Alternative and Renewable Fuel and Vehicle Technology Program

DRAFT FINAL PROJECT REPORT

# Alternative Fuel Readiness Plan for San Mateo County: Summary Report

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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 City/County Association of Governments of San Mateo County (C/CAG) 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

The City/County Association of Governments of San Mateo County (C/CAG), as the County's Congestion Management Agency (CMA) responsible for transportation planning has undertaken the preparation of an Alternative Fuel Readiness Plan for San Mateo County (Plan). This document serves as a resource and provide guidance to San Mateo County jurisdictions, which includes the 20 cities and unincorporated County, public agencies, private companies, and individuals regarding the increased use and incorporation of alternative fuel vehicles and alternative fuel infrastructure in communities within San Mateo County. This Plan provides an overview of each alternative fuel in the marketplace and presents the motivations for having an alternative fuel readiness plan, including existing legislation and incentives, environmental benefits, and economic factors. The growth of the alternative fuel market depends on the availability of 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 shows a projected decline in gasoline demand. 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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# 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 Resource Board |
| 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 |
| CAFE | 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 equivalent |
| 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 |
| HOV | High occupancy 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 |
| LCFS | Low Carbon Fuel Standard |
| 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 (U.S.) version 2 |
| SB | Senate bill |
| 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 water treatment plant |
| ZEV | Zero emission vehicle |

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# 1. Need for Alternative Fuel Readiness Planning

Transportation accounts for nearly 40 percent of California's total energy consumption and roughly 39 percent 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. 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.

Alternative fuel vehicles (AFVs) offer an important option for reducing GHG emissions. Alternative fuels allow for the continued convenience of personal vehicles, buses, and trucks, while reducing the environmental impacts from motorized transportation. Recognizing the need for addressing environmental impacts caused by transportation fuels, and in the interest of preparing for a fast growing AFV industry, C/CAG has undertaken the preparation of an Alternative Fuel Readiness Plan for San Mateo County (the Plan). The intent of this document is to serve as a resource and guide to jurisdictions, public agencies, private companies, and individuals regarding the implementation of AFVs and alternative fuel infrastructure (AFI) in San Mateo County.

## Legislative Background

The State of California has enacted a series of laws and executive orders over the past decade to support 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 (ZEV) population goals, and renewable electricity requirements. The passage of SB 350 in 2015 (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.

California's climate change goals 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 ARB appointed SB 375 goal of a 7% per capita reduction in GHGs from cars and light-duty trucks by 2020. California's various targets are summarized in Figure 1.

**Figure 1. Major Goals and Targets for Greenhouse Gas Reductions in California**

| | |
|---|---|
| GREENHOUSE GAS EMISSIONS | • 2020: GHGs reduced to 1990 levels [1]<br>• 2030: GHGs reduced to 40% below 1990 levels [6]<br>• 2050: GHGs reduced to 80% below 1990 levels [2] |
| SUSTAINABLE COMMUNITIES | • 2010: ARB sets reduction goals for metropolitan areas [3]<br>• 2020: Metropolitan areas meet 1st GHG reduction targets [3]<br>• 2035: Metropolitan areas meet 2nd GHG reduction targets [3] |
| ZERO EMISSION VEHICLES | • 2015: Metropolitan areas have infrastructure plans for ZEVs [4]<br>• 2020: California infrastructure supports 1 million ZEVs [4]<br>• 2025: 15% of new cars sales are ZEVs, 1.5 million ZEVs total on roads [4]<br>• 2050: Transportation GHGs are less than 80% of 1990 levels [4] |
| RENEWABLE ELECTRICITY | • 2013: 20% of electricity from renewable sources [5]<br>• 2020: 33% of electricity from renewable sources [5]<br>• 2020: 12,000 Megawatts of new electricity generated after 2010 [5]<br>• 2030: 50% of electricity from renewable sources [6] |
| GREEN STATE BUILDINGS | • 2018: State agency energy purchases 20% less than 2003 [7]<br>• 2020: State agency GHGs 20% less than 2010 levels [7]<br>• 2025: 50% of state agency buildings will be Zero Net Energy [7]<br>• 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
2. Schwarzenegger, A. 2005. Executive Order S-3-05. http://gov.ca.gov/news.php?id=1861.
3. Sustainable Communities and Climate Protection Act of 2008 (SB 375, Steinberg, Statutes of 2008). http://www.leginfo.ca.gov/pub/07-08/bill/sen/sb_0351-0400/sb_375_bill_20080930_chaptered.html.
4. Brown, G. 2012. Executive Order B-16-12. http://gov.ca.gov/news.php?id=17472.
5. California Renewable Energy Resources Act (SBX1 2, Simitian, Statutes of 2011). http://www.leginfo.ca.gov/pub/11-12/bill/sen/sb_0001-0050/sbx1_2_bill_20110412_chaptered.html.
6. SB 350, De León. Clean Energy and Pollution Reduction Act of 2015.
7. Brown, G. 2012. Executive Order B-18-12. http://gov.ca.gov/news.php?id=17508
8. AB 341, Chesbro, Statutes of 2011. http://www.leginfo.ca.gov/pub/11-12/bill/asm/ab_0301-0350/ab_341_bill_20111006_chaptered.html.
9. Brown, G. 2015. Executive Order B-30-15. https://www.gov.ca.gov/news.php?id=18938

San Mateo County jurisdictions and government agencies may be subject to additional emission reduction targets from 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). Additional statewide requirements might include road taxes, signage requirements, and comprehensive GHG reporting. New climate change goals will be

easier to achieve if San Mateo County cities are already well-educated on alternative fuels and have strategies in place for their increased use. Alternative fuel readiness requires a comprehensive understanding of the:

- Current availability of alternative fuels in San Mateo County
- Number of vehicles and amount of alternative fuel demand that can be expected in the future
- Range of potential new policies, strategies, and educational plans to address the changing landscape of alternative fuel vehicle use

Integrating alternative fuels into current practices will require overcoming a number of obstacles, including differences in cost from fossil fuels, technical issues such as availability of fueling infrastructure, adaptation of rules and regulations to alternative fuels, and education of consumers and government officials on the benefits of and incentives for alternative fuels. This plan provides information to address these challenges.

