limit value for the health effects of fuel vapors is a measure of fuel toxicity. The limits for all fuels except LNG vapor (considered to be nearly pure methane), and hydrogen are based on toxic effects. The limit values for these fuels are based on the lower flammability limit and the premise that inhalation of a flammable mixture of fuel and air constitutes a health hazard. In the case of hydrogen and natural gas, excessive exposure can also result in asphyxiation (U.S. DOT, 1999).

The environmental and health issues for each alternative fuel are described below.

Bio-/ Renewable Diesel

Environmental Issues

Bio-/ Renewable diesel is a biodegradable compound in the same range as biodegradable soaps and detergents. Therefore, there are no significant long-term environmental hazards associated with biodiesel (DOE, 2013a; U.S. DOT, 1999).

Health Issues

Bio-/ Renewable diesel does not generate significant vapors under normal transport and storage temperatures. The only potential health hazard is due to ingestion. However, if Bio-/ Renewable diesel were ingested, enzymes in the body would break the ester back into its original components, e.g., soybean oil and methanol. This raises the potential issue of methanol toxicity as a potential health hazard associated with biodiesel. Consequently, biodiesel cannot be considered to be non-toxic, as often cited in the promotional literature (DOE, 2013a; U.S. DOT, 1999).

Electricity

Environmental Issues

There are no specific environmental hazards associated with the transmission and use of electricity at a fleet facility (DOE, 2015a; U.S. DOT, 1999).

Health Issues

There are no specific health hazards associated with the transmission and use of electricity at a fleet facility (DOE, 2015a; U.S. DOT, 1999).

CNG

Environmental Issues

There are no significant environmental hazards associated with the accidental discharge of

CNG (DOE, 2013a; U.S. DOT, 1999).

Health Issues

The principal constituents of natural gas, methane, ethane, and propane, are not considered to be toxic. Natural gas is an asphyxiant, meaning that inhalation of significant quantities can result in unconsciousness or death by suffocation by displacing oxygen in a closed environment. CNG is often odorized to alert personnel of an accidental release or inhalation hazard (DOE, 2013a; U.S. DOT, 1999).

LNG

Environmental Issues

There are no significant environmental hazards associated with the accidental discharge of LNG (DOE, 2013a; U.S. DOT, 1999).

Health Issues

The health risks of LNG are the same as for CNG, however, unlike CNG, LNG cannot be odorized; therefore, there is some concern about the ability of personnel to detect accidental release concentrations. (DOE, 2013a; U.S. DOT, 1999).

LPG

Environmental Issues

There are no significant environmental issues associated with the spill of propane, since the liquid will quickly vaporize (DOE, 2015b; U.S. DOT, 1999).

Health Issues

The health risks of L)G are the same as for CNG. LPG is also odorized to alert personnel of a potential leak (DOE, 2015b; U.S. DOT, 1999).

Hydrogen

Environmental Issues

There are no significant environmental hazards associated with the accidental discharge of hydrogen since the gas will vaporize quickly(DOE, 2013a; U.S. DOT, 1999).

Health Issues

Hydrogen is not considered to be toxic. However, it is a simple asphyxiant which is a health risk because it can displace oxygen in a closed environment (DOE, 2013a; U.S. DOT, 1999).

Ethanol

Environmental Issues

The major environmental concern with ethanol is groundwater contamination; since it is water soluble, it is necessary to take stringent precautions in order to ensure that any ethanol spill does not reach a sewer or drainage system (DOE, 2013a; U.S. DOT, 1999).

Health Issues

Extensive skin exposure to ethanol can cause redness and irritation. Concern about intentional ingestion of ethanol by employees is mitigated by the fact that alcohols intended for industrial

use must be denatured in order to avoid the federal alcoholic beverage tax. Denatured alcohol is ethanol that contains a small amount of a toxic substance such as methanol or gasoline, which cannot be removed easily by chemical or physical means (DOE, 2013a; U.S. DOT, 1999).

Safety and First Responder Training Resources

General Safety Training Resources

Open source training materials for AFs are freely available online. These training and informational materials are prepared by stakeholders such as government bodies, trade associations and vehicle/technology manufacturers. Listed in this section are open source resources for each fuel type. This is not a comprehensive list of all the training materials available as the number of resources is significant. Rather than attempt to cover all available materials, a subjective attempt was made to identify a handful of high quality materials for use and dissemination to the stakeholders in San Mateo County.

Table 52 shows a list of AF training resources available online. Each table focuses on one fuel type. The table includes materials from a range of different agencies and stakeholder organizations. Materials include safety aspects of operations and maintenance tasks as well as accident response for the vehicles and fuel distribution network.

Noteworthy Resources for First Responders

The Emergency Response Guidebook: A Guidebook for First Responders During the Initial Phase of a Dangerous Goods/Hazardous Materials Transportation Incident (ERG) is used by emergency response personnel (such as firefighters, and police officers) in Canada, Mexico, and the United States when responding to a transportation emergency involving hazardous materials. First responders in Argentina, Brazil, and Colombia have recently begun using the ERG as well. It is produced by the United States Department of Transportation, Transport Canada, and the Secretariat of Communications and Transportation (Mexico). (See Figure 37).

Figure 37: Infrastructure Emergency Response Guidebook

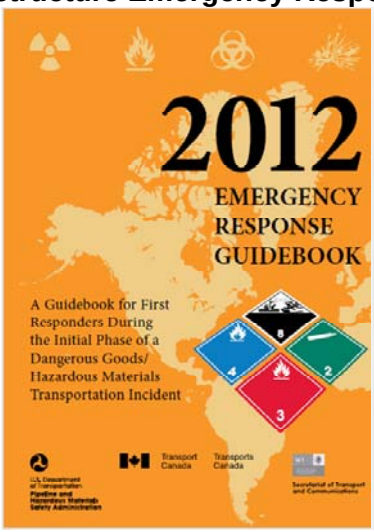


Table 52: Open Access General Safety Training Material

Training Material	Organization	Websites
Biofuels and Emerging Issues for Emergency Responders	Environmental Protection Agency	http://www.epa.gov/oem/docs/oil/fss/fss09/kimblebiofuels.pdf
Biodiesel and Ethanol	Environmental Protection Agency	www.nrt.org/production/NRT/RRT3.nsf/Resources/Sep2009ppt_1/$File/Ethanol & Biodiesel presentation.rev1.ppt
ETANKFIRE Ethanol Tank Fire Fighting	SP Technical Research Institute of Sweden	http://www.sp.se/en/index/research/etankfire/Sidor/default.aspx
Resources	Ethanol Emergency Response Coalition	http://www.ethanolresponse.com/pages/resources
Resources	Ethanol & Biodiesel Response Considerations - Training Materials and Videos	www.nrt.org/.../Ethanol%20&%20Biodiesel%20presentation.rev1.ppt
Emergency Response Guidebook: A Guidebook for First Responders	US DOT- Pipeline and Hazardous Materials Transportation Incident	http://phmsa.dot.gov/pv_obj_cache/pv_obj_id_7410989F4294AE44A2EBF6A80ADB640BCA8E4200/filename/ERG2012.pdf
Courses and Workshops	National Alternative Fuels Training Consortium	http://naftc.wvu.edu/course_workshop_information
First Responder Quick Reference Guide	National Alternative Fuels Training Consortium	http://afvsafetytraining.com/qrg.html
First Responder Quick Reference Guide - Mobile app	National Alternative Fuels Training Consortium	http://afvsafetytraining.com/qrg.html
2012 Emergency Response Guidebook Mobile App	US DOT- Pipeline and Hazardous Materials Transportation Incident	http://www.phmsa.dot.gov/
Clean Transportation Education Project, United States DOE Clean Cities	University of Oregon - Chemistry Labs	http://chemlabs.uoregon.edu/safety/NFPA.html
Alternative Fuel Vehicle Instructor Qualifications	California State Fire Training	http://osfm.fire.ca.gov/training/pdf/alternativefuelvehicles/Altfuelinstreq.pdf
State Fire Training	Office of the State Fire Marshall	http://osfm.fire.ca.gov/training/training.php
Emergency Response Guides	California Fuel Cell Partnership	http://cafcp.org/toolkits/safety/downloads

National Alternative Fuels Training Consortium

The National Alternative Fuels Training Consortium (NAFTC) is the only nationwide alternative fuel vehicle and advanced technology vehicle training organization in the United States. The NAFTC develops curricula and disseminates training about alternative fuels, alternative fuel vehicles, and advanced technology vehicle education. All courses and workshops are customizable to audience needs.

The first responder stakeholders in San Mateo County are in discussions with NAFTC to hold a series of training seminars in the county. NAFTC courses and workshops are offered in both traditional classroom and online learning formats. Participants learn by using educational discussions, videos, and assessments as well as lab and shop activities. Participants of the NAFTC training receive access to state-of-the art curricula, unsurpassed train-the-trainer courses and workshops, timely instructor updates, and professional development training. As a result, participants of the training are on the leading edge of alternative fuels, alternative fuel vehicles, and advanced technology vehicle education.

NAFTC offers comprehensive training sessions on:

- Introduction to Alternative Fuels
- Electric Drive
- Hydrogen & Fuel Cells
- Natural Gas & Propane
- Biodiesel & Ethanol
- First Responder
- Fleet Applications
- Fuel Economy & Idle Reduction

NAFTC also develops the Alternative Fuel Vehicle Quick Reference Guide (QRG) emergency Responders shown in Figure 38. The QRG 100-page guidebook covering all alternative fuel vehicles and includes identifying photos of each make and model. Each section includes detailed diagrams of the vehicles, switches, and valves, with additional photos and diagrams of the under hood components. This guide is also available as a mobile app.

Another noteworthy resource for first responders is the Emergency Response Guide for Alternative Fuel Vehicles produced by CAL FIRE–State Fire Marshal, shown in Figure 39 and included as an attachment to this report.

Figure 38: Alternative Fuel Vehicle Quick Reference Guide

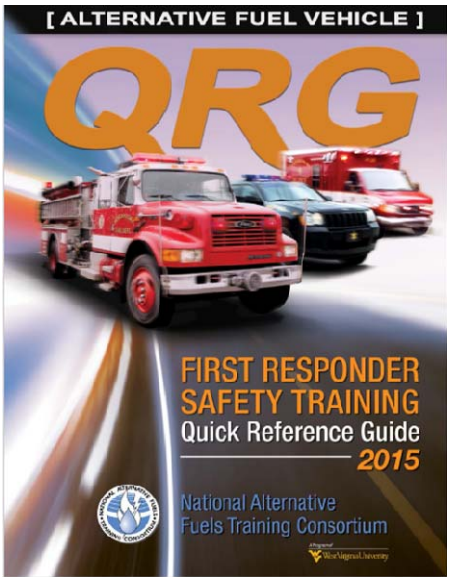
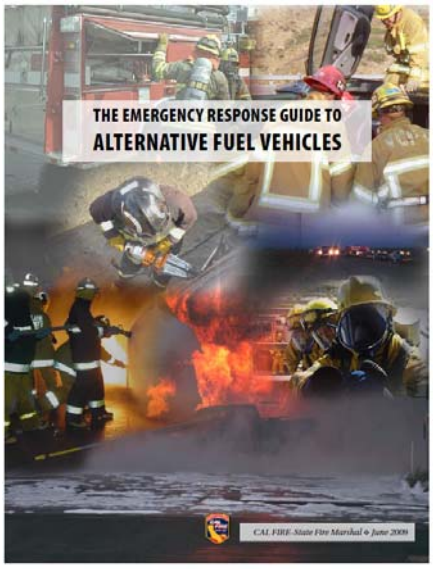


Figure 39: Alternative Fuel Vehicle Emergency Response Guide



EV Resources

A number of trade organizations and stakeholders groups are leading efforts at the national, state, and regional level to develop a curriculum and specialized training for electrical contractors and inspectors, workforce development training for EV fleet technicians, public charging station owners and operators, fleet managers, dealers, and automotive shops, and first responders and other safety officials. Table 53 provides a list of open access EV safety training material.

Table 53: Open Access Electric Vehicle Safety Training Material

Training Material	Organization	Websites
Behavior and Remediation	National Fire Protection Association	http://www.evsafetytraining.org/Training.aspx
Firefighter Safety and Emergency Response for Electric Drive and Hybrid Electric Vehicles	The Fire Protection Research Foundation	http://www.nfpa.org/~/media/Files/Research/Research%20Foundation/Research%20Foundation%20reports/For%20emergency%20responders/fftacticselecveh.pdf
Best Practices for Emergency Response to Incidents Involving Electric Vehicles Battery Hazards: A Report on Full-Scale Testing Results	The Fire Protection Research Foundation and Exponent	http://avt.inl.gov/pdf/energystorage/FinalReportNFPA.pdf
2013 Focus Electric Vehicle (EV Emergency Response Guide)	Public Safety Diver	http://www.psdiver.com/images/HYBRID_VEHICLE_EMERGENCY_RESOURCE_GUIDES-secure.pdf

Natural Gas/LPG Resources

Natural Gas stakeholders and governmental organizations are working at the national, state, and regional level to develop a materials and specialized training for natural gas and LPG contractors and inspectors, workforce development training for fleet technicians, fueling station owners and operators, fleet managers, dealers, and automotive shops, and first responders and other safety officials. Table 54 provides a list of open access safety training materials for natural gas and LPG.

Table 54: Open Access Natural gas / LPG Safety Training Material

Training Material	Organization	Websites
CNG/LPG Vehicles Emergency First Response Guide	IMPCO Automotive	http://impco-asap.com/cms/home/ownersguide_frg
Propane Emergencies Program	Propane Education and Research Council	http://www.propanecouncil.org/safety-and-training/propane-emergencies/
Propane Emergencies: Plan for Worst Case Scenario	John Spaulding-Fire Engineering.com	http://www.fireengineering.com/articles/print/volume-165/issue-4/departments/volunteers-corner/propane-emergencies-plan-for-worst-case-scenario.html
Ohio First Responder Safety Training CNG/ Electric Drive	Clean Transportation Education Project, United States Clean Cities	http://theseedcenter.org/Resources/Resource-Center/First-Responder-CNG_EV-Workshop---2010-reduced

Hydrogen Resources

The United States Department of Energy is leading the national effort to develop training and educational materials for hydrogen contractors and inspectors, workforce development training for fleet technicians, fueling station owners and operators, fleet managers, dealers, and automotive shops, and first responders and other safety officials. Table 55 provides a list of open access safety training materials for hydrogen.

Table 55 : Open Access Hydrogen Safety Training Material

Training Material	Organization	Websites
Introduction to Hydrogen Safety for First Responders	DOE-Hydrogen Program	http://hydrogen.pnl.gov/FirstResponders/Flash/Controller.faces
Hydrogen Safety Tips for First Responders	DOE-Hydrogen Program	http://www.dhses.ny.gov/ofpc/publications/documents/HydrogenPoster_v15.pdf
H2 Safety Best Practices	Pacific Northwest National Laboratory and Los Alamos National Laboratory	http://h2bestpractices.org/safety_planning/hazard_and_risk/ranking_risks/qualitative_risk.asp
Hydrogen Lessons Learned (H2LL)	DOE-Hydrogen Program	http://h2tools.org/lessons/
HyResponse Deliverables	HyResponse	http://www.hyresponse.eu/deliverables.php
ix35 FCEV Emergency Response Guide	Hyundi	http://cafcp.org/sites/files/ix35_FCEV_ERG_Eng.pdf
Hydrogen and Fuel Cell Safety Report	Fuel Cell & Hydrogen Energy Association	http://www.hydrogenandfuelcellsafety.info/

Other Resources

Local Official Training and Education Programs

The issues outlined in this report regarding AFV deployment are new to many stakeholders, including local government officials. As a result, local officials and first responders are encouraged to seek out training and educational resources that will help their respective communities become AFV ready. In addition to providing technical training on PEV maintenance and EVSE installation for staff, these resources enable local officials to become familiar with electric charging infrastructure and to understand the safety implications of vehicles and chargers (BAAQMD, 2014; ICF International, 2012).

There are a number of educational resources available to local governments and agencies in the San Mateo County, including:

- **Electric Vehicle Infrastructure Training Program (EVITP)**: The EVITP is a 24-hour course set up to train and certify electricians throughout California to install residential and commercial scale EVSE. The training program addresses the technical requirements to ensure that the equipment is properly installed and maintained, and also instructs stakeholders on issues related to EVSE deployment. EVITP has sponsored events in the Bay Area and will be expanding its role after recently receiving a grant from the California Employment Training Panel, funded by the California Energy Commission's Alternative and Renewable Fuel and Vehicle Technology Program.
- **The Green Team**: The Silicon Valley Clean Cities Coalition, Breathe California, and the Electronic Transportation Development Center offer a series of clean transportation technical classes, which include 50-hour courses on electric vehicles, hybrid electric vehicles, and EVSE.

- **California Plug-in Electric Vehicle (PEV) Collaborative**: The PEV Collaborative is launching a PEV Resource Center that will provide answers to key issues regarding EVSE to the following audiences:

    - Vehicle Consumers and Homeowners
    - Local Government Officials
    - Fleet Managers
    - Infrastructure and Electrical Contractors
    - Emergency First Responders
    - Educators and Instructors

    The PEV Collaborative also hosts a wide range of educational webinars, which in the past have included such topics as:

    - Title 24: Building Codes for Plug-in Electric Vehicles
    - Get Involved: Proposed Accessibility Standards for Electric Vehicle Charging Spaces
    - Paying for Juice
    - EV Charging Infrastructure: What Every Small Business Should Know

    (Presentation slides and recordings from past webinars can be accessed on their website: http://www.pevcollaborative.org/webinars_2015.)

The programs listed above are examples of the opportunities that local agencies have to educate themselves about EVSE issues such as permitting, installation, and zoning. Generally, these programs are provided at no cost to participants. In cases where programs require course fees, adjacent municipalities can coordinate and share curricula and lessons learned to reduce costs and allow a few local officials to complete formal training and certificate programs (ICF International, 2012).

National Training Resources and Initiatives

DOE Clean Cities

At the national level, Clean Cities has developed a 30-minute online presentation for electrical contractors and inspectors regarding EVSE residential charging installation. This online video covers a broad spectrum of topics aimed at informing electrical contractors of the key issues related to residential EVSE. The presentation begins with the history and evolution of the EV market and briefly summarizes the benefits of EVs. Then the presentation dives deeper into the responsibilities of electrical contractors and the details of the system setup, codes and standards, specific equipment and parts, types of stations, and safety (BAAQMD, 2014; ICF International, 2012). The presentation also touches on the importance of project management and communication with the utility and customer. For more information, please visit http://www.cleancities.tv/FeaturedContent/Training/EVSEResidentialChargingInstallation.aspx.

Electric Power Research Institute (EPRI)

EPRI conducts research and development related to the generation, delivery and use of electricity for the benefit of the public. EPRI has developed a plethora of technology, policy and economic analyses to drive long-range research and development planning and to support research in emerging technologies. This includes the development of research and resource material on electric vehicles, such as installation guidelines, grid interface requirements, and life-cycle cost analysis (BAAQMD, 2014; ICF International, 2012). For more information, please visit http://my.epri.com/portal/server.pt

United States Department of Energy

The Department of Energy has developed a series of training material for consumers, electrical contractors, fleet managers, and public charging stations hosts. These resources communicate benefits of PEVs and provide guidelines to installing infrastructure and maintaining PEVs. For more information, please visit http://www1.eere.energy.gov/cleancities/publications.html.

Bay Area Resources

Several organizations in the Bay Area are dedicated to supporting AFV deployment through education, advocacy, and coordination among government agencies, researchers, utilities, and members of the AFV industry (BAAQMD, 2014; ICF International, 2012).

The Bay Area EV Strategic Council

Bay Area stakeholders have responded to the challenge of coordinating action to support the deployment of PEVs and the charging infrastructure via the formation of the Bay Area EV Strategic Council. The mission of the EV Strategic Council is to establish the greater San Francisco Bay Area as the "EV Capital of the United States", as measured by the proportion of plug-in electric vehicles (PEVs) in the region. Founded in April 2011, the Council was conceived as a three year project to set the conditions for accelerated PEV adoption in the region. The Council is comprised of individuals from state, regional and local public agencies, PEV-related businesses, utility and major energy service companies, non-governmental organizations (NGOs), universities and research facilities, and the Clean Cities Coalitions.

San Francisco Clean Cities Coalition

The San Francisco Clean Cities Coalition works with vehicle fleet owners, fuel providers, community leaders, and other stakeholders to reduce petroleum use in transportation. SFCCC offers a wide variety of conferences, workshops, and meetings on a wide range of topics, such as fuels, advanced vehicles, and the alternative transportation sector. It hosts workshops and produces guides on the different options for alternative-fuel vehicles, including PEVs, and also on funding opportunities related to PEV deployment.