## Scope of the Plan

This Summary Report covers the main points from the full version of the Alternative Fuel Readiness Plan for San Mateo County, which addresses the following topics in depth:

- 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.
- Overview of alternative fuels and alternative fuel vehicles, including fuel production, vehicle operation basics, and fuel, vehicle, and infrastructure costs.
- Assistance strategies for infrastructure development, including vehicle population projections, fuel volume projections, minimum infrastructure requirements, and a siting plan for public stations.
- 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.
- Challenges to the growth of the AFV market and its supporting infrastructure, including economic challenges, regulatory challenges, and educational needs.
- Potential solutions to these problems and offer recommendations for the City and County of San Mateo to improve its readiness for AFVs and increase procurement.
- Training recommendations and resources that can help to prepare government employees and safety officials for the integration of AFVs and AFI in San Mateo County.
- Strategies for outreach and communication to San Mateo County stakeholders about alternative fuel readiness.
- Describes general conclusions and next steps that San Mateo County jurisdictions can take to implement the policies and changes recommended by the Plan.

Table 1 describes the contents of the full Alternative Fuel Readiness Plan Final Report, including the order of chapters and all appendices. Readers can consult this longer version of the Plan for additional depth of information about topics covered in this Summary Report.

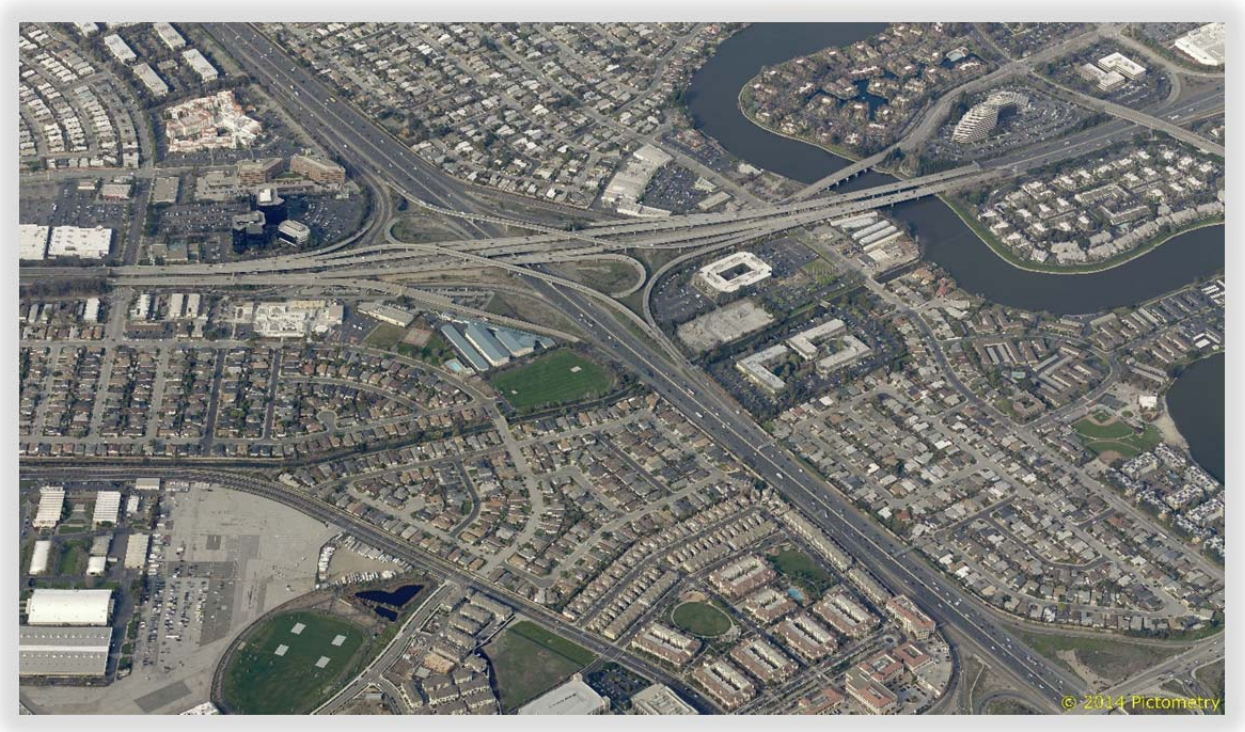
**Table 1. Contents of Full CEC AFRP Final Report**

| | |
|---|---|
| Chapter 1 | Introduction<br>• Legislative background<br>• San Mateo County context and factors |
| Chapter 2 | Overview of alternative fuels and alternative fuel vehicles<br>• Production of alternative fuels<br>• Use in vehicles<br>• Greenhouse gas emissions<br>• Incremental costs |
| Chapter 3 | Existing incentives and grant opportunities<br>• Federal programs<br>• State of California programs<br>• Local and regional programs |
| Chapter 4 | Challenges to alternative fuel vehicle deployment<br>• Economic<br>• Technical<br>• Regulatory<br>• Educational |
| Chapter 5 | Increased procurement strategies for alternative fuel vehicles<br>• Cost strategies<br>• Technical solutions<br>• Policy options<br>• Education and outreach |
| Chapter 6 | Training materials and resources<br>• Stakeholders<br>• Permitting<br>• Safety<br>• First responder training resources |
| Chapter 7 | Communication and outreach strategies<br>• Objectives<br>• Existing outreach and education programs<br>• Communication methods |
| Chapter 8 | Infrastructure development strategies for San Mateo County<br>• Projected vehicle populations<br>• Project vehicle miles travelled<br>• Projected fuel use<br>• Projected infrastructure needs |
| Chapter 9 | Conclusions and next steps<br>• Educate and train government staff<br>• Implement public outreach and marketing strategies<br>• Introduce policy initiatives to increase alternative fuel use<br>• Explore public-private partnership opportunities |

**Table 1. Contents of Full CEC AFRP Final Report (Continued)**

| | |
|---|---|
| Appendix A | PG&E Time of Use EV Rate Plans Description |
| Appendix B | Alternative fuel case studies: San Mateo County<br>• Case study 1: Propel fuel retail station in Redwood City<br>• Case study 2: South San Francisco Scavenger Company CNG production<br>• Case study 3: San Mateo waste water treatment plant CNG production |
| Appendix C | Life cycle carbon intensities of alternative fuels |
| Appendix D | Sample resources for alternative fuel webpage |
| Appendix E | Alternative fuels brochure template |

**Figure 2. Aerial Photo of San Mateo County**



# 2. Introduction to Alternative Fuels

Over the past decade, alternative fuels have been recognized as an important means of addressing three national and statewide challenges: the desire to lower carbon emissions, the need for greater national energy security, and rising or volatile oil prices. Increased popularity of alternative fuels has resulted in higher levels of infrastructure development as well as a wealth of technologies for alternative fuel transportation.