Silicon Valley Clean Cities

The Silicon Valley Clean Cities Coalition (SV Clean Cities) is a partnership of public, private agencies, businesses, and interested citizens dedicated to the advancement of alternative fuels in order to improve the air quality of the Silicon Valley. One of SV Clean Cities' goals is to increase the number of PEVs and charging stations though technical training, informational workshops,

grant-writing assistance, outreach on legislation and funding opportunities, and policy advocacy. PEV-related events organized by SV Clean Cities help homeowners and fleet managers understand options for selecting, purchasing, and deploying PEVs and EVSE.

East Bay Clean Cities Coalition

The East Bay Clean Cities Coalition works to promote PEVs and other alternative-fueled vehicles by providing information on vehicles, charging and fueling infrastructure, events, and funding opportunities. The Coalition has over 60 stakeholders representing Alameda County, Contra Costa County, and parts of Solano County, and is in the process of expanding to include Sonoma County and Napa County.

PEV Advocacy Groups

In addition to the groups mentioned above, several advocacy groups whose members are primarily PEV drivers and enthusiasts are also working to promote PEVs, both nationally and in the Bay Area and Monterey Bay Region. These organizations work to influence policymakers to support PEVs, maintain websites with information about PEVs and PEV-related advocacy opportunities, and organize meetings and events for current and potential PEV drivers. They include Plug in America, a national organization based in California, as well as several local chapters of the Electric Auto Association, such as the Golden Gate Electric Vehicle Association. Owners of EVs have also organized through Facebook and other social media outlets to create enthusiasts' groups for specific PEV models, such as the San Francisco Bay Area Nissan LEAF Owners Association (SF BayLEAFs).

California Plug-in Electric Vehicle Collaborative (PEVC)

The PEVC is working to launch a PEV Resource Center that will provide answers to key issues. The PEV Resource Center is currently under construction, but is anticipated to be live sometime in 2012. For more information, please visit http://www.evcollaborative.org/.The PEV Resource Center website will target the following audiences:

- Vehicle Consumers and Homeowners
- Local Government Officials
- Fleet Managers
- Infrastructure and Electrical Contractors
- Emergency First Responders
- Educators and Instructors

Electrification Coalition

The Electrification Coalition is a nonpartisan, not-for-profit group of business leaders committed to promoting policies and actions that facilitate the deployment of electric vehicles on a mass scale. They developed two policy reports: the fleet electrification roadmap and the electrification roadmap. For more information, please visit http://www.electrificationcoalition.org/.

Ready, Set, Charge California

Provides guidance to cities and counties on uniform inspection codes and PEV policy development and deployment. For more information, please visit http://www.baclimate.org/impact/evguidelines.html

Advanced Transportation Technology and Energy (ATTE) Initiative

In 1994 the California Community Colleges Chancellor's Office through its Economic and Workforce Development Program created the Advanced Transportation Technology and Energy (ATTE) Initiative. The ATTE supports the development and continuous improvement of technical education at community colleges throughout the state. Since that time the ATTE has served California's transportation and energy technology businesses through a myriad of program and workforce training activities. For more information, please visit http://www.attecolleges.org/. The ATTE program is offered by several community colleges throughout San Mateo County and provides 8 to 16 hour courses on:

- Hybrid Electric, Electric, and Gaseous Fuels Vehicle Identification
- Fundamentals of Hybrid Electric, Electric, and Gaseous Fueled Vehicles
- Vehicle components
- Alternative Fuels Infrastructure, Transport, Stations, and Safe Handling
- Equipment Identification for HEVs and Other Alternative Fueled Vehicles
- First Responder Procedures for:
    - Police (securing the area, recognizing potential hazards, protecting the public, etc.)
    - Firefighters (General Firefighting Measures, etc.)
    - Other Emergency Personnel

CHAPTER 7:
Communication Strategies

This chapter introduces outreach and communication strategies for educating stakeholders about alternative fuel readiness in San Mateo County. The Plan serves as a blueprint for San Mateo County to efficiently transition to the increased use and commercialization of alternative transportation fuels in the marketplace. For that to happen, stakeholders need to become actively engaged and understand the reasons for transitioning to alternative fuels. Active marketing, communication, and educational outreach will be essential.

This chapter fulfills Task 6 of the C/CAG agreement with the CEC to develop communication strategies that communicate the benefits of alternative fuel usage to stakeholders through:

- Developing a catalog of the local organizations initiating consumer education and outreach efforts in San Mateo County on AFs.
- Performing market analysis.
- Developing marketing materials and outreach strategies.

Objectives

The communications strategy for the Alternative Fuel Readiness Plan closely reflects C/CAG's overall goals. This section looks at San Mateo County's overall vision and core goals in having an Alternative Fuel Readiness Plan and suggests how communication strategies can help deliver these goals.

Goals for San Mateo County

The City/County Association of Governments of San Mateo County plans to facilitate the adoption of alternative fuels by businesses, government agencies, and cities within the county. The goal of the Alternative Fuel Readiness Plan is to prepare the County and the cities therein for the increased use and commercialization of alternative transportation fuels in the marketplace. The introduction of alternative fuel vehicles supports California's GHG reduction goals by reducing transport GHG emissions.

Communication Goals

The goal of the communication strategy is to create awareness of the existence of the Alternative Fuel Readiness Plan and convey the benefits of alternative fuel usage to San Mateo County government agencies and fleets, businesses and private fleets, and individual consumers.

Current Situation

Catalog of current consumer education and outreach efforts

A number of initiatives already exist in San Mateo County that focus on communicating the benefits of alternative fuel usage to targeted groups. Table 56 through Table 58 provide a catalog of current consumer education and outreach efforts. They list the organization associated with the education/outreach activity, the AF technology they focus on, a short description of the activity, and contact details. Table 59 shows alternative fuel trade organizations that are active in San Mateo County.

Table 56. Catalog of Current Consumer Education and Outreach Efforts in San Mateo County

Organization	AF Technology	Description & Activities	Contact Details
Bay Area Climate Collaborative (Now part of Prospect Silicon Valley)	PEV	A public-private initiative of the Silicon Valley Leadership Group. Established by the Mayors of San Francisco, San Jose and Oakland to accelerate the clean energy economy. BACC programs include facilitating the two largest electric vehicle (EV) fleet deployments in the country with 140 EVs to over a dozen municipalities.	http://baclimate.org/
Business Council on Climate Change (SF)	PEV	A San Francisco coalition dedicated to forging collaborative, local solutions to climate change.	www.bc3sfbay.org
Charge Across Town (SF)	PEV	Non-profit promoting PEVs in SF by collaborating with city governments, local businesses and the electric vehicle community. Currently running a charging initiative with Envision Solar's EV ARC ™ mobile chargers in SF.	www.chargeacrosstown.com

Table 57. Catalog of Current Consumer Education and Outreach Efforts (Cont'd)

Organization	AF Technology	Description & Activities	Contact Details
Plug in America (nationwide)	PEV	Non-profit organization advocating for PEVs. Hosting National Drive Electric Week 2015 from September 12 - 20th.	www.pluginamerica.org
Center for Sustainable Energy (nationwide)	PEV, FCEV	Non-profit that works with policymakers, regulators, public agencies and businesses as an expert implementation partner and trusted information resource. Also distributes CVRP rebates for CA.	energycenter.org
Silicon Valley Clean Cities Coalition	All AFVs	Coalition of local governments working to promote and expand access to alternative fuel vehicles, improve air quality, hold educational and training workshops, support alternative fuel legislation, and decrease dependence on imported oil.	www.svcleancities.org
Altcar Expo	BEV, PHEV, FCEV, CNG	Conference featuring Ride & Drive AFV opportunities & educational sessions.	http://altcarexponorcal.com/
Plug-in Electric Vehicle Collaborative (statewide)	PEV	Public/private organization focused on accelerating the adoption of PEVs in CA. Currently planning a series of statewide ride-and-drive events to provide real-world driving experience.	http://www.pevcollaborative.org/

Table 58. Catalog of Current Consumer Education and Outreach Efforts (Cont'd)

Organization	AF Technology	Description & Activities	Contact Details
GoElectricDrive Foundation	BEV, PHEV, and FCEV	Non-profit education organization, established by the Electric Drive Transportation Association (EDTA), promoting consumer awareness of electric drive vehicles.	http://www.goelectricdrive.org/
Northern California Alternative Transportation Fuel and Advanced Vehicle Technology Center	All AFVs	Expected to begin summer of 2015. A consortium of academic research centers plans to develop a suite of training, outreach, demonstration, and research activities.	http://its.berkeley.edu/news/ITS/20140307
Prospect Silicon Valley	All AFVs	Non-profit organization supporting emerging technology companies through access to facilities, platforms, partners, and market connections, including its Demonstration Center, a $12 million, 23,000 sq. ft. facility	http://prospectsv.org/
Sustainable San Mateo	All AFVs	Non-profit organization that produces an annual Indicators Report and hosts a Sustainability Awards Event. In 2014, the key indicator they surveyed SMC governments about was transportation.	www.sustainablesanmateo.org

Source: Life Cycle Associates, LLC

Table 59. Catalog of Trade Organizations Active in San Mateo County

Trade Organization	AF Technology	Description & Activities	Contact Details
Western Petroleum Gas Association, Propane Energy Research Council	LPGV	Trade organizations focusing on the following tasks to advance alternative fuels: • Outreach • Government affairs and monitoring • Codes and standards • Education • Safety and training	Westernpga.org www.propanecouncil.org
CA Natural Gas Vehicle Coalition, Natural Gas Vehicles for America	NGV		www.cngvc.org www.ngvamerica.org
CA Fuel Cell Partnership, Fuel Cell & Hydrogen Energy Association	FCEV		www.fuelcellpartnership.org www.fchea.org
National Biodiesel Board, California Biodiesel Alliance	BD		www.biodiesel.org www.californiabiodieselalliance.org
CA Electric Transportation Coalition, Electric Power Research Institute	PEV		www.caletc.org www.epri.com
Growth Energy, Renewable Fuels Association	E85		www.growthenergy.org www.ethanolrfa.org

Source: Life Cycle Associates, LLC

Selected Outreach Efforts and Materials

Several of the organizations above have initiated outreach efforts and created useful informational brochures that are available to city and County officials for advancing alternative fuel usage in their area. Table 60 summarizes selected outreach efforts and available materials.

Table 60. Selected Outreach Efforts and Materials

Efforts/Materials	Organization	Description
PEV Ride-and-Drive Series	Plug-in Electric Vehicle Collaborative	PEV Collaborative and its contractor, Charge Across Town, are planning a series of statewide PEV ride-and-drive events to provide real-world experience behind the wheel of a PEV.
Eight fact sheets on California-specific PEV topics	Plug-in Electric Vehicle Collaborative	The fact sheets provide timely, topical graphs and relevant communication points on the following PEV topics: 1. How do PEVs Benefit California? 2. What are the Benefits of Driving a PEV? What cars are Available? 3. PEV Charging: Where and When? 4. Fuel Costs: PEVs vs. Gasoline Cars? 5. How Do Communities Become PEV Ready? 6. How do Multi-unit Dwellings Become PEV Ready? 7. Workplace Charging: Why and How? 8. PEV Batteries: Safety, Recycling and Re-Use?
Driveclean.ca.gov	California Air Resources Board (ARB)	Driveclean.ca.gov is a buying guide to clean and efficient cars allowing the user to search and compare vehicles by make/model, vehicle category, technologies & fuel types, Smog Rating, Greenhouse Gas Rating or engine test group number. Users can also look up incentives in their specific region.
AltFuelPrices.com	Community of users dedicated to Alternative Fuel	AltFuelPrices.com helps consumers find prices and locations of AFV refueling or recharging stations around the United States including those for CNG, biodiesel, hydrogen and ethanol cars

Source: Life Cycle Associates, LLC

Appendix D includes links to these and other resources that cities may want to make available on their websites.

Target Audiences

This communication strategy is targeted at three distinct audience groups: government agencies, businesses and private fleets, and individual consumers. Understanding each audience's motivations, goals, concerns, and baseline knowledge of alternative fuels is crucial for creating effective communication. Each group and its key characteristics are summarized below.

Government Agencies in San Mateo County

California has long been a leader when it comes to environmental technology and policy. San Mateo County agencies and city and town councils have become accustomed to advancing clean technologies and have developed expertise in addressing environmental challenges.

Many local governments have been very progressive in establishing environmental and energy policies, ranging from clean fleet vehicle requirements to green buildings. Almost every city in San Mateo County has a climate action plan (CAP) that provides both broad strategies and specific measures to reduce the city's carbon footprint. Cities can include alternative fuels as an element of their CAP. All local governments are participating in the Regionally Integrated Climate Action Planning (RICAPS) program as a pathway to implementation of SB 375 as well as their own policies and goals.

However, state and local policies sometimes conflict with each other or hamper commercialization of alternative fuel projects. For example, Propel – a company that builds, owns, and operates a network of renewable fuel stations – encountered issues related to signage requirements at its Redwood City station. Because state law requires signs for every fuel sold but city regulations put limits on the number of allowed on-site signage, Propel had to put up paper signs once the station had exceeded its signage allowance under city regulations. As a result, manufacturers will be discouraged from choosing a particular city as a site for its alternative fuel project if city regulations make permitting, construction, and/or operation difficult. Therefore, state and local policies need to reflect a stable, long-term approach that supports the commercialization of alternative fuel technologies.

Educating San Mateo County government agencies on the benefits of alternative fuel technologies encourages them to take an active approach in the transition from fossil fuels to alternative fuels. Local policies have a big influence on the successful commercialization of AFs. San Mateo County agencies are generally motivated by the following factors: economic and societal benefit, leadership, need, legal requirements, and support for local companies (Cal EPA, 2005).

San Mateo County Fleets

Fleet vehicles are groups of vehicles owned and used by a company or government entity, including cars, vans, and trucks. Fleet vehicles tend to be operated on an ongoing basis and generally endure harder use than personally-owned vehicles. Purchasing criteria for fleet

vehicles include budget, performance, fuel consumption, and maintenance. Table 61 shows examples of fleet vehicles owned by company and government entities.

Table 61. Types of government and private fleet vehicles

Government Fleet types	Private Fleet Types
• Police • Sheriff • Fire • Building inspector • School buses • Public transit	• Shuttles • Delivery trucks • Waste haulers • Taxis • Rental cars • Ambulances • Public utilities

Source: Life Cycle Associates, LLC

Fleet vehicles provide a unique opportunity to increase use of alternative fuels because many vehicles are under the control of one organization. In addition, fleet vehicles often make use of their own fueling infrastructure. Transit buses, for instance, are suitable for advanced technologies because they operate in congested areas where pollution is a problem, are centrally located and fueled, and receive government support. For SamTrans, the primary public transport agency providing service to San Mateo County, electric buses appear to be the likely strategy. However, the introduction of electric buses is complicated by the turnover rate of diesel buses, potential diesel bus engine rebuilds, funding constraints, and future ARB requirements.

Fleets under the control of San Mateo County's government agencies can be encouraged to use alternative fuels through County and city policies. Government agencies can set a target for fleet fuel efficiency, mileage, or alternative fuel use that exceeds the national or state requirements. Ideally, fleet managers will have flexibility in choosing how to meet these goals. San Mateo County fleets may also be subject to statewide requirements that drive their AFV purchases in the future.

Businesses and Private Fleets

Like government fleets, businesses and private fleet operators often control large numbers of vehicles. Adoption of alternative fuel technology by businesses and private fleet operators illustrates to other key audiences that alternative fuel technology is reliable, safe and viable. Visible companies like SuperShuttle and FedEx are already running their trucks and vans on CNG. Communication with businesses and private fleet owners is crucial since they play an important role in making AFVs convenient, attractive and available to use.

According to the California Hydrogen Blueprint Plan (Cal EPA, 2005), fleet and commercial communities are cautious about becoming early adopters of alternative fuel technologies due to previous experience and issues surrounding infrastructure development. Fleet customers involved with compressed natural gas powered vehicles, for example, cite issues such as the lack of mainstream marketing initiatives and industry commitment to long-term production, as

well as fluctuating regulatory drivers. Hence, businesses and private fleet owners need to be assured that AF technologies and infrastructure have progressed and will continue to receive support. Further education about the economic and environmental benefits of using AF technologies is required in order to reduce hesitations of businesses and private fleet owners in terms of becoming adopters of AF technologies.

Consumers

According to several publicly available opinion surveys, public awareness and understanding of the general concept and value of alternative fuel technologies has increased over the last decade (Cal EPA, 2005). However, more outreach has is needed to ensure that consumers accept and demand alternative fuel technologies in their communities.

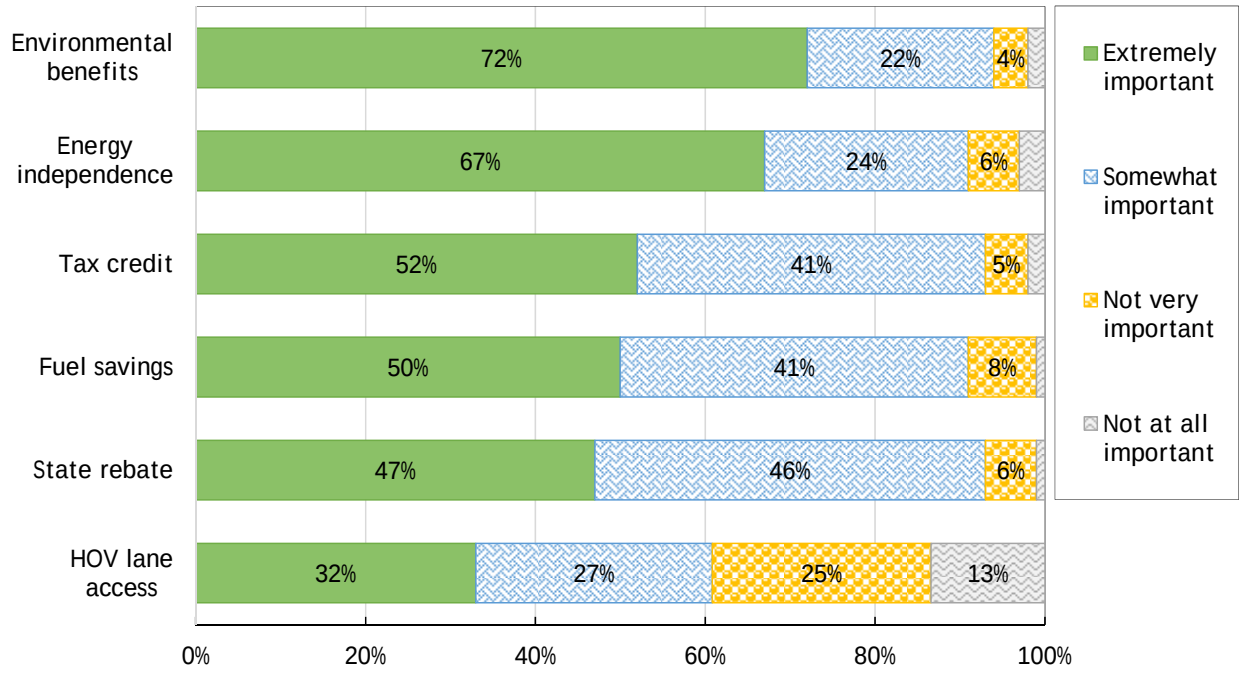
People generally support the concept of transitioning to an alternative fuel economy as an important strategy to reduce dependence on foreign oil and fossil fuel, and to create energy security. Yet many consumers are still not fully aware which AFV options are available to them and what kind of benefits AFVs provide. More education about the benefits of AFV is required.

When making vehicle purchasing decisions, consumers take into consideration both benefits and current challenges with AFV in terms of infrastructure, cost, safety, convenience and environmental impacts. Consumer's vehicle purchasing decisions are affected by the following criteria:

- Economic considerations
- Environmental benefits
- Performance attributes
- Comfort and convenience of use

The order of these motivations varies by consumer type. Economics are consistently named as a key issue across consumer markets (CSE for ARB, 2013; Deloitte Consulting LLP, 2010; Vyas, 2013). High up-front vehicle costs may act as a barrier, while low fuel costs relative to petroleum are an attractive feature for many consumers. Environmental benefits are another key motivator for AFV consumers (Turrentine, 2015; CSE for ARB, 2013). In a survey of PEV owners conducted by the Center for Sustainable Energy (CSE), 72% of respondents listed environmental benefits as their number one motivation to purchase a PEV. In addition, consumers are attracted to non-monetary benefits such as high occupancy vehicle (HOV) lane access and reserved parking (EPRI, 2001). 59% of survey respondents reported that HOV lane access was an important consideration in their decision to purchase a PEV (CSE for ARB, 2013). Drivers are also motivated by the energy independence that accompanies a move away from fossil fuels towards domestically produced fuels and electricity (CSE for ARB, 2013).