The most common alternative fuels include electricity, hydrogen, compressed natural gas, liquefied natural gas, liquefied petroleum gas, ethanol, biodiesel, and renewable diesel. Using these fuels instead of conventional fuels helps to reduce petroleum use, air pollution, and GHG emissions.

## Electricity

Plug-in electric vehicles (PEVs) operate on battery power with electric motors and are considered to be alternative fuel vehicles. The vehicles are either fully battery operated or plug-in hybrid with gasoline engines and hybrid power trains. In California, the majority of power plants run on natural gas, making its power grid relatively low in carbon intensity compared to that of other parts of the country. By 2020, California's electricity resource mix must be produced from 33% renewable sources such as wind, solar, and hydropower, which will bring the emissions profile for the CA grid down even more. Therefore electric vehicles charged in California, which have no tail pipe emissions, are much lower in GHG and air emissions than gasoline or diesel cars, especially given the efficiency of energy conversion in electric vehicles. PEVs can be charged at home, the workplace, or at public charging stations. Figure 3 shows the public charging stations in the Portola Valley Town Center.

**Figure 3. Electric Vehicle Charging at Public Station**

On average, plug-in hybrid electric vehicles (PHEVs) can travel on battery power alone for 15 to

35 miles, and 300+ miles in gasoline-electric hybrid mode. Typical battery electric vehicle (BEV) can travel between 70 and 100+ miles on a fully charged battery, although Teslas can travel 250 miles (CARB, 2015). By 2017, manufacturers are expected to produce three BEV models with driving ranges of 150 to 200 miles priced under $40,000: the Chevy Bolt, the Tesla Model 3, and the Nissan Leaf v2 (BACC, 2015). BEVs that have ranges up to 350 miles may be available later in the decade (Schorske, 2011).

Three primary types of electric vehicle supply equipment (EVSE) are used to charge electric vehicle (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. Level 2 chargers 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 BEV in about 20 minutes (DOE, 2013). Table 2 shows the typical charging times it takes to fully charge batteries for PHEVs and BEVs using different types of charging equipment. These 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.

**Table 2. 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.

## Hydrogen

Fuel cell electric vehicles (FCEVs) convert hydrogen fuel and break the molecules into protons and electrons to create an electric current. The electricity is then used to power the vehicle's motor, so the ultimate driving mechanism is electric power. Like BEVs, FCEVs do not emit tailpipe emissions. Fuel cell vehicles are 2 to 3 times more efficient than ICEVs (DOE, 2013; CARB, 2015). Most hydrogen fuel is currently produced by steam reforming of natural gas, although it can also be produced through electrolysis of water. Research efforts are under way to mimic photosynthesis and produce hydrogen fuel ($H_2$) directly from water (hypersolar.com, 2015).

In California, one third of the energy inputs for hydrogen fuel must be produced using renewable energy sources, such as wind, solar, or biomass. SB 1505 requires that on a statewide per-mile basis, well-to-wheel emissions of greenhouse gases for the average hydrogen powered vehicle in California are at least 30 percent lower than emissions for the average new gasoline vehicle in

California (Lowenthal, 2006).

Several hydrogen fuel cell vehicle models are or will soon be available on the U.S. commercial market. In June of 2014, Hyundai released the Tucson FCEV for consumer purchase. Toyota released its Mirai FCEV in 2015, and Honda launched a limited release concept FCEV called the Clarity in 2015. California's 2014 annual report found that 125 FCEVs are currently registered with the Department of Motor Vehicles (DMV), and projected that this will increase to 6,650 by 2017 and 18,500 by 2020. No FCEVs are currently sold in San Mateo County because no fueling stations are operating at this time. However, four stations are currently under development and should be open by the end of 2016.

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). Forty five 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.

## Natural Gas and Biogas

Natural gas vehicles use either liquefied or compressed natural gas (CNG) in a compression or spark- ignited engine. Between 80% and 90% of the natural gas used in the U.S. is domestically produced. Most natural gas is drawn from wells or extracted in conjunction with crude oil production. Natural gas can also be extracted from subsurface porous rock reservoirs through processes such as hydraulic fracturing (DOE, 2013).

Organic materials and other waste products provide a resource for renewable natural gas (RNG). This type of fuel has very low carbon intensity because the feedstock would otherwise be burned or landfilled. Biogas refers to methane produced from renewable feedstocks or waste sources, such as emissions from the biodegradation of landfill or waste water organic matter. Biogas is cleaned and converted to renewable natural gas, which is then burned in natural gas vehicles. Compressed natural gas (CNG) and liquefied natural gas (LNG) vehicles are most often operated by fleet owners, such as San Francisco International Airport's (SFO's) Super Shuttle. These fleets often maintain their own fueling stations.

Natural gas vehicles can be either bi-fuel, meaning they 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 always used to fuel vehicles in either a compressed or liquefied form. 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 (psi). 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 compression-ignited, like a conventional diesel engine (Whyatt, 2010). CNG vehicles typically achieve about the same fuel economy as a conventional spark ignited internal combustion engine vehicle (ICEV) and 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 natural gas is higher than gasoline, which results in a lower energy content per unit volume.

## Liquefied Petroleum Gas

Liquefied petroleum gas (LPG), which is primarily composed of propane, is a liquid fuel used to power light-, medium-, and heavy-duty propane vehicles. LPG is produced as 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 a gas that is used for combustion. Propane vehicles work much like spark-ignition gasoline-powered vehicles, and have similar power, acceleration, and cruising speed. Propane vehicles may be manufactured to be propane-dedicated or converted from gasoline or diesel vehicles using ARB and EPA approved retrofit systems.