Figure 40. Vehicle Purchasing Motivations



Source credit: Page 12 (CSE for ARB, 2013)

Vehicle purchasing motivations can differ by consumer category. High-income consumers are generally less price-sensitive and more motivated about environmental benefits and performance attributes. Economy car buyers, on the other hand, are looking for an affordable purchase. Long-term savings due to low fuel costs may not influence economy car buyers (EPRI, 2001).

Personal experience significantly improves understanding and comfort with AFVs. When people drive or take rides in AFVs, they are much more likely to appreciate that these vehicles are real, viable, and exciting to drive. To date, several AFV demonstrations are underway in California such as the statewide ride-and-drive events for Plug-in Electric Vehicles by the PEV Collaborative.

Opportunities and Challenges of Each Target Audience Group

Based on the analysis of the key audience groups, the following opportunities and challenges exist for each target audience group as shown in Table 62.

Table 62. Opportunities and Challenges of Each Target Audience Group

Target Audience	Opportunities	Challenges
Government Agencies in San Mateo County	City and County policy makers can serve as leaders in demonstrating both fueling facilities and use of AFV and stationary applications	High initial costs means that local leaders must clearly communicate economical and societal benefits to the local community
	Well informed permit officials can expedite AFI approval and lower costs	High turnover among inspectors and fewer approval requests for AFI requires frequent retraining
	Widespread training of safety officials can ensure appropriate emergency response and foster a feeling of safety in communities	Relatively low penetration of some AF types could result in lower interest in training
Businesses and Private Fleets	Adoption of AF technology by businesses and private fleets illustrates to other key audiences that technology is cost effective, reliable, and safe	Without financial and/or regulatory drivers to make AF technologies cost effective, businesses and private fleets are less likely to adopt AFV
	Businesses and private fleets function as important technology enablers via daily use of AFVs	Businesses and private fleets may be skeptical due to previous experience with AFV
Consumers	Creating interest and excitement about AFs can boost demand and acceptance of AFV as an alternative to conventional fuel vehicles	Failing to create appropriate communication processes will limit acceptance and use of AFs by the general public
	Placement of refueling and charging stations in the local community will increase perception of convenience of AFVs	Without sufficient demand for AFV, it will be hard to generate need for these sites
	Educating children in K-12 about AF technologies will influence the next generation of consumers, policy makers, educators and workforce	Curriculum models and school events currently do not incorporate AF technologies

Messages

Creating awareness of the Alternative Fuel Readiness Plan and conveying the benefits of alternative fuel usage requires the persuasive use of customized messages aimed at each of the key audiences. Targeted messages are important to make alternative fuels a consumer success with public users and customers. Nevertheless, one core message underlies these distinct messages and applies to all audiences in order to unify the communication process across every level.

Core Message

Cutting across all the audiences in the plan is one common message:

> *San Mateo County is a world leader in adopting alternative fuels and addressing energy, environmental and economic issues that are critically important to the State of California.*
>
> *Be part of it!*

This core unifying message applies to all audiences and needs to be conveyed explicitly or implicitly in all communications activities.

Distinct Messages for Audience Categories

The key audiences are divided into three groups as outlined earlier. The main messages that have to be communicated to these groups are as follows:

Message 1: Alternative fuels are available in San Mateo County, and there are benefits to using them.

Message 2: Many informational resources exist, including the Alternative Fuel Readiness Plan.

Message 3: Government agencies and some fleets share a role in complying with state regulations including emission standards and environmental policy targets.

Table 63 matches these messages with the appropriate target audience group. For each audience group, communication goals have been determined. Based on these communication goals, the key messages that the target audience group needs to hear are identified and action steps are proposed. While there is some degree of overlap in the messages for each group, the means of delivering the messages and the detailed message points will vary from one audience group to another.

Table 63. Messages for Each Target Audience Group

Target Audience	Goals of Communication	Key communication messages
Government Agencies in San Mateo County	Build support for the program and encourage San Mateo county government officials to provide key policy drivers and mitigate barriers for AF usage	Benefits/Availability of Alternative Fuels
	Build awareness of how AFs help meet state policy initiatives • Cities contribute in achieving state goals • County fleets contribute in achieving state goals	Every city and every county fleet counts in achieving state goals (AB32, SB 735, EOs) Cities can encourage AF usage, e.g. put requirement for fleets to use AFs or low emission fuels in Climate Action Plan
	Educate cities about alternative fuels as well as production, delivery, and safety	The Plan exists and contains information about educational resources
Businesses and Private Fleets	Businesses and Private Fleets adopt alternative fuel technology (company shuttles, delivery vehicles, on-site AFV infrastructure)	Economic and environmental benefits of Alternative Fuels Businesses and Private Fleets function as technology enablers by demonstrating that alternative fuel technology is reliable, safe and viable
Consumers	Consumers support and use AFVs	Economic, environmental, performance, and convenience benefits of AFV

Government Agencies

Moving alternative fuel technologies forward and spurring the installation of alternative fuel infrastructure requires County and city policymakers to encourage alternative fuel usage, provide key policy drivers, and mitigate barriers to implementation. With effective leadership;

- Alternative fuels will provide job growth in advanced energy and transportation technologies and strengthen the local economy.

- Alternative fuels will improve local air quality by reducing emissions that impact air health.
- Alternative fuels will provide the county with a more sustainable and secure energy system by reducing the State's dependence on fossil fuels.

San Mateo County agencies also need to understand that they share a role in complying with State regulations including emission standards and environmental policy targets such as AB 32 and SB 375.

Education about alternative fuels is necessary to help San Mateo County agencies understand that AF production, delivery, and use will be safe. Government agencies should be made aware that the Alternative Fuel Readiness Plan covers this educational aspect and serves as a resource to San Mateo County agencies.

Businesses and Private Fleets

Businesses need to be motivated by understanding that AF technologies can further their business and professional interests. The economic and environmental benefits of using alternative fuels in private fleets such as company shuttles and delivery vehicles should be highlighted:

- AFV prices are decreasing, while the fueling infrastructure is growing.
- Some AFVs are backed by tax incentives of up to $7,500 per vehicle resulting in more businesses being able to recoup the upcharge from standard models.
- AFVs often provide fuel cost savings over time especially when gas prices are high.
- AFVs provide time savings due to access to carpool lanes.
- Workplace charging options demonstrate a company's environmental leadership to their employees, their customers, and their communities.
- AFVs and supporting infrastructure can be listed as benefits to employees to help attract and retain talent.

Businesses and private fleet owners should also consider that they serve as role models to the community and consumers in general. Consumers will be more convinced that alternative fuel technologies are reliable, safe, and make economic sense if they see AFVs being used successfully by companies.

Consumers

In order to encourage consumers to invest in and use AFVs, they should be informed of the economic, environmental, performance, and convenience benefits of AFVs:

- Economic benefits: purchase incentives for zero-emission and clean-fuel vehicles; reductions in vehicle license fees; reduced fuel costs over time
- Environmental benefits: reduction of emissions that impact air quality and health

- Performance benefits: good handling and acceleration; low noise
- Convenience benefits: carpool lane access which reduces commuting time; free and preferred parking options in public garages, government buildings, higher education institutions, and at work; option to use ethanol or gasoline in FFVs; increasing fuel station availability

Introducing consumers to AFs and their benefits can begin at the earliest levels of education. The next generation needs the knowledge and skills to move San Mateo County towards transportation technologies that are clean, abundant, and non-toxic. By providing education and awareness of AF technologies in schools, San Mateo County can initiate positive change in the future (Cal EPA, 2005).

Consumers will begin to realize that AF technologies are becoming a viable alternative to conventional fuels and are no longer a transportation mode for early adopters only but a mainstream effort to reduce human impact on the environment.

Communication Methods

This section identifies the tools and activities that are most appropriate for communicating the key messages to each audience group previously identified. Communication methods are based on audience characteristics and messages. Communication methods and messages for each audience are summarized in Table 64.

Table 64. Communication Methods for Each Audience Category

Target Audience	Key communication messages	Communication Methods
Government Agencies in San Mateo County	Benefits/Availability of Alternative Fuels San Mateo County is a hotspot for alternative fuel usage. Be part of it.	• Alternative Fuels Readiness Plan • Video showcasing AF usage in SM County • Face-to-Face meetings and workshops with key stakeholders • Email campaign from C/CAG to each city and jurisdiction within San Mateo County • Access to the Plan and other resources on the San Mateo County website
	Every city and every county fleet counts in achieving state goals (AB32, SB 735, EOs) Cities can help encourage AF usage, e.g. put requirement for fleets to use AFs or low emission fuels in Climate Action Plan	
	The Plan exists and where to find resources	
Businesses and Private Fleets	Economic and environmental benefits of Alternative Fuels Businesses and Private Fleets function as technology enablers by demonstrating that alternative fuel technology is reliable, safe and viable	• Alternative Fuel Readiness Plan • Case Studies of other businesses using AFs • Guides/Strategies • Video showcasing AF usage in SM County • Access to the Plan and other resources on city website
Consumers	Economic, environmental, performance, and convenience benefits of AFV	• Alternative Fuels Readiness Plan • Video showcasing AF usage in SM County • Community events, such as "Earth Fair" and "Ride and Drive Events," showcasing AFVs • Educational school events for AFV such as "Clean Air Day" • Informational Brochures • Access to the Plan and other resources on city website and note about the Plan in regular resident communication

Alternative Fuel Readiness Plan

The Alternative Fuel Readiness Plan serves as a guidance document to public agencies, private companies and individuals regarding the incorporation of AFVs and AFI into San Mateo County. The Plan covers important aspects of alternative fuels including:

- Alternative fuel types
- Benefits of using and advancing AFs
- Available incentives for individuals, investors, and government
- Challenges to the growth of the AFV market along with potential solutions to improve San Mateo County's readiness for AFVs and increase procurement
- Training recommendations and resources to help prepare government employees and safety officials for the infusion of AFVs and AFI in San Mateo County
- Strategies for infrastructure development

This Alternative Fuels Readiness Plan is a valuable resource for each target audience, communication activities need to ensure audiences are aware that the plan exists and indicate where to access the plan. The recommended tools for spreading this message are presentations and workshops, email campaigns, as well as online access to the Plan on the C/CAG and city websites. Cities can also mention this Plan in their regular written communication with residents by adding a short statement to their regular notifications. Sending a separate note would be too much as per our judgement.

Presentations/Workshops

One option to make government agencies aware of the Plan is to conduct face-to-face presentations and workshops. As explained above, the Plan is an important resource for San Mateo County government agencies to learn more about alternative fuels including existing incentives, challenges, production, delivery, and safety. But in order to use the Plan as a resource, San Mateo County agencies need to be informed about the existence of the Plan. To achieve this, C/CAG and Life Cycle Associates conducted several face-to-face meetings and workshops informing key stakeholders about the Plan and its goals. The following presentations and workshops took place:

1. Presentation to the Joint Venture Climate Taskforce on 2/12/15
   http://www.jointventure.org/climatetaskforce
2. Presentations to C/CAG Resource Management and Climate Protection Committee on 1/21/15 & 10/21/15
   http://C/CAG.ca.gov/committees/resource-management-and-climate-protection-committee/
3. Presentations to C/CAG Technical Advisory Committee on 11/20/14 & 11/19/15
   http://old.C/CAG.ca.gov/tac.html

4. Presentation to C/CAG Congestion Management and Environmental Quality Committee on 11/30/15
   http://ccag.ca.gov/committees/congestion-management-and-environmental-quality-committee/
5. Presentation to RICAPS Multi-city Working Group Meeting on 7/28/15
   http://www.smcenergywatch.com/sites/default/files/RICAPS.2015.07.28_Whole%20presentation.pdf
6. Presentation to C/CAG Board of Directors on 11/12/15
   http://ccag.ca.gov/committees/board-of-directors/

Email Campaign

Another option to make government agencies aware of the Plan is to conduct a multi-stage email campaign targeted at each city in San Mateo County.

In the initial email, C/CAG should introduce the Plan along with a short explanation of why it was prepared and the information it offers to support government agencies, businesses, and consumers. The summary report should be attached to this initial email as a PDF and in the email text as a link to the C/CAG website. Furthermore, asking cities to make the Plan available on their own websites is a great option to reach businesses and consumers.

The second stage of the email campaign can focus on different aspects of alternative fuels readiness, such as incentives, challenges, recommendations, and strategies for infrastructure development. For example, each email during this stage could consist of a summary of the most important information from a chosen topic and then provide a link to the final report for more information. The goal is to get San Mateo government agencies interested in alternative fuels and build awareness of how AFs help meet state policy initiatives.

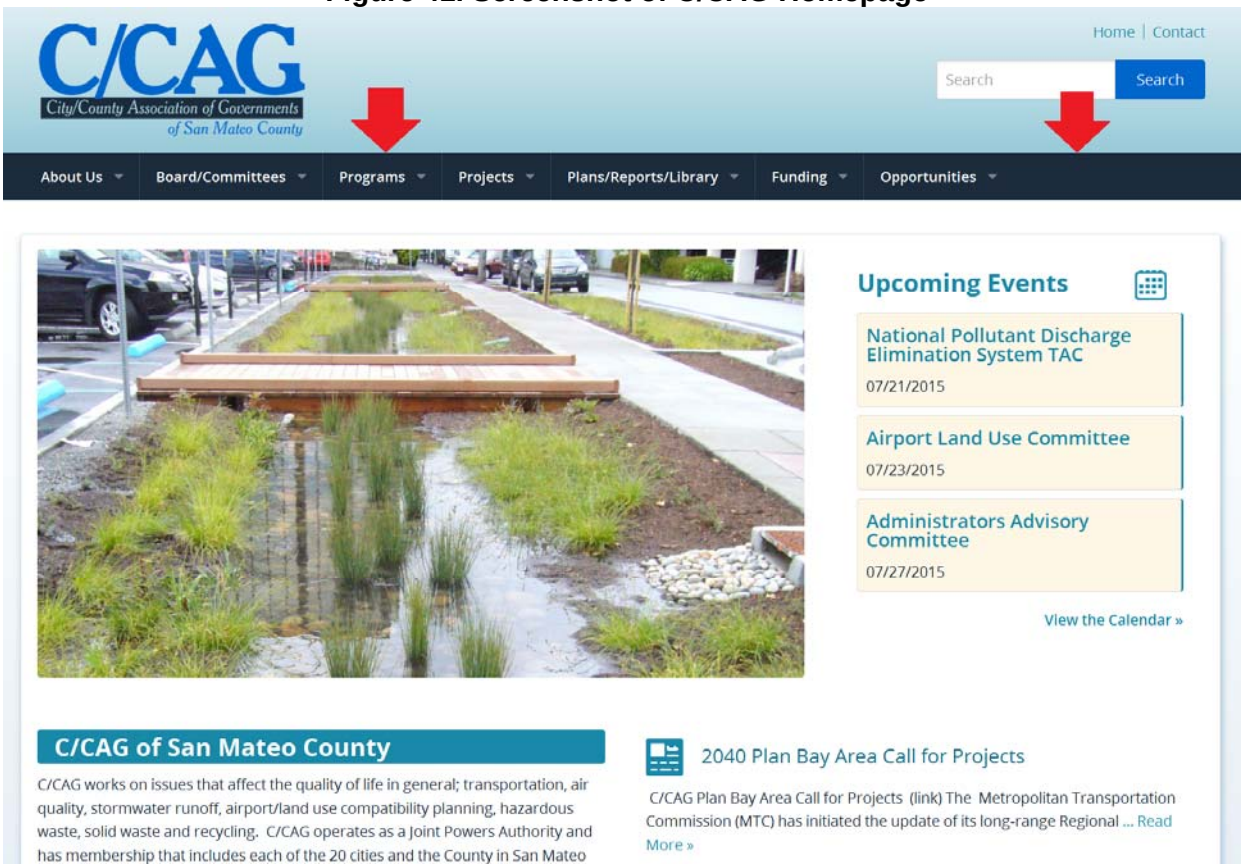
The last stage of the email campaign can consist of specific action items that cities can take in order to facilitate AF readiness in their jurisdiction. Suggestions for action items can include implementing a website section on the city homepage with resources on AFVs, hosting community events, encouraging educational events in local schools, and providing informational brochures.

If the email campaign is successful, it can be followed up with a monthly newsletter. This newsletter can showcase different AF projects that cities are currently engaged in. That way, the city with the project that is highlighted gets recognition for its efforts and other cities get inspirations for their own projects.

Website section about alternative fuels on C/CAG's homepage

C/CAG operates as a Joint Powers Authority and has membership that includes each of the 20 cities and the County of San Mateo. As such, C/CAG plays an important role in communicating the benefits of AFs to government agencies in San Mateo County. C/CAG can include a website section about AFs on their homepage that will serve as a central resource on AFs for San Mateo County government agencies.

Figure 41. Screenshot of C/CAG Homepage



Source: C/CAG Homepage

The AF section can either be added to the "Programs" section under "Transportation" or as a separate category altogether, as indicated by the two red arrows in Figure 2. This section can include useful resources such as access to the Plan, background info on AFVs, grant opportunities and other current incentives, as well as sample guidelines and worksheets for organizing events related to AFs. Appendix D shows a list of sample resources to include on the C/CAG alternative fuel website section.

Website section about alternative fuels on city homepages

As mentioned earlier, cities can help encourage AF usage and are crucial to effective communication with businesses and consumers. Each city can implement a website section on their homepage with resources on AFVs, similar to the one suggested for C/CAG. Resources for this website section can include a link to the Plan, links to case studies about alternative fuel use in a business context, fact sheets and user guides, links to incentive programs, and informational brochures. A frequently asked questions (FAQ) section can also be included. In addition, cities can announce events related to AF usage in this section, such as ride and drive events, earth fairs, or AFV exhibitions.

If cities provide a website section about alternative fuels on their homepage, consumers can easily research and find information, which will help them understand AF benefits and encourage them to transition to cleaner fuels and vehicles. Researching AF technologies and finding all the information necessary to make a purchasing decision can seem intimidating and often deters consumers from taking the next step. Compiling information in one central place cuts down the time consumers spent on researching AFs and helps them absorb information faster. Appendix D shows a list of sample resources to include in the alternative fuel section of city websites.

Video showcasing alternative fuel usage in San Mateo County

The core message of the communication plan that cuts across all audience groups is that San Mateo County is a world leader in adopting alternative fuels and addressing energy, environmental and economic issues that are critically important to the State of California; and that everyone should participate in this effort. It also serves to raise awareness that the Alternative Fuel Readiness Plan exists, and shows ways that individuals and governments can get involved.

To communicate this message, C/CAG and Life Cycle Associates developed a short informational video. The goal of the video is to show all audience groups that San Mateo County is a leader in alternative fuel usage and that alternative fuels are already used everywhere in San Mateo County. To achieve this, the video features alternative fuel leaders in San Mateo County and shows alternative fuels being used all over the County. The video includes at least one example of AFs being used in each of the three audience groups, as outlined in Table 65.

Table 65. Examples of Alternative Fuels Used in SM County

Target Audience	Example of AFs used in SM County
Government Agencies in San Mateo County	• Interview with C/CAG spokesperson • EV charger in Portola Valley
Businesses and Private Fleets	• SuperShuttle • Scavenger • Propel • Luxfer GTM
Consumers	• Interview with Menlo park resident Jennifer P. who is driving a Nissan Leaf

Consumers are encouraged to be part of the change towards a more sustainable fuel infrastructure. By seeing that their peers are already using alternative fuels, people in each audience group will feel motivated to use AFs themselves. The video suggests specific action items for consumers, such as buying an alternative fuel vehicle, fueling flex fuel vehicles with E85 instead of regular gasoline, fueling diesel cars with Biodiesel or Renewable Diesel, and supporting their city's climate action plan.

C/CAG can distribute the video to each city and jurisdiction within San Mateo County and feature it prominently on the San Mateo County website. The video can also be disseminated to the California Energy Commission, uploaded to YouTube, and promoted with Google AdWords.

Case Studies

Businesses are cautious about adopting alternative fuel technologies due to previous experience, economic feasibility, or issues surrounding infrastructure development. Reducing these hesitations requires further education about the economic and environmental benefits of AF technologies. Case studies of other businesses can be used to highlight the economic and environmental benefits of using AFVs in a business context and demonstrate to businesses that AF technologies and infrastructure have progressed. Case studies show how other companies are dealing with questions of cost effectiveness, maintenance and reliability, driving experience, and environmental impacts.

Case studies are also useful for communicating with San Mateo County fleets, which are also concerned with the economic viability of fuel and vehicle choices. Case studies of other businesses using AFs already exist and can be used for San Mateo County's communication efforts. Table 66 and Table 67 show examples of case studies that analyzed AF usage in a business context.

Table 66. Case Studies about AF Usage in a Business Context

Case Study	Study Object	Description	Link to case study
FedEx Express on Lessons Learned from EV Deployments	FedEx Express	Case study evaluating FedEx Express's global electric vehicle deployments. Includes strategic considerations, critical decision factors, EV fleet application and performance satisfaction.	http://www.fleetanswers.com/sites/default/files/FedEx_case_study.pdf
PG&E on how Electrification is Saving its Fleet Money Today	PG&E	Case study examining how PG&E is using electrification to save money on its fleet today. Includes strategic considerations, critical decision factors, EV fleet application and performance satisfaction.	http://www.fleetanswers.com/sites/default/files/PGE%20case%20study%20Final.pdf
Workplace Charging Case Study for EV	Facebook workplace charging stations	Case study analyzing charging station utilization at Facebook's office campus with AC Level 1, AC Level 2, and DC fast charging units.	http://avt.inl.gov/pdf/EVProj/WorkplaceEVSEUtilizationAtFacebookJun2014.pdf
SuperShuttle CNG Fleet Study Summary	SuperShuttle	Case study evaluating the fleet of CNG vans in the SuperShuttle fleet in Boulder, Colorado. The study looked at fleet facts, fleet's CNG experience, fuel economy and costs, maintenance and reliability, operating costs, capital costs and payback, and emission results.	http://www.afdc.energy.gov/pdfs/supershuttle.pdf

Table 67. Case studies about AF usage in a business context (Cont'd)

Case Study	Study Object	Description	Link to case study
CNG Refuse Fleets	Republic Services Groot Industries City of Milwaukee	Case study exploring the use of heavy duty refuse trucks fueled by CNG. Includes motivations for adopting CNG, vehicles and infrastructure deployed, fleet acceptance and feedback, deployment challenges, analysis of operational, environmental and business case data.	http://www.afdc.energy.gov/uploads/publication/casestudy_cng_refuse_feb2014.pdf
Business Case for CNG in Fleet Applications	Transit buses School buses Refuse trucks Para shuttles Delivery trucks Taxis	Business case giving guidance to fleet managers making decisions about using CNG.	http://www.nrel.gov/docs/fy15osti/63707.pdf
Propane School Bus Fleet (2014)	Five school districts that used propane fueled school buses	Case study examining the use of propane fueled school buses in five school districts. Includes motivations for adopting propane, vehicles and infrastructure deployed, analysis of operational and environmental data, business case data, and considerations for deployment in other fleets.	http://www.afdc.energy.gov/uploads/publication/case-study-propane-school-bus-fleets.pdf

Source: Life Cycle Associates

These and other case studies can be made available on the city's dedicated website section for AFs. The case studies are included in Appendix B as link suggestions.

Guides and Strategies

Guides, fact sheets, and strategy documents about AFs also provide businesses with hands on material that facilitates understanding of AFs and ultimately aids in decision making. Guides provide information in a condensed and graphic form, making it easy for businesses to comprehend necessary information to get started with AF technologies. Likewise, strategy documents and fact sheets make information easily digestible and simplify and expedite the planning process. Guides, fact sheets and strategy documents about AFs should be made

available on the city's dedicated website section for AF resources. See Appendix D for resource suggestions.

Community Events

As mentioned earlier, cities play an important part in encouraging AF usage. Personal experience significantly improves understanding and comfort with AFVs. Cities can engage consumers and generate interest in AFVs by organizing events in their city that showcase alternative fuels. Possible events include "Earth Fairs", AFV exhibits, or "Ride and Drive" events. This gives consumers the opportunity to see AFVs up close, receive information, ask questions, and drive or take rides in AFVs.

On its National Drive Electric Week website, Plug-In America, the Sierra Club and the Electric Auto Association provide resources to help cities organize local events for AFV. These resources include tips on getting started, event planning, publicity, insurance coverage, event preparation and more.

In addition to holding local AF events, cities, C/CAG, or an environmental coordinator can also visit car shows, festivals and farmer's markets and set up informational booths, display posters, and pass out brochures. These events are an opportunity to directly communicate with the public and educate them about the benefits of AFs. (See Figure 42).

Figure 42. Woodside/ Portola Valley Earth Fair 2015 in Woodside, CA

Photo Credit: Life Cycle Associates

Informational Brochures

Environmental coordinators can pass out short informational brochures about AFVs to consumers at community events, for example at an Earth Fair. These informational brochures should give consumers an overview of which AFs exist, listing the AFV types, and giving a brief summary of the benefits of using AFVs.

Simplicity is key in getting people to read the informational brochures. The brochures will be handed out at community events where people have a relatively short attention span, so complex explanations and long text will not be able to hold people's attention. The brochure should consist of short text and bullet points that are easy for people to digest along with matching graphics. The goal is to get people curious to learn more about AFVs and refer them to the AF section on city websites for more information.

See Appendix E for an Alternative Fuel Brochure Template.

Implementation

In order to implement the strategy set out in this chapter and deliver the key communication messages to each target audience, resources have to be allocated for each communication method. Table 68 and Table 69 outline possible steps and the required resources to implement the described communication methods. The table also includes proposed distribution channels for each communication method and identifies who should be responsible for implementing the communication method.

Table 68. Outreach Methods and Resources for Implementation

Communication Methods	Required Resources	Distribution Channel	Responsible Party
THE PLAN	Create website section for alternative fuels, make THE PLAN accessible on C/CAG and city websites	C/CAG Website City websites	C/CAG Cities
Presentations/ Workshops with key stakeholders	Rent meeting room, prepare meeting announcement and agenda, prepare presentation materials, prepare briefing materials	TBA	C/CAG and environmental coordinator
Email campaign	Assemble recipient list, formulate email content, determine emailing dates, respond to questions and inquiries, monitor response	Email	C/CAG
Website section about alternative fuels on the C/CAG homepage	Create website section for alternative fuels, research and post links about grant opportunities, incentives, and other resources, collect feedback from stakeholders to improve and update section	C/CAG website	C/CAG
Website section about alternative fuels on the homepage of each city	Create website section for alternative fuels, post links to information and resources on AFs relevant to consumers and businesses, post announcements about local AFV events, maintain and update section	City websites	Cities
Video showcasing AF usage in San Mateo County	Conceptualize video, write script, contact and interview stakeholders, take photos, film AFVs and technology, determine distribution channels, cut and edit final video, distribute video	C/CAG website City websites YouTube Google AdWords	C/CAG and environmental coordinator

Table 69. Outreach methods and resources for implementation (Cont'd)

Communication Methods	Required Resources	Distribution Channel	Responsible Party
Case Studies	Find and/or write appropriate case studies, upload case studies to AFV website section	City Websites	C/CAG and City
Fact Sheets	Find fact sheets/ guidelines/ strategies related to AFs, organize these into useful list, upload to AF website section	City Websites	City
Community Events	Draft event concept, find location, plan and organize event, prepare event announcement and agenda, prepare event materials and activities, purchase and ship event supplies, advertise event	City	City
Educational School Events	Brainstorm and conceptualize event, prepare event announcement and agenda, prepare event materials and activities	Local Schools	C/CAG or environmental coordinator
Informational Brochures	Draft brochure content and prepare graphics, print brochures and/or make them available online	City websites City events	City and environmental coordinator

Source: Life Cycle Associates

Evaluation

This section outlines ways to measure the success of the communications plan. Table 70 recommends tools for evaluating the effectiveness of the individual communication methods. These recommendations can be adjusted and expanded upon as needed.

Table 70. Success Measures

Communication Methods	Success Measures
The Plan	Number of Downloads
Presentations/ Workshops with key stakeholders	Direct feedback after meetings
Email campaign	Email opening and response rates, number of cities implementing section about AFs on their website
Website section about alternative fuels on the C/CAG homepage	Website analytics: visitor count, page views, bounce rate, session duration
Website section about alternative fuels on the homepage of each city/ Case Studies/ Guides and Strategies	Website analytics: visitor count, page views, bounce rate, session duration, clicks on case study and guideline links
Video showcasing AF usage in San Mateo County	Google AdWords analytics, YouTube clicks, media coverage
Community Events	Attendance, brochure distribution, perceived interest
Educational School Events	Student survey that measures understanding of covered topics before and after the event
Informational Brochures	Informal interviews of consumers at community events to gauge current perception and understanding of AFV

Source: Life Cycle Associates

In addition to having success measures in place, we also recommend setting milestones beforehand to measure progress towards communication goals. These milestones will help in evaluating the effectiveness of conducted communications.

CHAPTER 8:
Assistance Strategies for Infrastructure Development

Optimal distribution of the infrastructure for refueling alternative fuel vehicles will require planning and forethought. Station density should be highest in areas of dense population, and complemented by stations on important thoroughfares, highways, and appealing destination locations. The number of fueling sites needed will depend upon the amount of a given fuel that is demanded, which in turn depends upon the number of vehicles being driven that use that fuel. Therefore, the development of a comprehensive siting plan requires:

1. Assessment of countywide travel and commute patterns and vehicle miles traveled;
2. Prediction of vehicle populations and fuel demand volumes;
3. Analysis of county population density by geographic area;
4. Identification of refueling hubs, such as commercial areas, highways, and airports.

Effective infrastructure planning will enable all San Mateo County residents to access the fuel they need as conveniently as possible. Fuel providers and retailers can also plan best when they are informed about future levels of fuel demand and distribution needs across the county. Chapter 8 fulfills the requirements of Task 7 of C/CAG's agreement with the CEC to develop strategies to assist fuel wholesalers and retailers with conceptualizing a regional infrastructure siting plan. We project future vehicle population and fuel demand through the year 2030 in San Mateo County and provide guidelines for optimal refueling locations.

Base Case Vehicle Populations and Fuel Use

Projected Vehicle Populations

Alternative fuel use will grow in proportion to California's LCFS requirements. Life Cycle Associates modeled the expected changes in San Mateo County vehicle populations through 2030 based on purchasing trends and regulatory mandates. ARB's Emissions Factor (EMFAC) 2014 model was used to estimate the number of AFVs that will be registered in San Mateo County through 2030 (CARB, 2014a). EMFAC provides projections of gasoline, diesel, and electric drive vehicles by vehicle class. EMFAC reports all electric drive vehicle miles traveled (VMT) together, combining PHEV, BEV, and FCEVs. The California Zero Emission Vehicle (ZEV) mandate was used to estimate the split of electric drive vehicles between PHEVs, BEVs, and FCEVs, which changes over time. We have grouped the vehicle classes into four main categories: light-duty auto, light-duty truck, medium-duty vehicle, and heavy-duty vehicles[1].

The EMFAC vehicle projections make the following assumptions:

[1] Medium duty is defined as classes 3-6 and heavy duty is classes 7 & 8.

- Electric drive vehicles include all BEVs, all FCEVs, and 40% of PHEVs, which corresponds to the amount of electricity used in the average PHEV. The remaining balance of PHEVs are included in the gasoline category.
- Light duty NGVs and FFVs are included in the gasoline category.
- Medium- and heavy-duty NG vehicles are included in the diesel category.

To determine the split of electric drive vehicles between BEV, PHEV, and FCEV, the ZEV Mandate "Likely Compliance Scenario" was used[1]. Since current DMV estimates of BEVs registered to San Mateo County exceeds the numbers projected by EMFAC2014, BEVs were estimated based on the current population and with a growth rate that corresponds with the EMFAC growth projections.

The DOE Argonne National Lab's VISION model "provides estimates of the potential energy use, oil use and carbon emission impacts of advanced light- and heavy-duty vehicle technologies and alternative fuels through the year 2050"(anl.gov, 2015). VISION 2014 baseline model projections were used to estimate FFV and CNG vehicle populations[2]. The resulting base case vehicle projections are provided in Figure 43 through Figure 49. The graphs demonstrate the following trends:

- As Figure 43 shows, gasoline vehicle populations make up the vast majority of light-duty vehicles, both now and in 2030. Figure 45 shows that total gasoline vehicle population will increase 6 % between 2015 and 2030 but that light-duty autos will decline 24 % and light-duty trucks will increase over 50 %.
- As shown in Figure 43, the population of light-duty FFVs, capable of consuming either E85 or E10 (i.e. standard gasoline), are anticipated by VISION to nearly triple between now and 2030. Figure 45 demonstrates that the majority of this increase will be occurring in the light-duty truck category
- Also shown in Figure 44Figure 43, ZEV populations are mandated to increase dramatically by 2030. The ARB "Likely Compliance Scenario" assumes that PHEVs are more popular than BEVs, which runs contrary to actual sales trends over the past several years. BEV sales currently dominate the ZEV market in San Mateo County, as shown in Figure 47. Approximately 34,000 PHEVs and 19,000 BEVs are anticipated in San Mateo County by 2030. Over 6,000 FCEVs are expected by 2030.
- EMFAC predicts that light-duty diesel populations, displayed in Figure 48, will more than double in the next 15 years, with most of this increase coming from light trucks.
- VISION predicts that light-duty auto CNG registrations, shown in Figure 49, will remain relatively stable, but that light-duty truck CNG registration will increase four-fold. Medium- and heavy-duty CNG vehicles will grow by a factor of 2.5.

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[1] ZEV Calculator from ZEV Mandate Proceedings, Dec 2012.

[2] Argonne National Laboratory VISION model based on AEO2014 projections of vehicle market shares from EIA.