## Liquid Biofuels: Ethanol, Biodiesel, and Renewable Diesel

Biofuels are fuels produced from biogenic raw materials. Feedstock options for liquid biofuel production that are in commercial production today include:

- Sugar and starch crops: e.g. corn, sugarcane, sugar beets
- Cellulosic materials: e.g. switchgrass, forest residue, bagasse, municipal waste
- Oils and fats: e.g. soybean oil, canola oil, used cooking oil, animal fats, algae oil

Ethanol is primarily produced from corn and sugarcane. New technologies are being developed for waste feedstocks as well. Most gasoline sold in California is already made up of 10% ethanol (called E10), a blend which all modern vehicle engines can use. Higher levels of ethanol can also be used in vehicles classified as Flexible Fuel Vehicles (FFVs). 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 achieve less mileage for the same volume of fuel. However, handling is similar if not improved, since ethanol has a higher octane number than gasoline and affords the driver increased power and performance (DOE, 2013). Special sensors in the FFV detect the ethanol-to-gasoline ratio, and adjust its performance accordingly.

Vegetable oils and animal tallow can be used to produce biodiesel and renewable diesel, another low GHG option for vehicle fuel. These fuels are generally blended into diesel fuel at about a 4% level and are used in conventional diesel vehicles. These fuels are also available at higher level blends. Biodiesel blends have been sold at up at 20% biodiesel, but drivers must be cautious not to fuel at blend levels of higher than 20% may violate their warrantees. Renewable diesel achieves conventional on-road diesel specifications and therefore does not typically violate manufacturer warrantees.

**Figure 4. Propel E85 and RD Station in Redwood City**

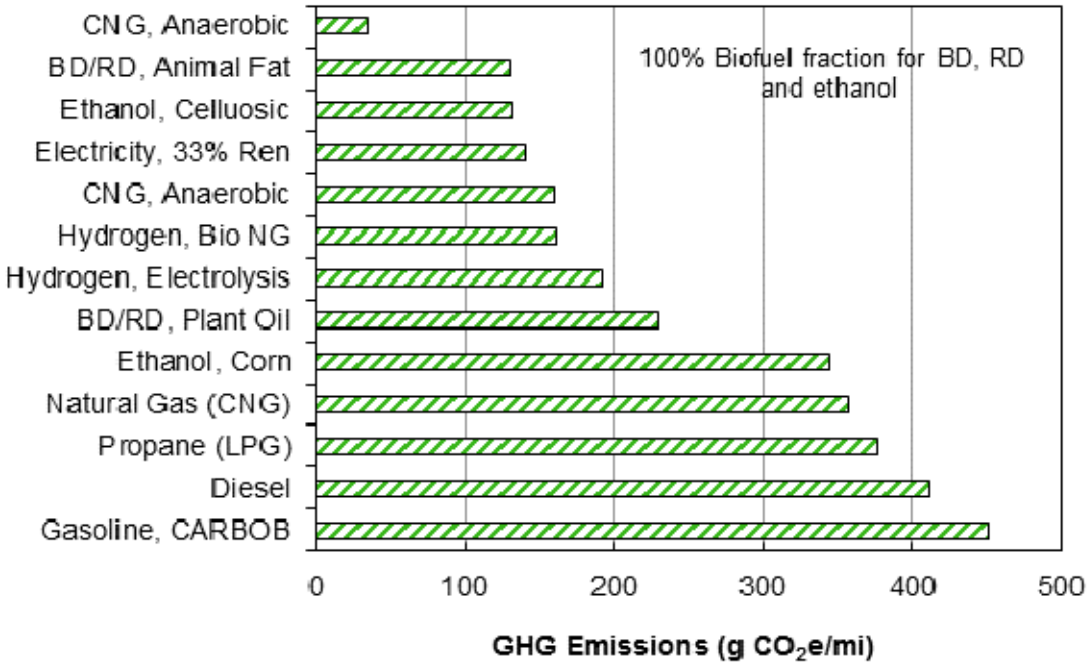
Liquid biofuels are sold in conventional retail stations as low level blends in gasoline or diesel or

as clearly marked high level blends. Figure 4 shows the Propel Fuel station in Redwood City that dispenses E85 and RD.

## Greenhouse Gas Emissions

Figure 4 shows an estimate of the GHG emissions that result from the production and combustion of a range of fuels used to power vehicles. ARB provides a list of default carbon intensities for each type of fuel under the Low Carbon Fuel Standard (LCFS). The comparison reflects the 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. This calculation gives an estimate of the grams of $CO_2e$ emitted per mile, which allows for a comparison of fuels based on their actual fuel usage. As Figure 5 shows, the method of production makes a large difference in the carbon intensity (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 due to avoided landfill emissions. The vehicle also affects the total well-to-wheel (WTW) emissions from passenger cars. Diesel WTW emissions are lower WTW than gasoline because diesel vehicles are more efficient than gasoline vehicles.

**Figure 5. Greenhouse Gas Emissions per Mile for Light-Duty Vehicles[1]**




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 of Full Report for more detail.

1. In Figure 5, the emissions shown for biodiesel, renewable diesel, and ethanol, which are typically blended into petroleum fuels, are based on an assumed 100% fraction of that alternative fuel. Electricity grid assumes 33% renewable sources. NGVs are assumed to be spark-ignited ICEVs.

## Advantages and Disadvantages of Each AFV

Drivers are accustomed to the prices and maintenance activities associated with petroleum fueled vehicles. However, AFVs contain new and different technologies, and require new approaches to fueling, use, and maintenance. Understanding strengths and weaknesses of each type of AFV allows consumers and policy makers to make well 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 in some cases.

Table 3 displays a brief overview of the pros and cons of each type of AFV. It also shows the carbon intensity of each AFV from the fuel production stage through the point of combustion of fuel in a vehicle. For comparison purposes, the WTW CI of gasoline is about 100 grams of carbon dioxide equivalents per mega joule of fuel (g $CO_2$e/MJ), and diesel is about 102 g $CO_2$e/MJ.