Figure 43. Projected Light Duty Vehicle Populations, All Fuels

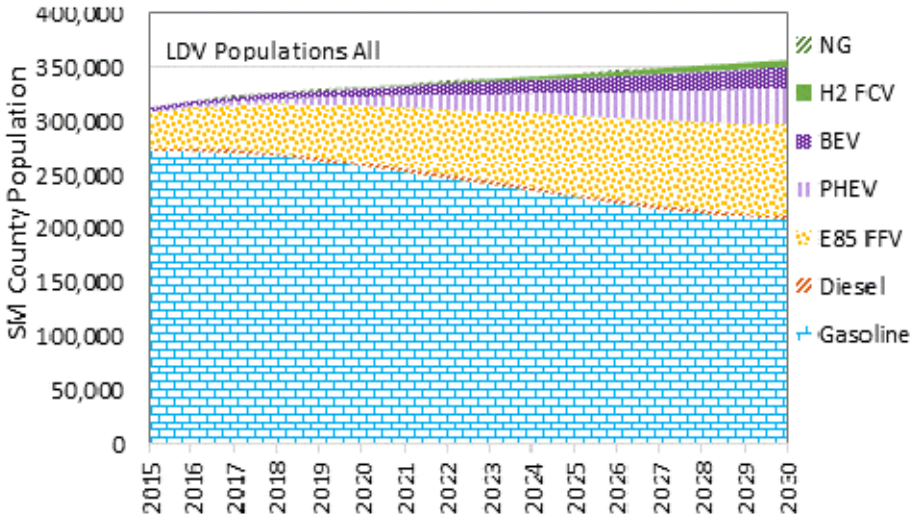


Figure 44. Projected AFV Populations

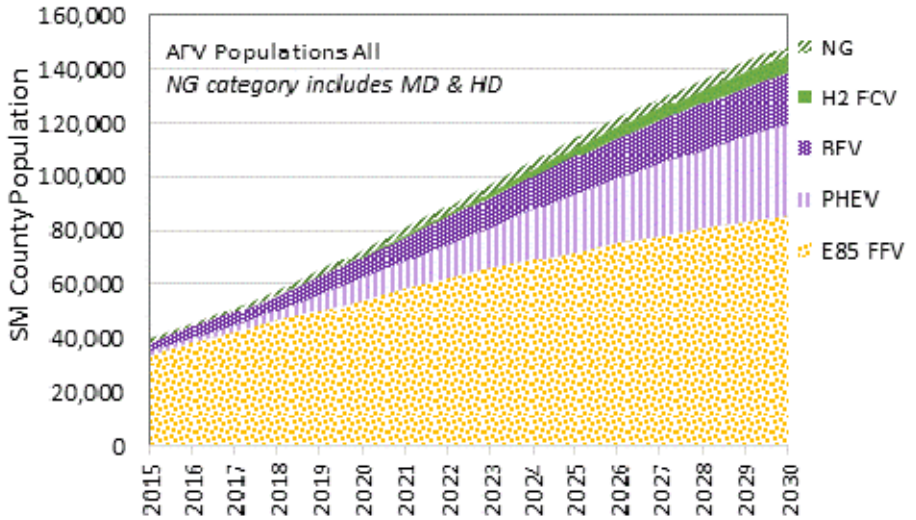


Figure 45. Projected Gasoline Vehicle Populations

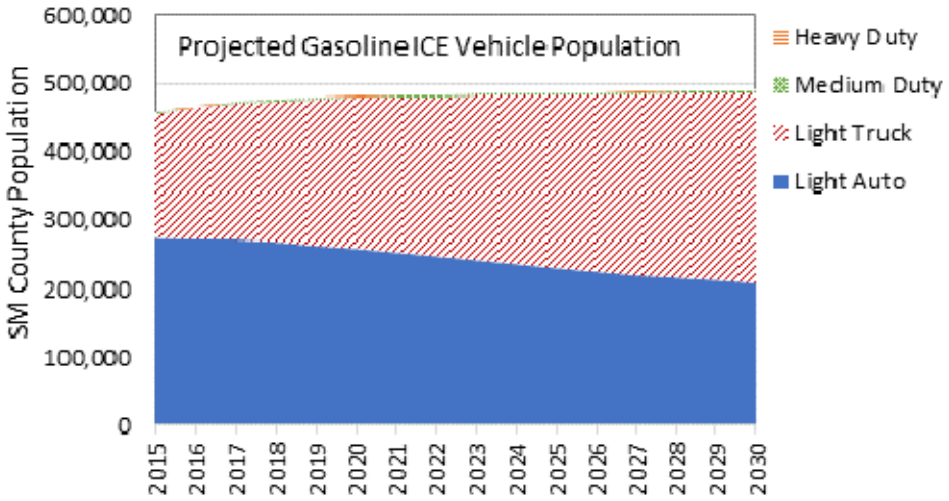


Figure 46. Projected FFV populations

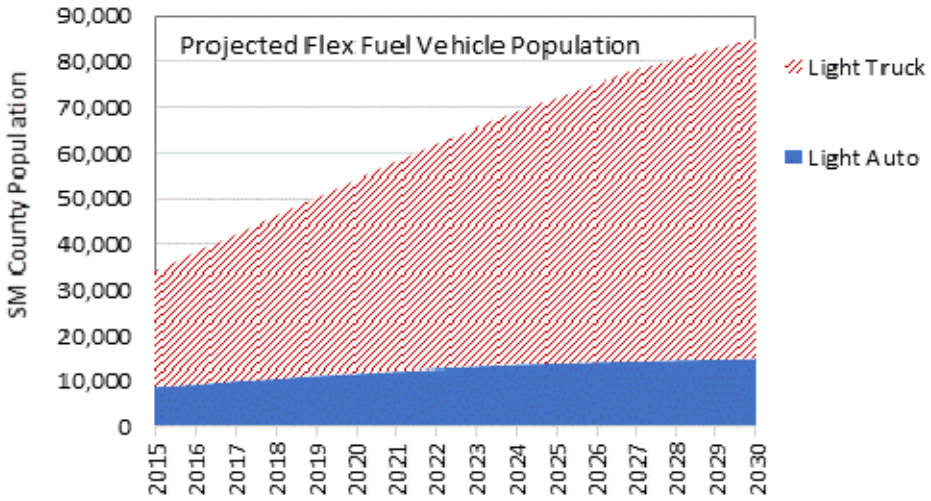


Figure 47. Projected Light Duty ZEV Populations

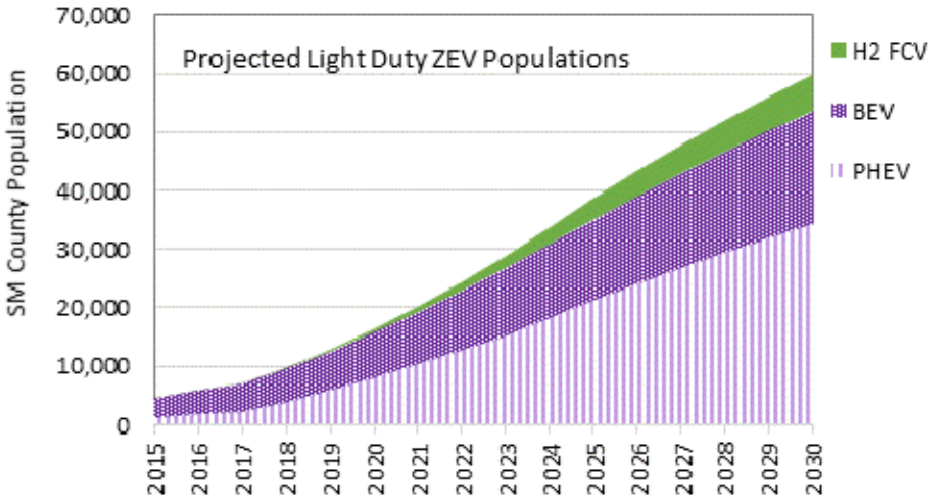


Figure 48. Projected Diesel Vehicle Population

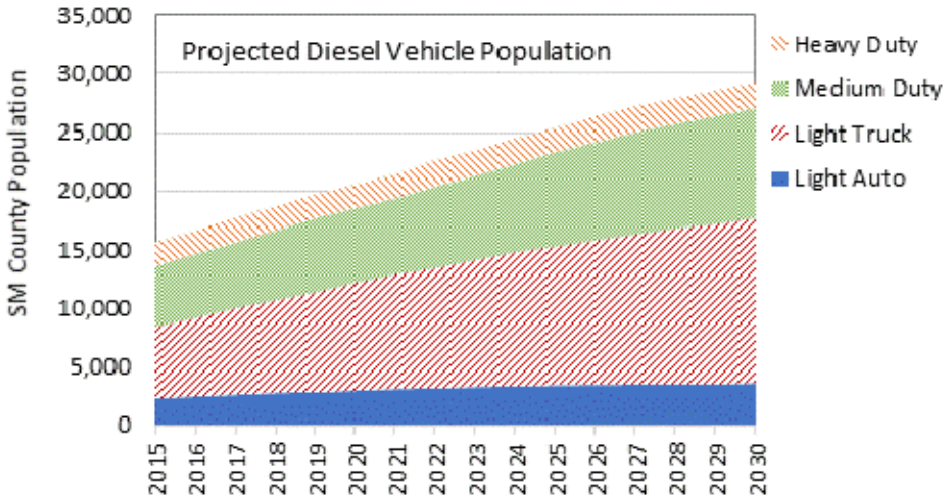


Figure 49. Projected NG Vehicle Population

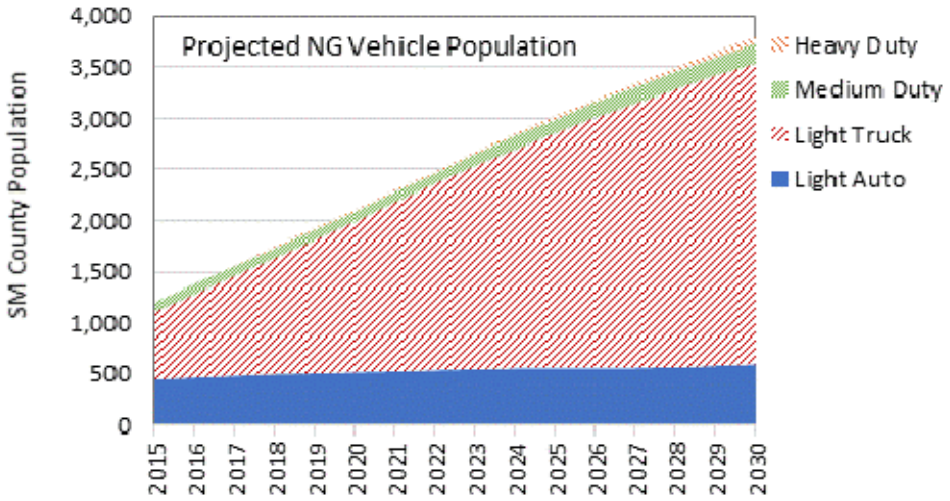
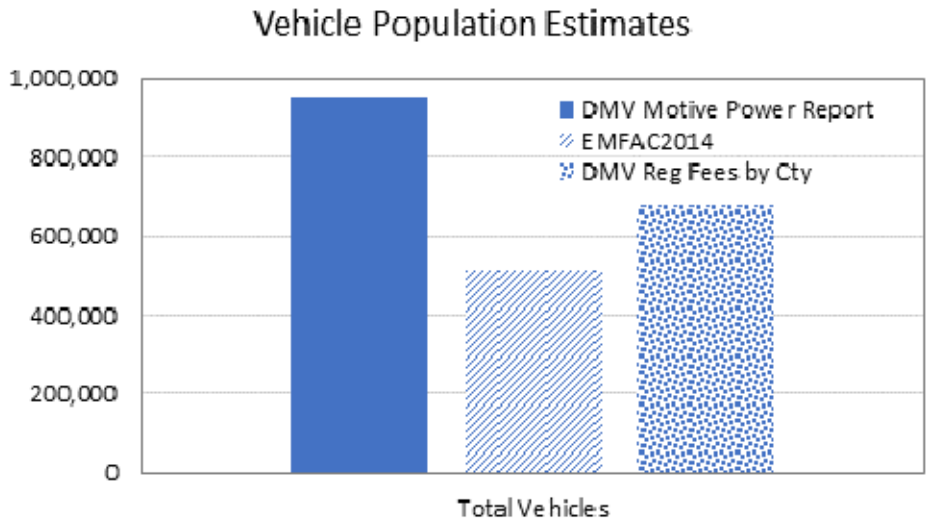


Figure 50 shows that the EMFAC population estimates for San Mateo County are lower than the DMV estimates. ARB states that they build their model based on the DMV database, however, the values do not seem to be consistent. Current clean vehicle rebate program (CVRP) statistics for San Mateo County support an even higher current estimate for PEV populations. In order to reflect these numbers, which we believe are more accurate for San Mateo EV populations in June of 2015, we have replaced the 2015-2030 BEV vehicle populations estimates with numbers that are consistent with the current CVRP estimates by assuming 800 new BEV purchases per year through 2020, and using the EMFAC BEV growth rates from 2021-2030. The PHEV population was adjusted for the year 2015 based on CVRP statistics since EMFAC overestimates the number of PHEVs currently in San Mateo County. For following years, EMFAC PHEV populations are used.

Figure 50. Comparison of DMV and EMFAC Vehicle Population Estimates



Projected VMT in San Mateo County by Vehicle Type

The actual amount of fuel used in San Mateo County depends not only on the types of cars purchased but also on the miles traveled by each vehicle. This metric is expressed in terms of vehicle miles travelled (VMT). In addition to the projections of vehicles registered in San Mateo County, EMFAC also projects VMT within the county, regardless of registration location, and includes both vehicles that are registered in San Mateo County and vehicles that merely pass through. San Mateo County contains two important highways, Route 101 and Interstate 280, both of which receive substantial traffic from the North and South.

The San Francisco Bay Area Metropolitan Transportation Commission (MTC) provided the in-county VMT estimates to ARB for EMFAC2014. EMFAC splits VMT by fuel type (gasoline, diesel, electricity). We have further split the gasoline and diesel VMT into FFV and CNG vehicle populations by assuming the same percentage of total vehicle population as used in the VISION model. BEV and PHEV VMT were adjusted based on the increased populations discussed in the previous section. Figure 51 through Figure 55 show projected VMT within the county for different alternative fuel types and support the following observations:

- Comparing the number of total VMTs in Figure 51 to other graphs shows that the bulk of total VMT in all years are from light-duty gasoline vehicles, both auto and truck.
- Figure 52 shows that the main increase in diesel VMT is from light- and medium-duty trucks, and that all other sources of diesel VMT remain approximately constant.
- FFVs (shown in Figure 53) and ZEVs (shown in Figure 54) are projected to have similar VMT levels by 2030, while diesel VMT (shown in Figure 52) is approximately half of FFV and ZEV mileage.
- As shown in Figure 54, PHEVs are projected to make up more than half of the 2030 ZEV population. FCEVs make up only a small portion of total ZEV VMTs.
- NG vehicles, shown in Figure 55, have very low projected VMT (108,000 miles per day), with most of it coming from light trucks. Other types of NGV show little growth.

Figure 51. Projected Gasoline ICE VMT

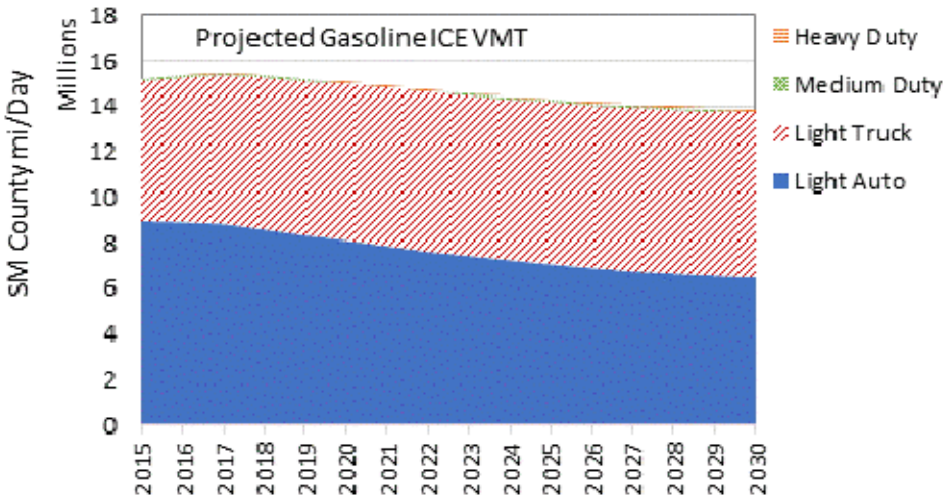


Figure 52. Projected Diesel Vehicle VMT

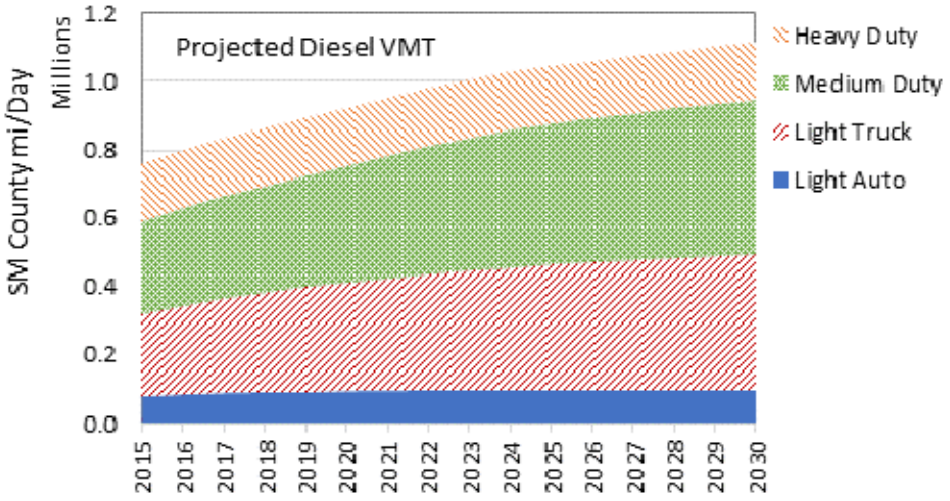


Figure 53. Projected FFV (E85) VMT

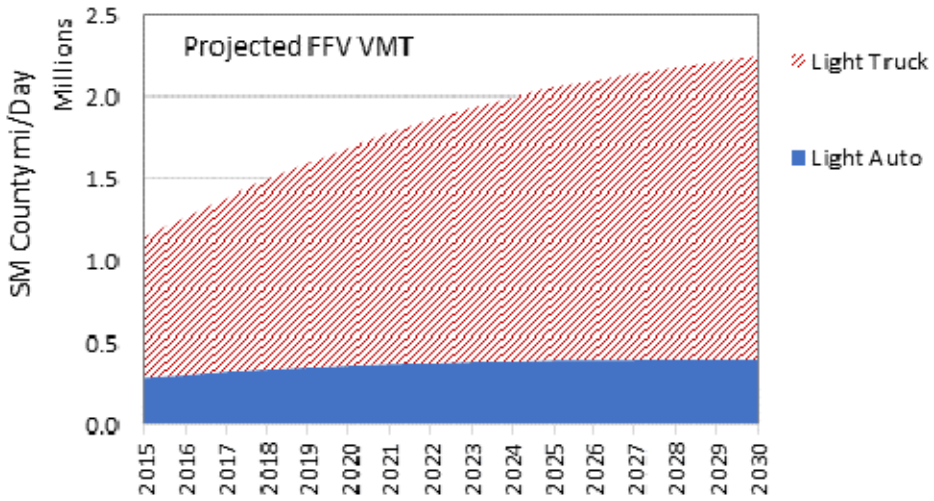


Figure 54. Projected ZEV VMT in San Mateo County

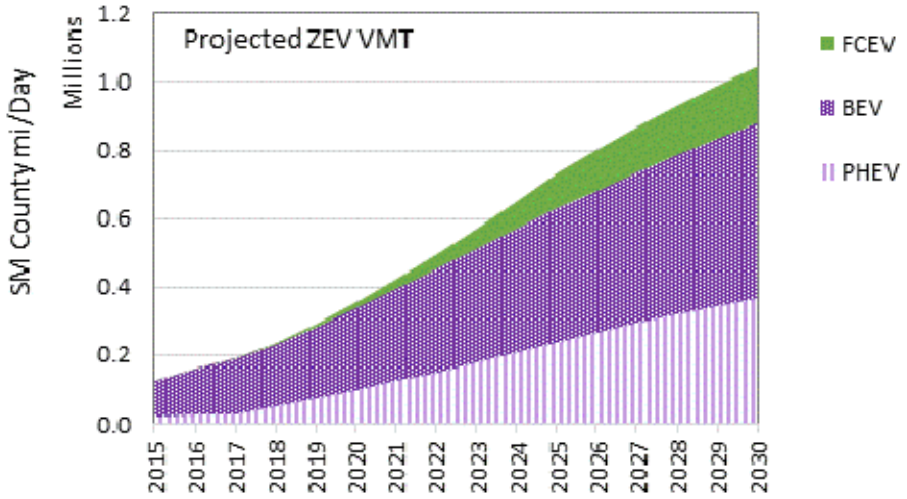
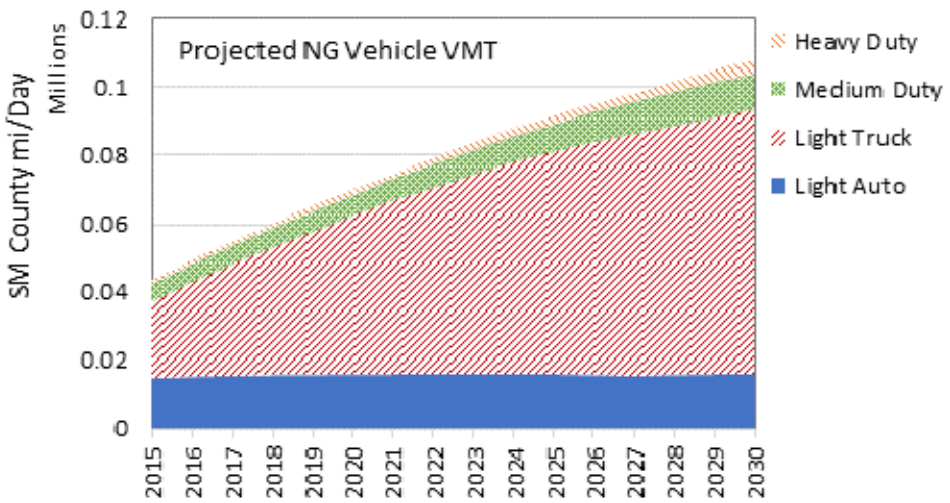


Figure 55. Projected NG vehicle VMT in San Mateo County



Projected Fuel Use in San Mateo County

Annual fuel consumption is the primary variable in determining the number of refueling stations needed in San Mateo County. Annual fuel consumption within San Mateo County for each vehicle type is estimated from VMT projections and calculated average fuel economy values from EMFAC for each vehicle fuel type/class. Gasoline and E85 volumes were adjusted based on CEC recorded gasoline volumes for 2014[1]. BEV electricity usage is also adjusted upward based on the corrected vehicle populations as reported by the CVRP statistics described above.

Figure 56 through Figure 66 detail the projected trends in fuel usage through the year 2030 for both light-duty autos and light-, medium-, and heavy-duty trucks. The trends in San Mateo County fuel demand are discussed in the following section. In general, we see a decrease in the total consumption of gasoline. This is due to several factors. For one, national CAFE standards require increasing levels of efficiency and fuel economy, so that driving an equivalent number of miles will require less fuel. For another, VMT around the country have been dropping for the last ten years. The reasons for this are the subject of much debate, and it remains to be seen if the trend will continue. Alternative fuels and diesel will experience growing demand during the next 15 years. Figure 56 shows all fuels, including petroleum-based fuels, on one graph in order to compare the total volumes on the same scale. It shows a steep decline in gasoline and a slight decline in diesel, while NG, electricity, and hydrogen increase slightly. Gasoline remains the most highly demanded fuel in terms of total quantity in spite of this decline.

Figure 57 shows the same graph but with gasoline and diesel removed to show the trends of alternative fuels in more detail. It's clear that electricity makes up a much larger quantity of

[1] Volumes used were presented at the ARB LCFS workshop on October 27, 2014.

gasoline gallon equivalents (GGE) than hydrogen, and E85 will decrease slightly by 2030. LPG doesn't even register since the volume is so small. The graphs that follow show each fuel type individually so that individual volumes are more visible.

Figure 58 shows gasoline fuel use in ICEVs and PHEVs. Gasoline fuel consumption by FFVs is not included in this figure. Reduced VMT projections, combined with significant improvements in fuel economy, result in a nearly 40 % decrease in gasoline consumption between 2015 and 2030 on this graph. Note that the medium- and heavy-duty vehicles continue to use a nearly constant amount of gasoline, while light-duty auto and truck experience large decreases.

Figure 59 provides the estimated fuel use in San Mateo County by FFVs. This fuel could be all gasoline or a combination of gasoline and E85. Note that the projected increase in FFV VMT results in an increase in fuel use until 2023, after which time VMT projections level off and improvements in fuel economy combine to reduce FFV fuel consumption. However, the number of FFVs in use have the ability to consume significantly more ethanol than is expected if they were to be fueled on higher ethanol content gasoline blends.

The FFV forecast from EMFAC provides the amount of fuel consumed by FFVs, but does not project how much of this fuel will be consumed in regular gasoline (E10) and how much will be consumed as E85. In 2014, ARB published a number of compliance scenarios with projections of alternative fuel volumes. The compliance scenarios provide total ethanol consumption. We have compared this to the IEPR total projected gasoline volume to estimate the amount of ethanol that would need to be consumed as E85. Table 71 summarizes the projected amount of ethanol consumed as E85 in the state. The ratio of E85 to E10 is also shown and is applied to the total fuel consumed by ICEVs and FFVs to arrive at the amount of E85 demand projected in San Mateo County.

Figure 56. Projected Vehicle Fuel Use in San Mateo County (All)

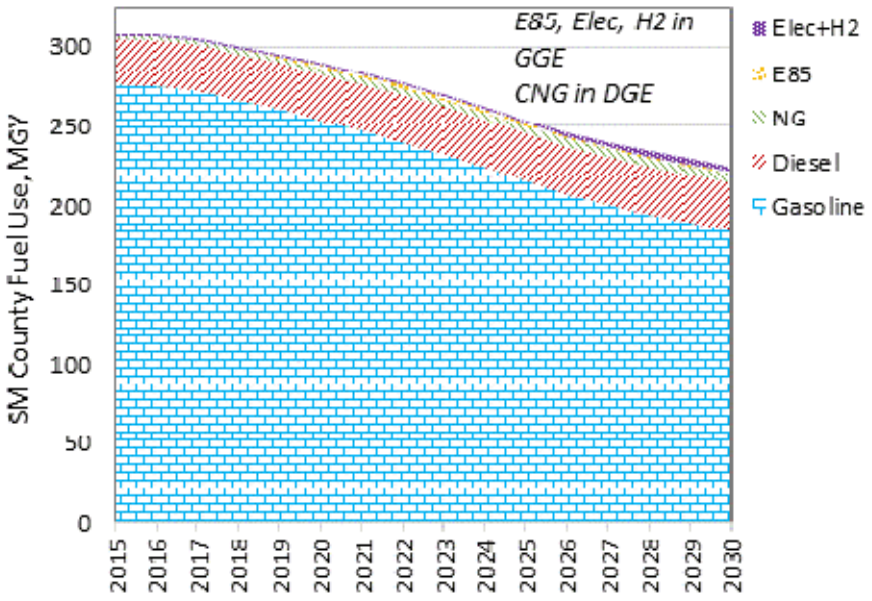


Figure 57. Projected Alternative Fuel Use in San Mateo County

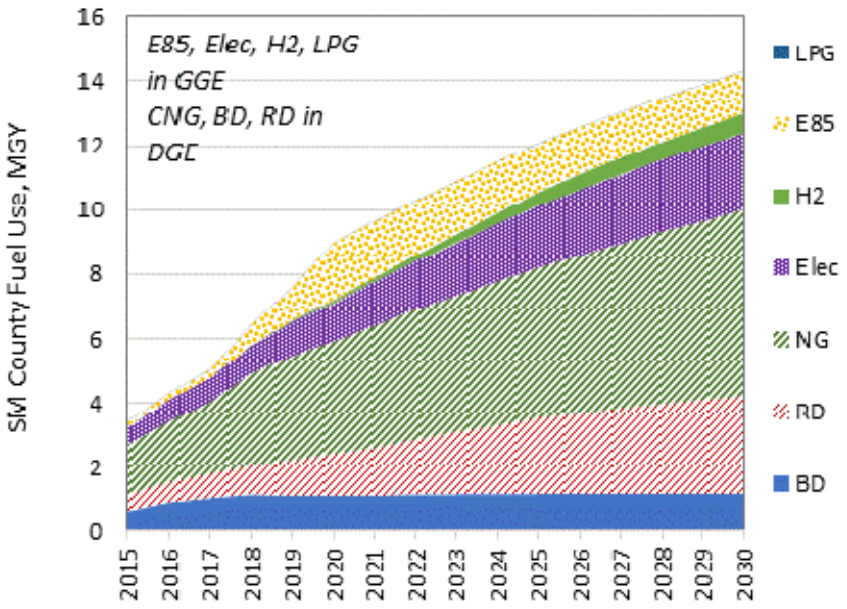


Figure 58. Projected Gasoline Vehicle Fuel Use in San Mateo County

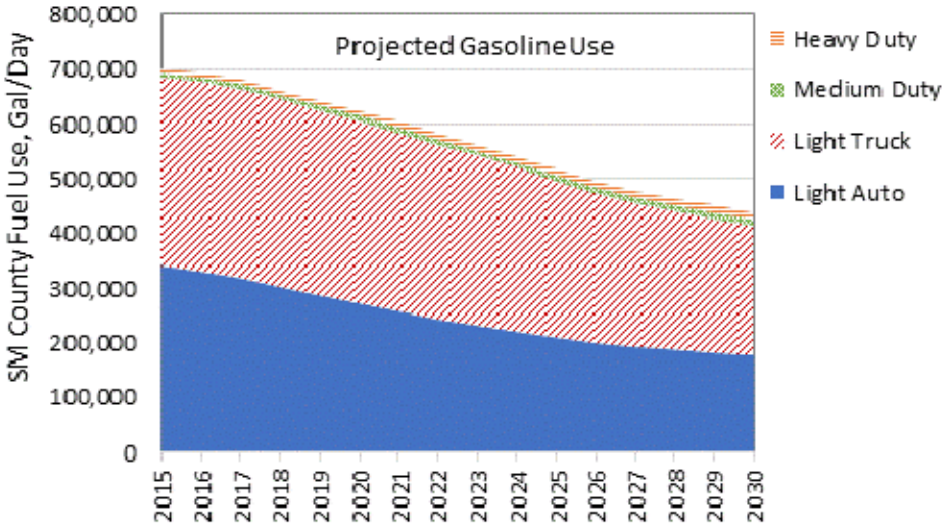


Figure 59. Projected FFV Fuel Use (gasoline/E85) in San Mateo County

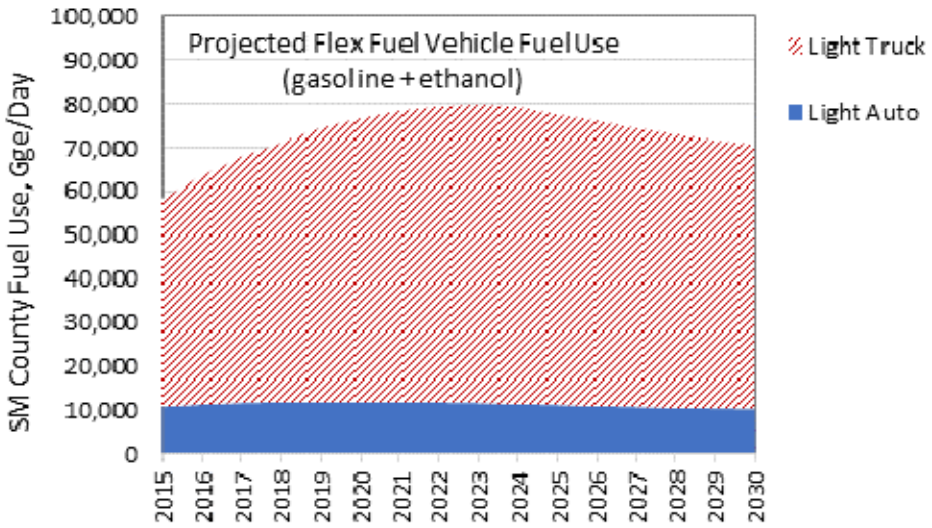


Table 71. Implied E85 consumption based on LCFS projected ethanol use and IEPR projected gasoline use

	Units	2015	2016	2017	2018	2019	2020
LCFS Total Ethanol[1]	MGY	1,480	1,455	1,440	1,440	1,430	1,435
IEPR Gasoline (E10)[2]	MGY	14,700	14,417	14,248	14,022	13,682	13,287
IEPR Ethanol in E10[3]	MGY	1,470	1,442	1,425	1,402	1,368	1,329
Ethanol as E85[4]	MGY	10	13	15	38	62	106
E85[5]	MGY	12	16	18	45	73	125
E85	MGGEY	9	12	13	33	54	93
E85/(E85+E10)	%	0.06%	0.08%	0.09%	0.24%	0.39%	0.70%
SM County E85	MGGEY	0.2	0.2	0.3	0.6	1.0	1.8
SM County E85	MGY	0.2	0.3	0.3	0.8	1.4	2.4

1. LCFS Workshop, October 27, 2014. Adjusted based on IEPR.
2. Schremp, G., 2015. California Transportation Fuel Trends in Historical Demand, Joint Lead Commissioner Workshop on Transportation Energy Demand Forecasts.
3. 10% of IEPR gasoline forecast is ethanol in gasoline.
4. Difference between LCFS ethanol projection and IEPR ethanol in E10.
5. Assume E85 is 85% ethanol by volume.

Fuel consumption by ZEVs is provided in Figure 60. The electricity segment shows electricity consumption by BEVs and PHEVs (the gasoline consumed by PHEVs is included in Figure 58), which increases by a factor of about 8. Hydrogen consumption by FCEVs also increases from zero to about 2,000 GGE/day.

Figure 61 provides a projection of in-county diesel consumption. Diesel consumption follows the projected steady increase in diesel VMT. Medium and heavy duty trucks consume the bulk of the diesel fuel. Most of the increase comes from medium-duty trucks; light- and heavy-duty truck fuel consumption remains fairly steady while light auto diesel consumption decreases slightly. Note that this graph includes all the fuel consumed by diesel vehicles, including renewable and biodiesel.

EMFAC does not provide biodiesel or renewable diesel fuel volumes. However, the ARB has presented volumes for these fuels associated with the LCFS targets. Unfortunately, their projections only extend to 2020. Since RD and BD are both blended into petroleum diesel, their volumes can be calculated based on a percentage of total EMFAC diesel volume. Blend percentages were calculated from the ARB data until 2020, after which point the 2020 blend fractions were held constant, which accounts for the leveling off effect seen in Figure 62.

Figure 63 shows projected natural gas vehicle fuel consumption in San Mateo County. Most of the NG is consumed by light-duty trucks, with lesser amounts by heavy- and medium-duty trucks. The NG consumption projection in Figure 64 is based on projections of vehicle populations in the VISION model (recall that the ARB's EMFAC model did not provide any information on NG vehicles). The VISION model projects a 2.5 fold increase in light-duty truck populations, resulting in a ratio of natural gas use to diesel use of 5 %.

Another check on natural gas consumption is to use the CEC's Integrated Energy Policy Report (IEPR) ratio of CNG consumption to diesel consumption (CEC, 2013). In 2030, the IEPR projects that the ratio of natural gas to diesel fuel is 11%.

Because the VISION model provides average estimates for the entire country, its projections may not accurately reflect natural gas use in San Mateo County. In 2013, the California Energy Commission projected transportation-related consumption of NG for the state. In addition, ARB projected statewide NG fuel consumption through 2020 in their LCFS scenarios. These two statewide projections are shown in Figure 64.

We can compare these two California estimates to the VISION estimate by showing the NG consumption as a percentage of diesel use. Figure 65 provides this comparison. By 2030, CEC projects that the ratio of NG to diesel will be 11% in California while the VISION model predicts a ratio of less than 6%. The LCFS projection stops in year 2020 at a ratio of 12%; if we extrapolate linearly, the 2030 ratio should be just under 20%. For planning purposes, we assume that a ratio of up to 20% will occur in San Mateo County. This results in the NG fuel consumption profile shown in Figure 66.

Figure 60. Projected Electricity and Hydrogen Consumption in San Mateo County.

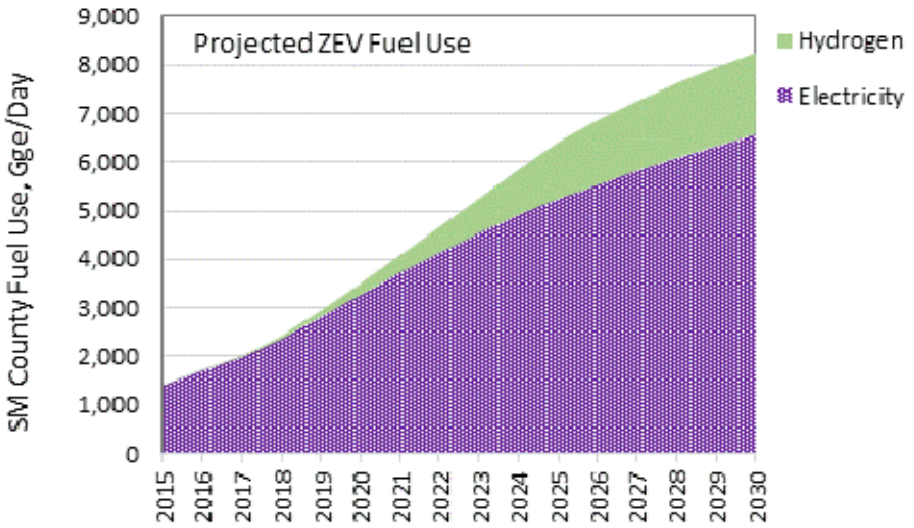


Figure 61. Projected Diesel Consumption in San Mateo County

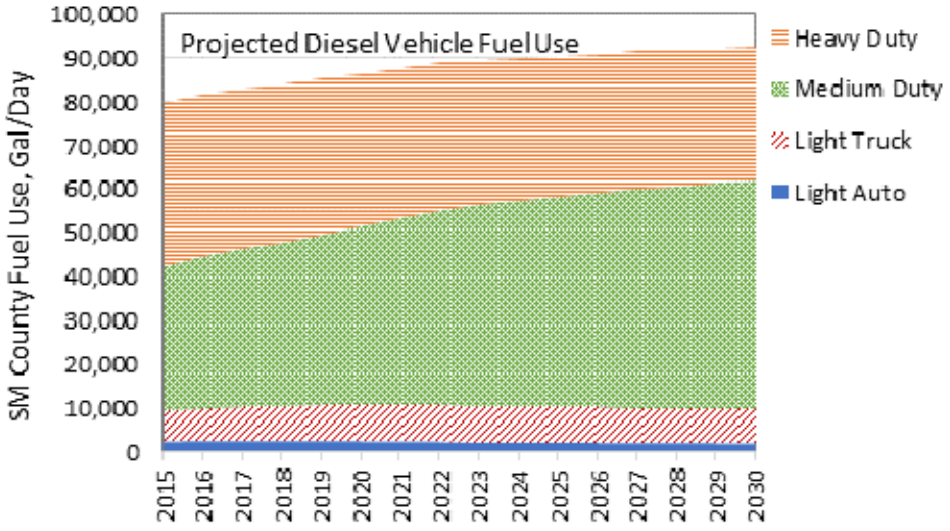


Figure 62. Projected Renewable Diesel and Biodiesel fuel consumption in San Mateo County

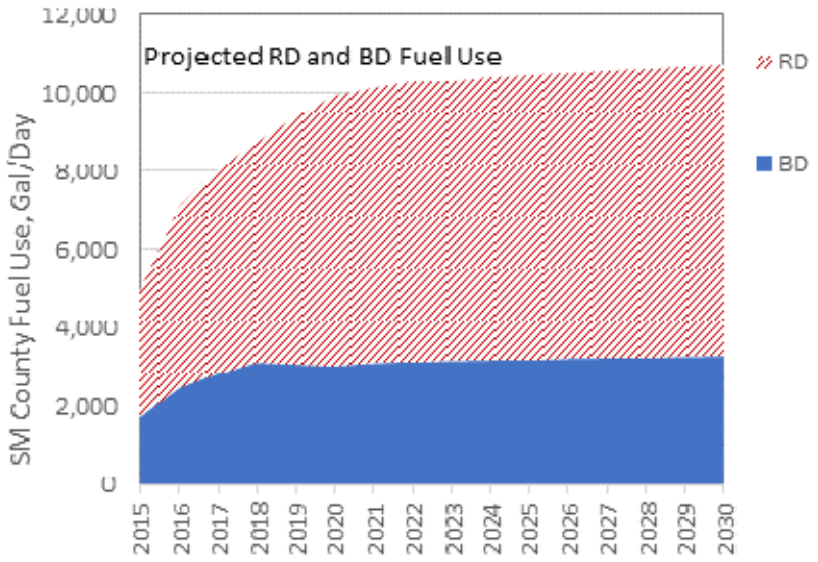


Figure 63. Projected NG vehicle fuel consumption in San Mateo County

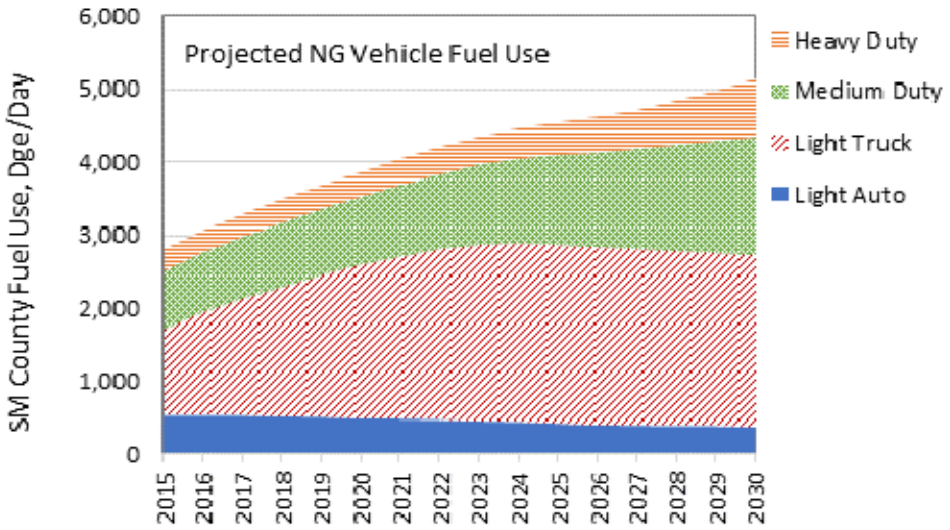


Figure 64. Projected NG vehicle fuel consumption in California

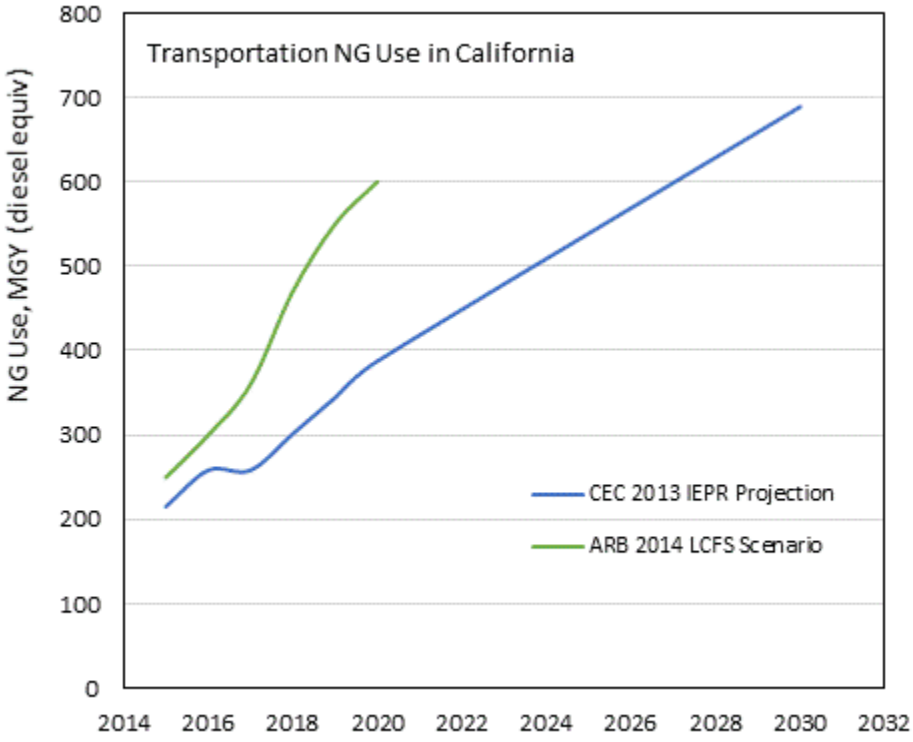


Figure 65. Projected Ratio of NG to Diesel use.

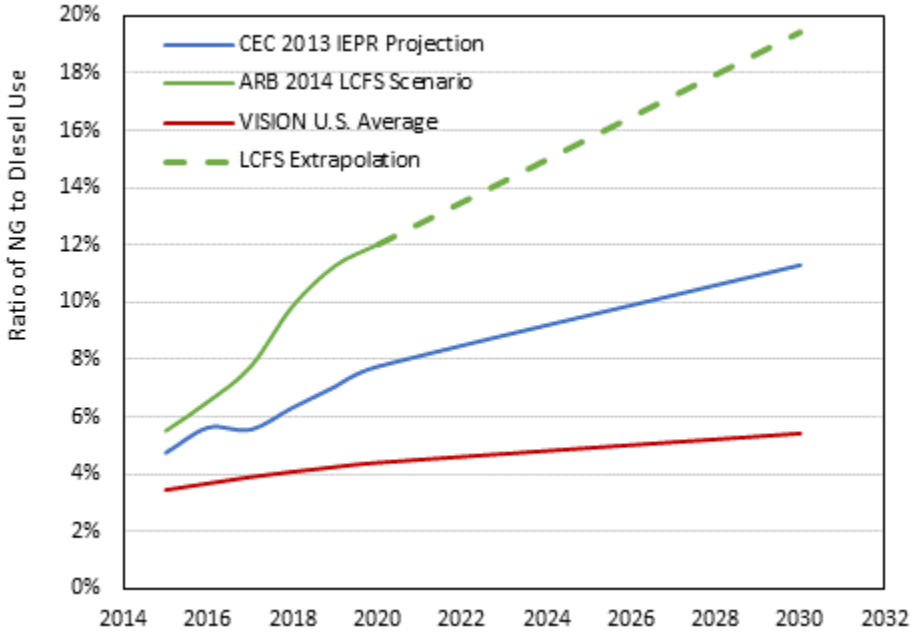
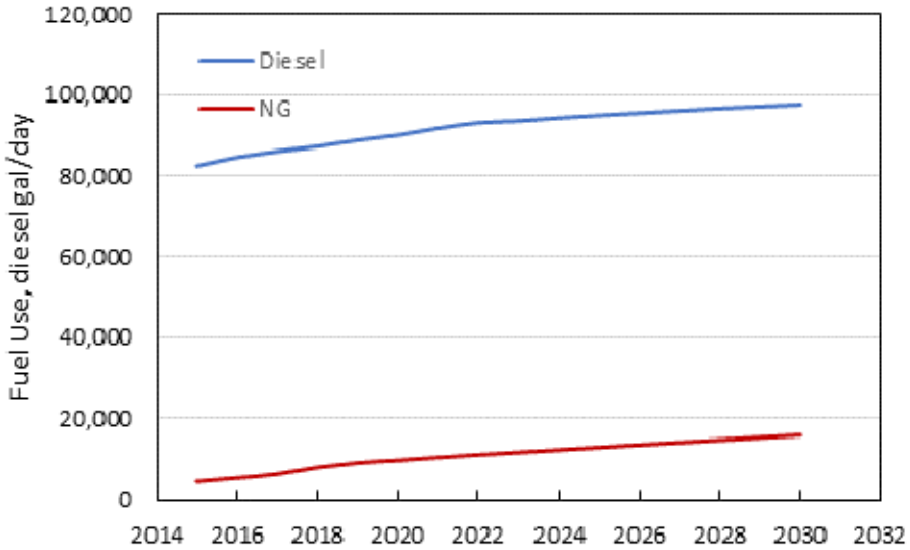


Figure 66. Analysis Upper Bound of Transportation NG Use in San Mateo County.