**Table 3. Advantages of Different Alternative Fuels**

| AFV Fuel | Well to Wheel Carbon Intensity[1] ($gCO_2e/MJ$) | Pros | Cons |
|---|---|---|---|
| Electricity[2] | CA Grid Avg.: 31 | ZEV & very efficient<br>Low fuel cost<br>Many incentives available for vehicle | High vehicle price<br>Short driving range<br>Long charging time |
| Hydrogen[3] | NG Reforming[4]: 35.33<br>Electrolysis[4]: 42 | ZEV & very efficient<br>Long driving range<br>Short fueling time<br>Scalable in size | High vehicle cost<br>High fuel cost<br>Low infrastructure density |
| Natural Gas | RNG: -34.7 to 46<br>Fossil CNG[1]: 76<br>Fossil LNG[5]: 94.4 | Low fuel cost<br>Clean burning fossil fuel<br>Long driving range | Low infrastructure density<br>Low efficiency compared to diesel |
| Ethanol | Corn Stover: 41.05<br>Sugar Cane: 56.7<br>Corn: 75.97 | Large quantities available<br>Works in existing stations<br>Vehicle cost is like ICEV<br>Long driving range<br>Short fueling time | E85 fuel cost is higher than gasoline per unit of energy. |
| Biodiesel/ Renewable Diesel | Animal fat: 38/32<br>Plant oil: 57/53<br>Used Cooking Oil: 20/18 | Works in existing stations<br>Long driving range<br>Short fueling time<br>Used in diesel vehicles | Warrantee may be voided by high biodiesel blends<br>Limited supply |
| Propane[5] | 78 to 83 | Long driving range<br>Short fueling time<br>ICEVs may be converted | Low infrastructure density<br>Few dedicated vehicles available for sale |

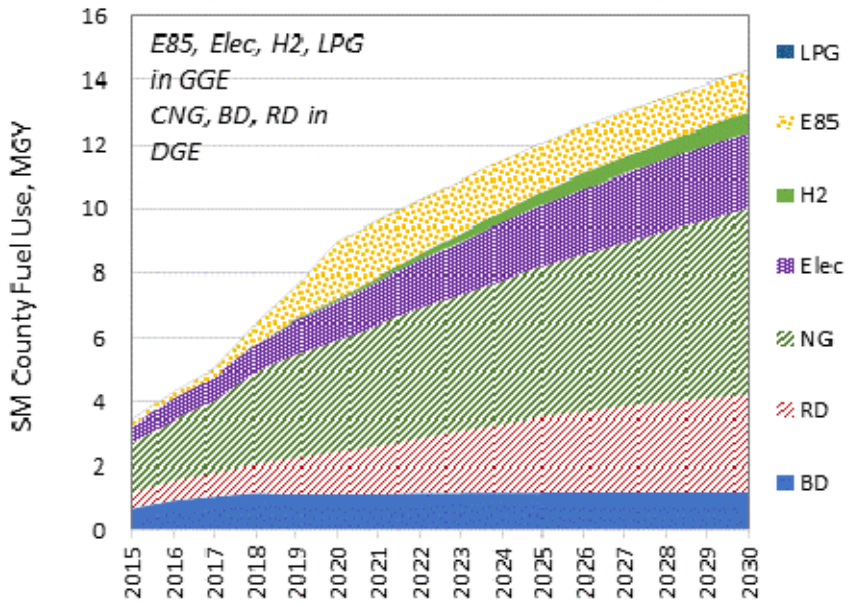
1. CARB. 2015. LCFS 2015 Final Regulation.
2. Electricity CI is EER adjusted by a factor of 3.4.
3. Hydrogen CI is EER adjusted by a factor of 2.5.
4. NG reforming assumes 100% renewable biogas feedstock. Electrolysis assumes California grid electricity, 33% renewable.
5. Propane is not currently included in the LCFS. The CI listed is based on an unpublished Life Cycle Associates study.

# 3. Alternative Fuel Infrastructure Needs in San Mateo County

Alternative fuel use will grow in proportion to California's Low Carbon Fuel Standard (LCFS) requirements. Life Cycle Associates modeled the expected changes in San Mateo County's vehicle populations through 2030 based on purchasing trends and regulatory mandates. ARB's Emission Factors (EMFAC) 2014 model was used to estimate the number of AFVs registered in San Mateo County through 2030 (CARB, 2014). EMFAC provides projections of gasoline, diesel, and electric drive vehicles by vehicle class. EMFAC reports all electric drive VMTs together, combining PHEV, BEV, and FCEVs. The California ZEV mandate was used to estimate the split of electric drive vehicles between PHEVs, BEVs, and FCEVs, which changes over time. Gasoline and E85 volumes were adjusted based on CEC recorded gasoline volumes for 2014[11]. The projected fuel demand volumes for all alternative fuels are shown in Figure 5.

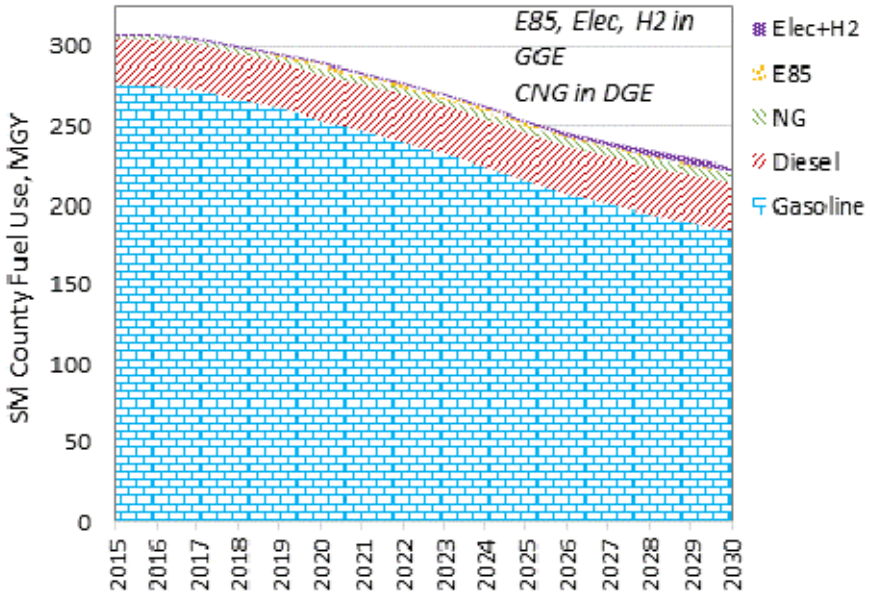
Fuel demand for FCEVs and PEVs is expected to grow quickly, although it will remain a small percentage of total vehicle fuel demand. Renewable diesel, biodiesel, and ethanol volumes are presented here as isolated volumes, but will primarily be blended into gasoline and diesel in practice. Natural gas shows considerable growth due to increased use of CNG trucks. The projected growth in E85 occurs if LCFS ethanol volumes persist with projected E10 sales. LPG volumes are expected to by ARB to be very small. Figure 7 displays the alternative fuels next to fossil gasoline and diesel, showing that while the alternative fuel volumes will grow, they will remain a small fraction of the total fuel used.