Estimating Fueling Infrastructure Needs

Achieving optimal public refueling accessibility requires planning on the part of public agencies, which have the power to incentivize construction in certain areas and can emphasize the need for even distribution of infrastructure. Desirable public refueling site qualities include:

- High residential density;
- High commercial density;
- Proximity to major roads and highways;
- Reasonable driving distance between refueling stations of the same type;
- Accessibility to low-density tourist destinations like beaches, parks, etc.

Each refueling location has its own maximum dispensing capacity, based on storage tank size and average dispensing time. For example, hydrogen refueling takes only about 5 minutes per vehicle, so hydrogen stations are not limited by dispensing time. But hydrogen fuel must be stored onsite and takes up a large amount of space, especially considering hydrogen setback requirements. Electric vehicle charging, on the other hand, can take between half an hour and several hours. However, no onsite storage is required since the station is simply connected to the electric grid.

In addition to these constraints, retailers are affected by the collective supply and demand balance. At the same time, drivers don't want to drive long distances to find fuel when they need it. An optimal siting plan will account for the total demand but ensure that refueling locations are geographically distributed in convenient locations without excessive distances between sites or over supply to any one area. Table 72 provides the estimated fuel use in San Mateo County in year 2030 as described in the previous section.

Table 72. San Mateo County Projected Fuel Volumes in 2030

Fuel	Units	Quantity
Gasoline (E10)	Million gal/yr as gasoline	185
Diesel	Million gal/yr as diesel	30
Ethanol	Million gal/yr as E10	18.5
	Million gal/yr as E85	1.7
CNG	Millon gal/yr as diesel	5.8
Electricity	Million gal/yr as gasoline	2.4
Hydrogen	Million gal/yr as gasoline	0.61
Biodiesel	Million gal/yr as diesel	1.2
RD	Million gal/yr as diesel	2.71
LPG	Million gal/yr as gasoline	0.01[1]

Table 73 shows the number of stations required to service the projected fuel volumes. Gasoline volumes are expected to decrease by a third by 2030, so we estimated that station demand would decrease by the same amount. Diesel stations for 2015 are based on an assumption that 55% of current gasoline stations contain diesel outlets. However, the number of diesel stations increases by 2030 based on the relative increase in diesel volumes expected. The infrastructure demand calculations for alternative fuels are described in the sections that follow.

Table 73. Infrastructure Demand in San Mateo County

Fuel Type	2015[2]	2030[3]
Gasoline	197	130
Diesel	109	125
Electricity[4]		
Level 1/2- Residential	3,408	27,603
Level 2- Work	222	3,350
Level 2- Public	152	222 to 370
DCFC	22	22
Hydrogen	0	5 to 8
Natural Gas	4	18
Bio-Diesel	1 (now sells RD)	5
Renewable Diesel	1	Blended into Diesel
Ethanol-85	1	5

[1] LPG volume calculated based on DMV data and held constant.
[2] AFDC, 2015. Alternative fueling station counts by state. http://www.afdc.energy.gov/fuels/stations_counts.html
[3] EMFAC model.
[4] Level 2 residential charging calculated based on assumption of 90% BEV owners and 30% PHEV owners. Includes number of individual charging ports instead of stations.

Gasoline, Diesel, and E85 Dispensing

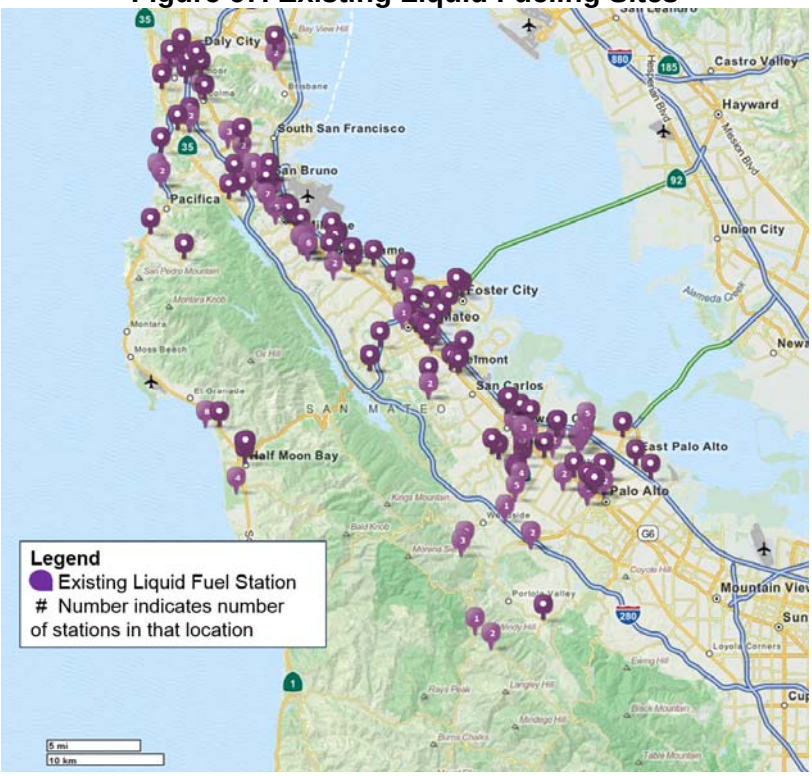
Due to reductions in projected VMT and improvements in fuel economy, a 33% decrease in gasoline consumption of gasoline is forecasted between 2015 and 2030. This likely means that up to one third of existing gasoline fueling stations may close.

The gasoline sold in California currently contains 10% ethanol. However, given decreasing gasoline sales and the ARB's estimates for ethanol production, E85 sales will have to increase in the year 2020 to make up the difference. The LCFS scenarios indicate that up to 13,000 gal/day of E85 could be consumed in the county. If we assume that it takes 30,000 gal/month for the E85 refueling equipment investment to be worthwhile, this corresponds to the addition of at minimum one E85 dispenser to 5 refueling stations in the county in 2030. If we utilize the California Clean Fuels Outlet Regulation (stipulates one station for every 300,000 gge/yr) then a total of 5 stations dispensing E85 would also be required.

Diesel fuel is currently available at about 55% of gasoline dispensing locations. However, total diesel volumes will increase from about 80,000 to 90,000 gallons per day in San Mateo County. Therefore, by 2030, demand will require an additional 16 diesel dispensers.

Because liquid fuels such as biodiesel, renewable diesel, and E85 can be dispensed from modified gasoline stations, currently existing gasoline stations are the most likely siting location for future liquid fuel dispensers. These sites are shown in Figure 67.

Figure 67. Existing Liquid Fueling Sites



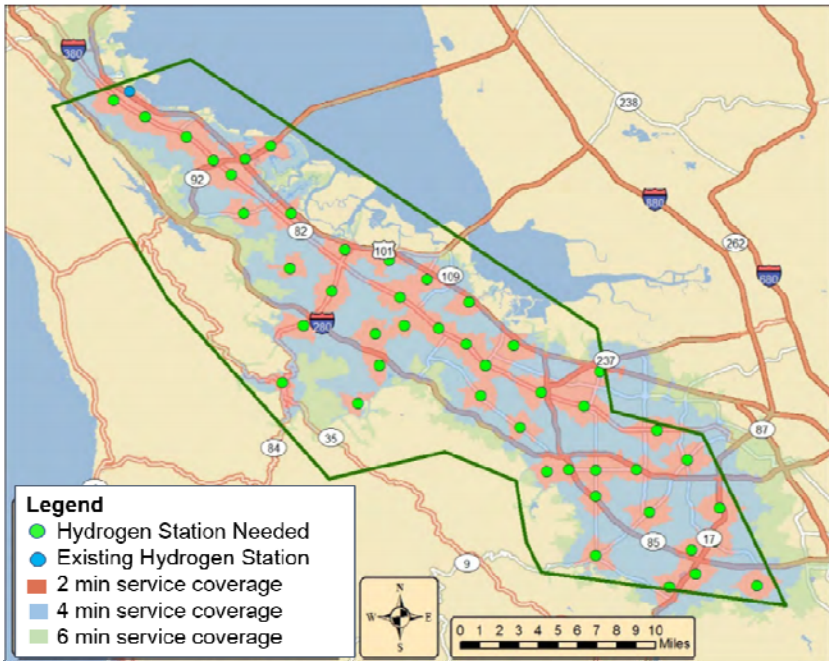
Source of site locations: Google, 2015. google.com/maps.

Hydrogen Fueling Stations

Hydrogen dispensers are typically installed on the property of an existing gasoline station. We assumed 1 dispenser per station and a monthly dispensing volume of 12,000 kg, or 400 kg per day. Given the volume of hydrogen projected for 2030, this results in a need for 5 or more stations. While there are no currently operating hydrogen stations, 4 are in development in San Mateo County already, and should open before the end of 2016. Given the slow increase in FCEVs expected, these stations should be sufficient for several years to come.

The CEC determined that the level of existing gasoline station coverage can be duplicated for hydrogen with only 13-21 % as many outlets, provided that the outlets were strategically located. For the South Bay Area, they recommend a total of 47 hydrogen stations, or 21.8% of existing gasoline stations. This would allow for a maximum of 6 minutes of travel time between stations. They also recommend that stations sited near residential areas be prioritized since 75% of refueling trips begin or end at the home (Brown, 2013). The analysis factored in median household income, population density, travel density, zoning and land use constraints, and planned and existing infrastructure. Figure 68 displays the hydrogen fueling locations recommended in the CEC's analysis. This map also shows coverage by driving time, giving the 2, 4, and 6 minute station driving range. While this map was specifically developed for hydrogen fuel, the coverage information can be applied to other fuels as well if a refueling density on par with gasoline is determined to be necessary for their successful implementation. However, the map in Figure 68 does not cover the full area of San Mateo County, which extends up to Daly City and all the way to the West coast.

Figure 68. Peninsula Hydrogen Station and Driving Coverage Map



Source: Brown, T., Stephens-Romero, S., Soukup, J., Manliclic, K., Samuelsen, S., 2013. The 2013 Strategic Plan for the Inaugural Rollout of Hydrogen Fueling Stations in California. doi:600-10-002

CNG Refueling

If we assume NG volumes consistent with ARB's LCFS scenarios, then by 2030 up to 5.8 million diesel gallon equivalents per year will be consumed in the county. According to the California Clean Fuels Outlet Regulation, one station is required for every 400,000 therms of NG dispensed. This corresponds to a total of 18 CNG refueling stations in the county.

Four CNG refueling stations in the county currently allow public access: PG&E stations in Daly City and San Carlos, a Clean Energy station at San Francisco Airport, and a Trillium station in Millbrae. This means that an additional 14 refueling stations will be needed by 2030.

Future demand for CNG is expected to be primarily truck fleet based. The majority of CNG infrastructure expansion will therefore happen in privately developed fueling stations that may or may not be open to public access, and thus are not shown on the siting maps below.

Electric Vehicle Supply Equipment

There are three main categories of Electric Vehicle Supply Equipment (EVSE):

- Residential Level 2
- Workplace and City Center Level 2
- Public fast charge stations.

Level 2 EVSE refers to 220 volt chargers. Publicly accessible EVSE is usually located where cars commonly park, such as city parking, airports, and retail parking lots. These locations are referred to here as city center EVSE. A significant number of EVSE are also located at workplaces. Table 74 summarizes the locations of publicly available EVSE in SMC at present (AFDC, 2015). The 128 workplace EVSE in Menlo Park are located at Facebook offices while most of the 58 stations in Millbrae are located at the airport. Approximately 60% of the level 2 EVSE is located at workplaces. Approximately half of the DC fast charge equipment is located at workplaces.

Table 74. Existing San Mateo County Publicly Accessible EVSE

City	Level 2		Level 3 (DC Fast Charge)
	Workplace	City Center	
Atherton	2		
Belmont	4		2
Brisbane	2		
Burlingame	5	4	
Colma	1		2
Daly City	4	2	2
Half Moon Bay		3	
Menlo Park	128	4	2
Millbrae		58	
Pacifica		1	1
Portola Valley	4	4	
Redwood City	51	23	8
San Bruno	4	16	
San Mateo	5	11	
South San Francisco	12	26	5
Total	222	152	22

Source: (AFDC, 2015)

For residential chargers, it is generally assumed that 90 % of BEV owners and 30 % of PHEV owners will purchase and install Level 2 chargers (CSE, 2013). Based on projected 2030 populations of BEVs (14,460) and PHEVs (34,429) populations this translates to a total of 23,343 residential Level 2 chargers installed by 2030.

For workplace charging equipment, a recent study by the National Renewable Energy Laboratories estimates that 15 % of the PEV population will utilize workplace charging with 2.4 charging sessions per day per unit (Melaina, 2014). In 2015, this formula results in 136 workplace chargers – at present there are 222. By 2030, this results in 3350 workplace chargers, a large increase.

The study also provides estimated densities for urban area EVSE under two scenarios: a home dominant charging scenario and a high public access scenario. Table 2 provides the number of chargers per 100 miles of urban area for each scenario. According to a GIS map of urban areas in San Mateo County,[1] approximately 175 square miles of land are classified as urban. Based on the CEC formula, there should be 222 level 2 chargers and 6 DC fast charge stations for the "Home Dominant" scenario and 370 level 2 EVSE and 12 DC fast chargers for the "High Public Access" scenario. According to Table 74 above, there are 152 public Level 2 EVSE in city centers and 22 DC fast charge stations at present, so approximately 70 more level 2 EVSE would be

[1] https://maps.smcgov.org/planning/

needed by 2030 to meet the "home dominant" scenario. As shown in Table 75, no more DC Fast charge equipment would be required to meet either CEC scenario.

Table 75. Urban Area EVSE per 100 square miles

	Home Dominant	High Public Access
Level 2 Public	127	294
DC Fast Charge Public	3.5	9.8

(Melaina, 2014)

Finally, the number of DC fast charge stations located along freeways provide an important link for EVSE coverage. The West Coast Green Highway plan is to locate DC fast charge EVSE every 25 to 50 miles along major highways (WA DOT, 2014). Highways 101 and 280 each run approximately 25 miles north-south through San Mateo County. Therefore the county would require 2 DC fast charge stations, one on each freeway. Highway 101 currently has at least one DC fast charge station, but Highway 280 has none. Figure 69 shows that publicly accessible EVSE is already quite widespread through San Mateo County. However, some gaps in coverage stand out. Fast chargers are present, but not evenly distributed. The only fast charger on Highway 1 is located in Pacifica. Highway 280 and its exits are completely devoid of fast chargers through San Mateo County, meaning that an EV driver who needed to refuel quickly would have to travel on to the 101 for fast charging to be an option. Level 1 and Level 2 public chargers are scattered all along Highway 101, but again are almost nonexistent if a driver has to travel to the west of 101. In the Home Dominant EVSE scenario, this may not be an issue, especially if workplaces continue adding charging stations that are accessible to commuters. However, it may be worth considering the need to add a few fast charging locations on the Western edges of San Mateo County's main highways and its coasts in case of emergencies.

Figure 69. San Mateo County EV Charging Sites

Source: http://www.plugshare.com/

Destination Locations

In addition to placing infrastructure in areas that are highly trafficked and densely populated, AFV drivers want to be able to travel to tourist destinations such as beaches, state parks, harbors, and shopping districts. This makes the vehicle a full service transportation option instead of just a commuting car.

Retail Approach

The retail approach differs slightly for each alternative fuel. Gasoline fuel volumes are expected to decrease, and the retired stations and pumps will most likely be converted to other liquid fuels, such as E85, biodiesel, or renewable diesel. Regular diesel pumps may dispense a blend of diesel and RD or BD, with a few dedicated specialty pumps for very green consumers. Propane vehicle populations are not expected to grow, so the current system of mixed use propane dispensers should be sufficient, although county jurisdictions may want to encourage installation of a dedicated vehicle dispenser so as to capture road taxes from fueling. The majority of natural gas in vehicles is expected to be used for fueling of medium- and heavy-duty fleet trucks, which require its higher energy density and driving range. These vehicles will be fueled by private dispensers, which if opened to public access should be sufficient to serve all the NGV demand. Plug-in electric vehicle populations are expected to grow, and EVSE will be needed in all of the places drivers may want to go: work, highways, destinations such as beaches or parks, and residences. Hydrogen dispensers are expected to be installed primarily in large gasoline stations with sufficient setback distances and zoning approval. See Table 76 for retail approaches.

Table 76. Alternative Fuel Retail Approach

Fuel		Retail Strategy	Volume Source
Blended Fuels	Gasoline	Declining sales. Keep existing stations.	EMFAC 2014
	Diesel	Modest growth in sales. Convert dispensers as volume increases.	EMFAC 2014
	E10	Continue blending into gasoline as 10% of E10 gasoline.	CEC IEPR
	E85[1]	Install more dedicated pumps in existing stations. Storage tanks can already accommodate. 2% of gasoline sales as E85 in retail gasoline stations	VISION/EMFAC 2014
	Biodiesel[2]	Convert dispensers as volume increases. Blend with diesel at 4%. Limited high level blends at retail stations.	EMFAC 2014/LCFS
	Renewable Diesel[2]	Convert dispensers as volume increases; blend with diesel	
Dedicated Fuels	EVSE[3]	Require EVSE capacity in new buildings. Install Level 2 EVSE in commercial spaces and workplaces and Level 2 EVSE for residential as needed.	EMFAC/ZEV Mandate CEC PEV Report, 2014
	Hydrogen[3]	Integrate into existing retail gasoline stations with sufficient available space Hydrogen will replace some gasoline demand.	EMFAC/ZEV Mandate CEC H2 Strategic Plan, 2013
	CNG[4]	CNG stations will be co-located with private fleets but should be made publicly accessible.	VISION/EMFAC
	LPG	LPG is dispensed at retail stations for cylinder and vehicle refills. Installation of a vehicle dedicated dispenser would allow CA to collect road tax.	Assumes constant vehicle population.

1. Used CA ratio of E85 to gasoline from CEC IEPR.
2. Projection for CA BD/RD assumes 2020 blend % from ARB LCFS Scenario remains constant from 2020 to 2030.
3. Projection for CA Electricity and Hydrogen assumes LCFS consumption increases linearly from 2020-2030.

CHAPTER 9:
Conclusions & Next Steps

San Mateo County will be the site of significant growth in alternative fuel demand in the years to come. Cities and the County will be far more prepared for this increase if they consider in advance the impacts that a transition from fossil fuels to alternative fuels may have locally. The first step is to understand the current state of alternative fuels in California and San Mateo County: what are alternative fuels and how are they used in vehicles; what incentives are available for them; how are they currently regulated. The second step is for each government entity to consider the role it chooses to play in the integration of alternative fuel into the local vehicle mix. What policies and incentives should be offered to make alternative fuels more available and appealing? Third, it is necessary to assess the local influx of alternative fuels that is expected in the coming years based on regulatory models and state goals. With this knowledge, cities can develop siting and zoning plans to ensure sufficient coverage of each fuel. And last but not least, cities need to communicate these plans and this knowledge to residents, investors, and the community at large.

The implementation of the Alternative Fuel Readiness Plan for San Mateo County will depend on cities and residents taking this information and applying it in neighborhoods, businesses, and government policies. The course of action that is right for a given community or individual will vary, but we recommend the following as possible next steps for implementing the Plan:

1. Educate and train government staff on issues related to alternative fuels regulation.

- Review guidelines for streamlined permitting, such as developing checklists and templates, arranging pre-submittal meetings, allowing online submission of permits, and streamlining processing procedures.
- Adopt and become familiar with existing standards for alternative fuel infrastructure stations, including those from National Fire Protection Association, California Code of Federal Regulations, and any local codes or standards.
- Review California's Title 24 Green Building Code. The 2013 Green Building Code currently applies throughout the state, but sections of it were most recently updated as of July, 2015, including those that deal with electric vehicle capacity and parking. Staff should receive training to ensure that they are familiar with the most recent updates.
- Review signage requirements for refueling stations and parking spots, including maximum number of allowable signs at stations and surrounding area and approved signs per CA Department of Transit Traffic Operations Policy Directive 13-01.

2. Implement outreach and marketing strategies specified in the Plan.

- Create a webpage on city or County website with information and useful resources about alternative fuels. Include background information, grants, incentives, funding opportunities, and links to coalitions and advocacy groups.

- Organize community events, such as workshops on alternative fuel vehicle options and incentives, Earth Day Festivals, and Ride and Drive demonstration events.
- Introduce educational events at K-12 schools to introduce children to alternative fuels.
- Distribute brochures about alternative fuels at relevant gatherings.

Introduce initiatives to increase alternative fuel vehicle use in San Mateo County fleets.

- Coordinate with other agencies to develop aggregate purchase orders.
- Identify funding opportunities from BAAQMD, CARB, CEC, DOE, etc. for building refueling infrastructure, purchasing vehicles, or converting organic feedstocks into biomethane.
- Perform environmental cost benefit analyses for different AFV options based on individual fleet needs (range, capacity, overnight storage)
- Include green procurement requirements in contracting evaluation.

Explore public-private partnership opportunities.

- Build refueling stations on public land and outsource construction and maintenance to a private company.
- Purchase or lease fleet vehicles from a retailer who can capture the federal tax incentive for PEVs and pass on savings.
- Explore options for converting potential feedstocks (e.g. landfill gas, waste water, or municipal waste) into alternative fuels for use in vehicles. The sale of LCFS credits can help to offset the cost of infrastructure. Construction and technology may be leased or purchased from private company, additional funding may be available from public sources.
- Consider the possibility of partnering with companies that can fund infrastructure development through the sale of advertising space.

Acronyms

AB	Assembly Bill
ABAG	Association of Bay Area Governments
ADA	Americans with Disabilities Act
AF	Alternative fuel
AFI	Alternative fuel infrastructure
AFV	Alternative fuel vehicle
AHJ	Authority having jurisdiction
AQIP	Air Quality Improvement Program
ARB	Air Resources Board
ARFVTP	Alternative and Renewable Fuel and Vehicle Technology Program
ATVMLP	Advanced Technology Vehicles Manufacturing Loan Program
B20	Biodiesel 20%
BAAQMD	Bay Area Air Quality Management District
BD	Biodiesel
BEV	Battery electric vehicle
Btu	British thermal unit
C/CAG	City/County Association of Governments of San Mateo County
CA	California
CAFÉ	Corporate Average Fuel Economy
CAP	Climate action plan
CARB	California Air Resources Board
CEC	California Energy Commission
CEQA	California Environmental Quality Act
CFR	Code of Federal Regulations
CI	Carbon intensity
CNGV	Compressed natural gas vehicle
CO_2e	Carbon dioxide equivalents
CSE	Center for Sustainable Energy
CVRP	California Vehicle Rebate Project
DGS	Department of General Services
DOE	Department of Energy
E85	Ethanol 85%
EISA	Energy Independence and Security Act
EM	Electric motorcycle
EMFAC	on-road vehicle emission factors model
EO	Executive order

EPA	Environmental Protection Agency
EV	Electric vehicle
EVSE	Electric vehicle supply equipment
FCEV	Fuel cell electric vehicle
FFV	Flexible fuel vehicle
GHG	Greenhouse gas
GREET	Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation
HEV	Hybrid electric vehicle (not plug in)
HOV	High occupance vehicle
HVIP	Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project
ICEV	Internal combustion engine vehicle
IEPR	Integrated Energy Policy Report
IRS	Internal Revenue Service
kg	Kilogram
LCA	Life cycle assessment
LCFS	Low Carbon Fuel Standard
LCI	Life cycle inventory
LNGV	Liquefied natural gas vehicle
LPGV	Liquefied petroleum gas vehicle
MOU	Memorandum of understanding
mpg	Miles per gallon
MPO	Metropolitan Planning Organization
MTC	Metropolitan Transportation Commission
MUD	Multi-unit dwelling
NAFTC	National Alternative Fuels Training Consortium
NFPA	National Fire Protection Association
NGV	Natural gas vehicle
NREL	National Renewable Energy Laboratory
OEM	Original equipment manufacturer
PEV	Plug-in electric vehicle
PG&E	Pacific Gas & Electric
PHEV	Plug-in hybrid electric vehicle
RD	Renewable diesel
RFS2	Renewable Fuel Standard (United States) version 2
SB	Senate bill
SCS	Sustainable communities strategy
SMC	San Mateo County
TOU	Time-of-use
TZEV	Transitional zero emission vehicle

U.S.	United States
UBC	Uniform Building Code
UFC	Uniform Fire Code
V	Volts
WTT	Well-to-tank
WTW	Well-to-wheels
WWTP	Waste waster treatment plant
ZEV	Zero emission vehicle

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Appendix A.
PG&E Time-of-Use EV Rate Plans

PG&E has developed rate plans that are specifically designed to address the needs of customers who are charging electric vehicles. Different rate plans apply to residential versus commercial/government entities. This Appendix describes the various rate plan options that are being offered by PG&E to address the different needs of their EV customers.

There are two basic types of rate plans offered by PG&E. The first is a flat rate program, where the rate stays constant throughout the day, with different prices charged in the summer versus the winter months. The second type is a time of use (TOU) program, where electric charges vary based on the time of day and the season. Prices are higher during summer weekday afternoons when electric demand is higher, typically noon to 6 p.m., May through October. In return, time-of-use rates are lower at all other times. Time of use plans are available to all customers. E1 is the default general tiered rate plan for residential customers, and E6 and E7 are the default TOU residential plans.

However, PG&E also has two rate plans that are specifically designed for buildings that have electric vehicle charging units installed and want to be able to charge them at night at a lower cost, EV-A and EV-B. As of a 2012 survey, 84% of PG&E PEV owners were using TOU plans at home (CSE for ARB, 2013). EV-A rates apply to customers who have only one meter for the entire house. This kicks the house into higher rate charges than it would typically see without EV charging, but lower rates than would be charged if the EV unit was on a residential plan. EV-B rates are for customers who have made the investment to install a second meter dedicated to the EV charging unit. The household meter remains on a residential plan. The EV-B rate plan generally incurs a lower monthly bill than EV-A plan, but may not be worth the up-front investment. According to PG&E, the cost of installing electrical equipment for a second meter ranges from $1,000 to $3,000. The second meter itself costs $100.

There are environmental benefits from charging during off-peak hours. These are the times with lowest electric grid load. In California, nearly 100% of the marginal electricity, that which is added at high peak load times, comes from natural gas. However, natural gas electric generation efficiency ranges from about 30% efficiency to 50% efficiency (CSE for ARB, 2013). The lower efficiency natural gas plants are added at times of peak electricity consumption. Charging PEVs during off-peak periods can reduce GHG emissions from PEV charging by anywhere from 15-50% (CSE for ARB, 2013).

Different rates are charged in the summer, winter, and during peak, partial-peak, and off-peak times. The dates and times are as follows:

Summer (service from May 1 through October 31):
Peak: 1:00 p.m. to 7:00 p.m. Monday through Friday
Partial-Peak: 10:00 a.m. to 1:00 p.m. AND 7:00 p.m. to 9:00 p.m. Monday through Friday
Plus 5:00 p.m. to 8:00 p.m. Saturday and Sunday
Off-Peak: All other times including Holidays.

Winter (service from November 1 through April 30):
Partial-Peak: 5:00 p.m. to 8:00 p.m. Monday through Friday
Off-Peak: All other times including Holidays.

Table 77. PG&E Time Of Use Rate Schedules

Rate Schedule	Season	Time-of-Use Period	Energy Charge [2/] ($/kWh)				
Summer: May-Oct Winter: Nov-Apr			**Tier 1** (Baseline)	**Tier 2** (101-130% of baseline)	**Tier 3** (131-200% of baseline)	**Tier 4** (201-300% of baseline)	**Tier 5** (Over 300% of baseline)
Residential Time-of-Use Schedule E-6 and Rate Schedule EM-TOU [6/]	Summer	Peak	$0.31247	$0.33568	$0.42309	$0.48309	$0.48309
		Part-Peak	$0.19720	$0.22041	$0.30782	$0.36782	$0.36782
		Off-Peak	$0.12042	$0.14364	$0.23104	$0.29104	$0.29104
	Winter	Part-Peak	$0.14159	$0.16480	$0.25221	$0.31221	$0.31221
		Off-Peak	$0.12476	$0.14797	$0.23538	$0.29538	$0.29538
			(No Tiers for EV-A or EV-B Plans)				
Residential Time-of-Use Service for Plug-In Electric Vehicle, Schedule EV, Rate A	Summer	Peak	$0.42586				
		Part-Peak	$0.22374				
		Off-Peak	$0.09826				
	Winter	Peak	$0.29179				
		Part-Peak	$0.17179				
		Off-Peak	$0.10115				
Residential Time-of-Use Service for Plug-In Electric Vehicle, Schedule EV, Rate B	Summer	Peak	$0.42030				
		Part-Peak	$0.22096				
		Off-Peak	$0.09786				
	Winter	Peak	$0.28582				
		Part-Peak	$0.16880				
		Off-Peak	$0.10072				

Appendix B.
Alternative Fuel Case Studies

Case Study 1: Propel Fuel Retail Stations

Alternative Fuels: E-85, B-20, B-99, HDR

Founded: 2004

Scope: 43 Flex Fuel & 36 advanced diesel locations across CA and WA; 1 station in San Mateo County (Redwood City).

Funding Source: Venture Capital, Private Investment

Business Model for Site Development:

- Clean Fuel Point Program- Propel leases a portion of existing station and builds, operates, and manages its fuel dispenser at no cost to host.
- Branded Supply Program- Host adds Propel fuels to its suite and pays for construction and maintenance, but recoups costs from profits on sales.

Business Model for Fuel Retail:

- Any flexible fuel vehicle owner or diesel vehicle owner can purchase fuel.
- Clean Drive membership allows users to track decreased environmental impacts.

Decision Factors for Station Development:

- Permitting Speed: prefer cities that are ready for alternative fuels versus cities that are not.
- Installation requirements: prefer to retrofit and convert existing tank for storage instead of installing new underground tank.

Issues encountered:

- Long lead time for canopy permitting (> 1year). Conditional use permit not granted at first.
- State requires signs for every fuel sold, while city puts limits on number of allowed on-site signage: Propel maxed out signage and had to put up paper signs.
- Difficulties dealing with Certified Unified Program Agencies, especially if enforced by fire department: One local arm of CUPA required Propel to put a UL certification sticker on its above ground fueling station, even though CUPA regulates things below the ground.

Recommendations for cities:

- Decrease permitting time to 6 month or less.
- Align city and state signage requirements.

Case Study 2: South San Francisco Scavenger Company - CNG Production

Alternative Fuel Produced: Biogenic Compressed Natural Gas (CNG) for waste collection vehicles

Constructed: 2014

Scope:

- Transforms 11,200 tons of yard and food waste to 100,000 diesel gallon equivalents per year
- Fuels 10 of its waste collection trucks daily

Funding Sources:

- California Energy Commission: $2.6M
- Sales tax exemption: $400k
- Fuel savings: $400k

Technology Used:

- Dry anaerobic digestion by Zero Waste Energy, LLC
- CNG fueling station by Clean Energy Fuels Corp

Reasons for Installation of Biodigester:

- Environmental regulatory obligations
- Decided to make a transport fuel instead of feeding electricity to the grid because truck fuel accounts for ~70% of the operation's GHG emissions.

Issues encountered:

- Construction took 8-9 months; whole process took 2-3 years.
- Fire permitting required that they install sprinklers over the digester canopy and a fire hydrant in spite of existing safety measure at facility and low methane emissions.
- California Environmental Quality Assessment permitting review was required and had to be completed prior to applying for CEC grant.

Recommendation for cities:

- Make sure city and county officials are well-educated on alternative fuels and permitting issues.
- Don't increase costs of construction with unnecessary delays or additional requirements.

Case Study 3: San Mateo Waste Water Treatment Plant

Alternative Fuel: Biogenic Compressed Natural Gas (CNG) for vehicles

Expected to be Operational: 2016

Scope:

- Inputs of ~90,000 gallons municipal waste water treatment solids per day
- Produces and converts 100 ft^3/minute of biomethane → amounts to 160k diesel gallon equivalents annually
- Will fuel 40 city trucks
- Reduces carbon emissions by approximately 45,400 metric tons CO_2e, over a 25-year period

Funding Sources:

- California Energy Commission: $2.45M
- City of San Mateo Match Funding: $2.45M
- Fuel savings for City of San Mateo: $700k

Technology Used:

- Unison Solutions, Inc. brand anaerobic biogas digester and scrubber that removes contaminants and carbon dioxide to produce biomethane that meets the SAE J1616 fuel standards.
- Onsite storage and compression of biomethane fuel.

Reasons for Installation of Biodigester:

- Pilot project to demonstrate feasibility to other waste water treatment facilities.
- Replaces petroleum based fuels for city fleets and ultimately leads to savings for City of San Mateo.

Issues encountered:

- New city permits were not required nor were a California Environmental Quality Act review. This is primarily because they already have permits for biodigestion and biogas flaring.

Recommendation for cities:

- Waste water treatment facilities in other cities should consider the possibility that biogas could be converted to CNG for city fleets.

Appendix C.
Life Cycle Carbon Intensities of Alternative Fuels

Fuel Pathway	CI g/MJ LHV Basis	Comment
CARBOB	99.78	From Table 6 of 2015 LCFS Regulation Order[1]
CaRFG	98.47	From 2015 LCFS Regulation Order[1]
Diesel	102.01	From Table 6 of 2015 LCFS Regulation Order[1]
Electricity, 33% renewable	105.16/3.4 = 30.93	From Table 6 of 2015 LCFS Regulation Order[1]
Hydrogen, Bio-NG reforming	88.33/2.5 = 35.33	From Table 6 of 2015 LCFS Regulation Order, on-site NG reforming with renewable feedstocks[1]
Hydrogen, electrolysis	(105.91*.66*1.5) /2.5 = 42.32	Assumes efficiency of 66% for electrolysis processing. Power grid is assumed to be 33% renewable.
Fossil CNG/LNG	76	Average from UC Davis LCFS Status Report Dated April 2015[2]
Renewable CNG	29	Average of HSAD, WWT and LFG CI values in Table 6 2015 LCFS Regulatory Order[1] weighted by number of existing pathways in each category.
Corn Ethanol	75.97	From Table 7 of 2015 LCFS Regulation Order[1]
Sugarcane EtOH	56.66	From Table 7 of 2015 LCFS Regulation Order[1]
2nd Gen EtOH	20	Based on Abengoa LCFS pathway document
Biodiesel from Plant Oil	56.95	From Table 7 of 2015 LCFS Regulation Order[1]
BD Waste Oil	23	2014 volume weighted average of UCO and tallow[4]
2014 BD Avg	23	2014 volume weighted average for BD
RD	23	Average from UC Davis LCFS Status Report Dated April 2015[2]

1. CARB, July 2015. Proposed third LCFS 15-day regulation order. http://www.arb.ca.gov/regact/2015/lcfs2015/lcfs15appa.pdf
2. Yeh, S. & J. Witcover, J. Bushnell. 2015. Status Review of California's Low Carbon Fuel Standard April 2015 Issue (REVISED VERSION). UCD-ITS-RR-15-07. http://www.its.ucdavis.edu/wp-content/themes/ucdavis/pubs/download_pdf.php?id=2491.
3. Corn ethanol volumes by CI from ARB Quarterly Data Report
4. BD volumes from ARB Quarterly Data Report, CI values are averages of all current pathways (UCO = 20, tallow = 43).

Appendix D.
Sample Resources for Alternative Fuel Website

Background Information

Alternative Fuel Readiness Plan for San Mateo County

Alternative Fuels Data Center: Information Source for Alternative Fuels and Advanced Vehicles

A guide to understanding the well-to-wheels impact of fuel cell electric vehicles

Grant Opportunities and other Current Incentives

BAAQMD Grants for Light Duty EVs in Fleets

BAAQMD Grants for Heavy Duty EVs

BAAQMD Grants to Install EV Supply Equipment

California Clean Vehicle Rebate Program (up to $5,000 per vehicle)

Federal EV Tax Credit (up to $7,500 per vehicle)

PG&E EV Rate Information

Resources for City Agencies

Clean Cities Tools: Tools to help you save money, use less petroleum, and reduce emissions

How Do Communities Become PEV Ready?

A Guide to EV Ready Communities

Resources to help cities organize and run local EV events

Tips for Scheduling PEV Ride and Drive Events (including Ride and Drive checklist, Evite example, press release example, liability waiver example)

Form Partnerships to Reduce Petroleum Use in Transportation

Resources for San Mateo County Fleets

Case studies and success stories about alternative transportation technologies and fuels

Business Case for Compressed Natural Gas in Municipal Fleets

Experiences with Compressed Natural Gas in Colorado Vehicle Fleets

Case Study - Compressed Natural Gas Refuse Fleets

Case Study - Propane School Bus Fleets

Resources for Emergency Responders (Training and Safety)

General safety training resources

Basic response guides and case study examples from biofuel spills

Information on Biodiesel and Ethanol

ETANKFIRE Ethanol Tank Fire Fighting (methodology for suppression of tank fires containing ethanol fuels)

Ethanol & Biodiesel Response Considerations - Training Materials and Videos

Training Guide to Ethanol Emergency Response

2012 Emergency Response Guidebook: A Guidebook for First Responders

2012 Emergency Response Guidebook Mobile App

Courses & Workshops from the National Alternative Fuels Training Consortium (NAFTC)

First Responder Quick Reference Guide 2014

For more specific resources on EV, natural gas, and hydrogen, please refer to the chapter on Training and Safety in the Plan.

Information on Alternative Fuel Vehicles

Electric Vehicles

How do PEVs Benefit California?

What are the Benefits of Driving a PEV? What cars are Available?

PEV Charging: Where and When?

Fuel Costs: PEVs Vs. Gasoline Cars?

PEV Batteries: Safety, Recycling and Re-Use?

Electric Vehicles 101

How Fuel Cell Electric Vehicles (FCEV) Work

Flexible Fuel Vehicles

FlexFuel FAQ

Ethanol Fact Sheet

Biodiesel Vehicles

Biodiesel Fact Sheet

Biodiesel FAQ

Natural Gas Vehicles

Compressed Natural Gas Fact Sheet

Liquefied Natural Gas Fact Sheet

Resources for Consumers

Useful Tools

Driveclean.ca.gov (Buying guide to clean and efficient cars/ helps you find incentives)

AltFuelPrices.com (Find prices and locations of AFV refueling or recharging stations)

FuelEconomy.gov (Mileage and cruising range information on most AFVs, including a simple cost calculator)

Incentives

BAAQMD Vehicle Buy Back Program for Individuals

California Clean Vehicle Rebate Program (up to $5,000 per vehicle)

Federal EV Tax Credit (up to $7,500 per vehicle)

PG&E EV Rate Information

Resources for Businesses and Private Fleets

Guides/ Strategies

Workplace Charging: Why and How?

Workplace Charging Tip Brochure

EV Fleet Deployment Strategies

Why and how to organize workplace PEV Ride and Drive Events

Incentives

California Clean Vehicle Rebate Program (up to $5,000 per vehicle)

Federal EV Tax Credit (up to $7,500 per vehicle)

PG&E EV Rate Information

Case Studies

FedEx on Lessons Learned from Global EV Deployments

PG&E on how Electrification is Saving its Fleet Money Today

Facebook Workplace Charging

SuperShuttle CNG Fleet Study Summary

Business Case for Compressed Natural Gas in Fleet Applications

Compressed Natural Gas Refuse Fleets

Propane School Bus Fleets

Articles

SunRidge Farms buys AFVs as part of an overall strategy to go green

AT&T Announces Deployment of Its 4,000th AFV

Resources for Multi-Unit Dwellings

How do Multi-unit Dwellings Become PEV Ready?

PEV Charging Infrastructure Guidelines for Multi-unit Dwellings

Multi-unit Dwelling Tip Brochure

PG&E EV Rate Information

Appendix E.
Alternative Fuel Brochure Template

C/CAG

XY.Z % decrease
in CO2 emissions compared to conventional fuels

Alternative Fuels

The Future of Driving

Alternative fuel technologies are becoming a viable alternative to conventional fuels. No longer are Alternative fuel vehicles a transportation mode for just a few environmentally conscious people. They are a mainstream effort to reduce human impact on the environment. You too, can be part of this effort!

Alternative Fuel Options

Several options are available to choose from when purchasing an alternative fuel vehicle:

- Electric
- Hydrogen
- Ethanol (Flex Fuel Vehicles)
- Biodiesel
- Compressed Natural Gas
- Liquefied Petroleum gas

Energy Security

Produced from a variety of renewable resources, such as *plant oils, fats, grass, landfill gas and even waste*, Alternative Fuels are very diverse and reduce our dependence on fossil fuels.

Powered by Life Cycle Associates

C/CAG

Benefits of Using Alternative Fuels

Economic benefits

Purchase incentives for zero-emission and clean-fuel vehicles
Reductions in vehicle license fees
Reduced fuel costs over time
Energy security and stable fuel prices

Environmental benefits

Reduction of emissions that impact air quality and health

Performance benefits

Energy economy ratio (EER) of 3.4 for electric vehicles

Convenience benefits

Carpool lane access which reduces commuting time

Free and preferred parking options in public garages, government buildings, higher education institutions, and at work

Option to use ethanol or gasoline in FFVs

Increasing fuel station availability

What's Next?

To learn more about alternative fuel vehicles, check out the Alternative Fuel Section of [City of xyz] website at [*website address*]. There, you will find many resources on alternative fuels including information on each alternative fuel type, fact sheets and user guides, links to incentive programs, useful tools like the alternative fuel station locator, and case studies about alternative fuels used in a business context

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