**Figure 6. Projected Alternative Fuel Demand**




[11] Volumes used were presented at the ARB LCFS workshop on October 27, 2014.

**Figure 7. Projected Fuel Demand (All Fuels)**




## Retail and Infrastructure Plan

Achieving optimal public refueling accessibility will require planning on the part of public agencies, which have the power to incentivize construction in certain areas and coordinate 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 dispensing time. For example, hydrogen refueling takes only about 5 minutes, so hydrogen stations are not very limited by dispensing time, but hydrogen fuel must be stored onsite and takes up a large amount of space, especially given the land footprint of large hydrogen setback requirements. Electric vehicles, on the other hand, can take between half an hour and several hours to charge, which limits the number of cars a station can serve. However, no onsite storage is required since the station is simply connected to the electric grid.

AFV drivers will be most satisfied if they do not have to drive long distances to refuel their vehicles. An optimal siting plan will account for the total demand but ensure that refueling locations are geographically distributed in convenient locations without having excessive distances between sites or over supplying any one area. Table 4 displays the projected fuel volume demand for 2030.

**Table 4. San Mateo County Projected Fuel Volumes in 2030**

| Fuel | Units | Quantity |
|---|---|---|
| Gasoline (E10) | Million gal/yr as gasoline | 182 |
| Diesel | Million gal/yr as diesel | 26 |
| Ethanol | Million gal/yr as E10 | 18.2 |
| | Million gal/yr as E85 | 6.5 |
| CNG | Million 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[1] | Million gal/yr as gasoline | 0.01 |

1. LPG volume calculated based on DMV data and held constant over time.

Table 5 shows the number of stations required to service the demand from the projected fuel volumes. Gasoline volumes are expected to decrease by a third by 2030, so station count could potentially decline. Diesel stations for 2015 are based on an assumption that 55% of current gasoline stations contain diesel outlets. However, the number of diesel stations in 2030 increases based on the relative increase in diesel volumes expected. Calculation assumptions are described in the sections below.

The use of high level blends may expand in order to meet the requirements of the LCFS, which was readopted in September of 2015. For example, this study projects the number of E85 fueling dispensers in San Mateo County will need to increase from 1 to 13 in to achieve projections of LCFS volume requirements. Fuel retailers can integrate dispensers for these fuels into existing retail fuel stations, especially if gasoline demand declines.

**Table 5. San Mateo County Projected Fuel Volumes in 2030**

| Fuel Type | 2015[1] | 2030[2] |
|---|---|---|
| Gasoline | 197 | 130 |
| Diesel | 109 | 123 |
| Electricity[3,4] | | |
| Level 1/2- Residential | 340 | 23,343 |
| Level 2- Work | 222 | 3056 |
| Level 2- Public | 152 | 222 to 370 |
| DCFC | 22 | 22 |
| Hydrogen | 0 (4 in development) | 5 to 8 |
| NG | 4 | 18 |
| 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. CARB. 2014. EMFAC2014 database. http://www.arb.ca.gov/emfac/
3. Level 2 residential charging calculated based on assumption of 90% BEV owners and 30% PHEV owners.
4. Number of individual charging ports.

Liquid fuels such as biodiesel, renewable diesel, and E85 are compatible with gasoline stations after slight modifications, so currently existing gasoline stations are the most likely siting location for future liquid fuel dispensers. These sites are shown in Figure 8.

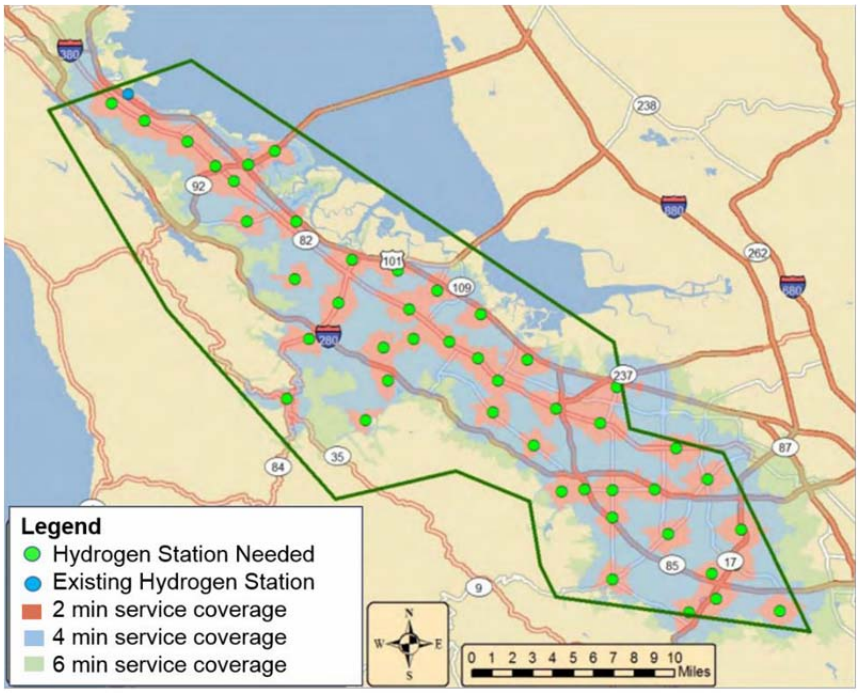
**Figure 8. Existing Liquid Fueling Sites**

Source: Google Maps
Note: Not all existing fueling stations are represented.

A CEC study determined that the current level of gasoline station coverage can be duplicated for hydrogen with only 13 to 21 percent of the outlets, provided that the outlets are 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. The study 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 13 displays the hydrogen fueling locations recommended in the CEC's analysis for the South Bay. This map also shows coverage by driving time, giving the 2, 4, and 6 minute station driving range.

Four hydrogen stations are currently in development in San Mateo County. One is in South San Francisco, and it is already under construction. A second station is located in Woodside, and it has received approval to build. The remaining two stations, in Redwood City and Foster City, are still in the planning and pre-permitting phase. Therefore, San Mateo County is well on its way to developing the five to eight fueling stations it will need in 2030. The locations shown in Figure 9 offer information about promising locations. A substantial transition to hydrogen would need to occur to require this many stations.

**Figure 9. SF Peninsula Hydrogen Station and Driving Coverage Map**



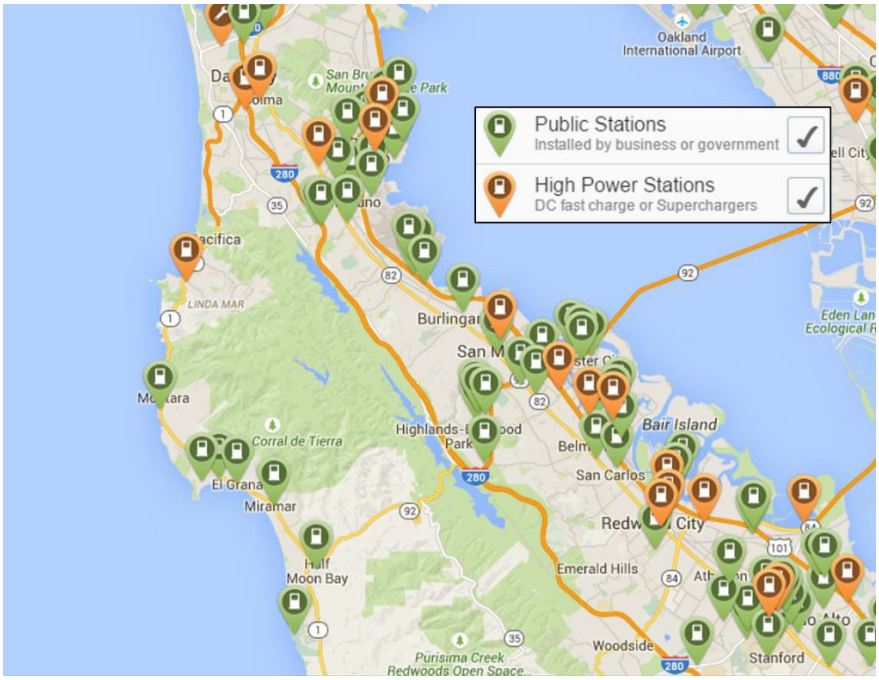

Source: Brown, T., Stephens-Romero, S., Soukup, J., Manliclic, K., Samuelsen, S., 2013. The 2013 Strategic Plan for the Inaugural Rollout of Hydrogen Fueling Stations in California. doi:600-10-002

For residential chargers, it is generally assumed that 90 percent of BEV owners and 30 percent of PHEV owners will purchase and install Level 2 chargers (CSE, 2013). Based on projected 2030 populations of BEV (14,460) and PHEV (34,429) populations, this translates to a total of 23,343 residential Level 2 chargers installed by 2030.

For workplace charging equipment, a recent National Renewable Energy Laboratory (NREL) study estimates that 15 percent 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 3056 workplace chargers, a large increase.

Finally, the number of DC fast charge stations located along freeways provide an important link for EVSE coverage. The West Coast Electric Highway plans 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 has one DC Fast Charger, but Highway 280 has none. Figure 10 shows that publicly accessible EVSE is already quite widespread through San Mateo County. However, some gaps in coverage are apparent.

**Figure 10. San Mateo County EV Charging Sites**




Source: http://www.plugshare.com/

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, which should be included in AFI site planning.

# 4. Incentives for Alternative Fuels

AFVs offer many advantages over conventionally fueled vehicles. These vehicles generate lower GHG emissions throughout their life cycle and produce lower quantities of pollutants such as particulate matter, smog precursors, and sulfur dioxide. Communities may also enjoy economic benefits from infrastructure development and reduced public health costs associated with improvements in air quality from AFVs. PEVs and FCEVs are quieter than conventional vehicles since they have electric motors instead of combustion engines, thereby reducing noise pollution. Additionally, alternative fuels like renewable electricity, hydrogen gas, bioCNG, corn and biomass-based ethanol, and biodiesel and renewable diesel are typically domestically produced, resulting in an increase in energy independence.

As with any new technology, the roll out of AFVs faces some challenges. Since the public benefit of increasing the use of AFVs is significant in spite of these challenges, various incentives exist in order to make them more attractive to consumers and speed their deployment. The following list summarizes the types of policies and incentives that governments 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 that have also been put in place are likely to result in an increase in the use of AFVs, such as:

- Criteria air pollutant and GHG emission regulations
- Fuel economy regulations
- Government fleet AFV or ZEV requirements

Rebates and tax credits can reduce the purchase price of an alternative fuel vehicle significantly. Table 6 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 6. Vehicle Purchase Rebates and Tax Credits**

| AFV Type | BAAQMD Public Agency PEV Program | CARB Clean Vehicle Rebate Program | IRS Tax Credit |
|---|---|---|---|
| Battery Electric Vehicles | $2,500 | $2,500 | $7,500 |
| Plug-in Hybrid Electric Vehicles | $1,000 | $1,500 | $4,000 |
| Electric Motorcycles | $2,500 | $900 | $2,500 |
| Fuel Cell Electric Vehicles | $2,500 | $5,000 | $0 |

Many other kinds of incentives are available for infrastructure installation, vehicle purchase, fuel production, and new business or technology development. At the federal level, tools such as tax credits, grants, and low-interest loans exist for individuals, businesses, and government agencies. At the state level, tax exemptions and grant funding may be available to individuals and government agencies. California also offers behavioral incentives such as high occupancy vehicle (HOV) lane access, and has regulatory programs such as the Low Carbon Fuel Standard that allow fuel producers to profit from generating and selling carbon credits. The Bay Area also has a number of local opportunities for agencies that want to invest in alternative fuel vehicles or infrastructure. Table 7 displays a summary of all the available incentives currently offered to consumers, businesses, and government agencies in San Mateo County.

**Table 7. Summary of Existing AFV Incentives**

| 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 RFS2) | California Low Carbon Fuel Standard (LCFS) | |
| Infrastructure | Zero Emissions Airport Vehicles and Infrastructure Pilot Program | Alternative and Renewable Fuel and Vehicle Technology Program (ARFTVP) | BAAQMD *Charge!* Program |
| | | AB 8 and Hydrogen Fuel Cell Vehicles | Plan Bay Area EV Charger Network |
| | | SB 1128 Sales Tax Exclusion | |
| 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 | Voluntary Accelerated Vehicle Retirement Program | |
| | DOE Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) | | |

# 5. Challenges to AFV and AFI Development

AFVs 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, and AFV technologies have become a viable alternative to gasoline and diesel fuels. However, challenges to widespread adoption could slow or even derail their contribution to this important goal. Our research shows that the challenges facing AFV adoption, AFI development, and local readiness for AFVs fall into four main categories:

1. Economic challenges:

- Alternative fuel vehicles and infrastructure often have higher 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 currently is 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 ICEVs.

3. Regulatory challenges:

- Local rules, standards, and regulations may need to be updated to ensure that building and zoning codes cover alternative fuels.
- Permitting process may be slow due to unfamiliarity and caution on the part of government officials and building inspectors.

4. Educational challenges:

- Consumers are wary of new and unfamiliar technologies.
- Consumers and investors are unaware of incentive programs.
- Consumers may not have full understanding of economic and environmental benefits of AFVs.
- Emergency responders need additional training on alternative fuels.

## Vehicle Cost

AFVs are often more expensive to make than ICEVs, partially due to the higher cost of batteries, compressed gas tanks, and other special components, 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.

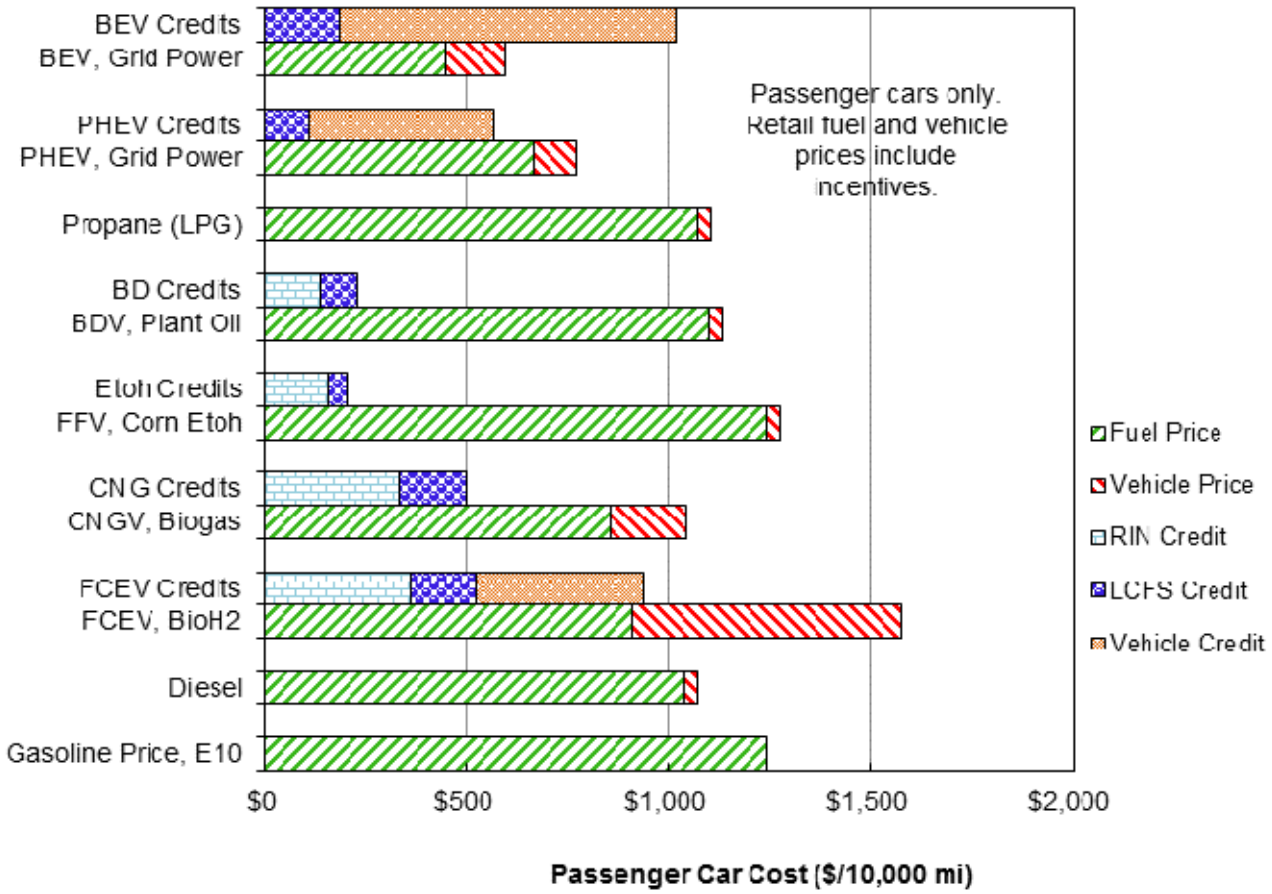
The price of alternative fuels also differs from that of petroleum based fuels. Here, again, government incentives generate additional revenue for the producers of alternative fuels. Producers of low carbon

intensity fuels can generate carbon credits through the California Low Carbon Fuel Standard (LCFS credits), AB 32's cap and trade program (offset credits), and the EPA's Renewable Fuel Standard (RINs). Under these regulations, petroleum fuel producers are obligated to obtain LCFS credits and RINs and offset their carbon emissions with offset credits, which reduces the retail price that consumers pay for alternative fuels.

Figure 11 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 shown below, AFVs costs are within +/- 30% of the cost of 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, biodiesel, and renewable diesel. Petroleum based diesel is also more efficient and cost-effective in light-duty vehicles than gasoline. 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 11. Incremental Vehicle Cost[1,2]**

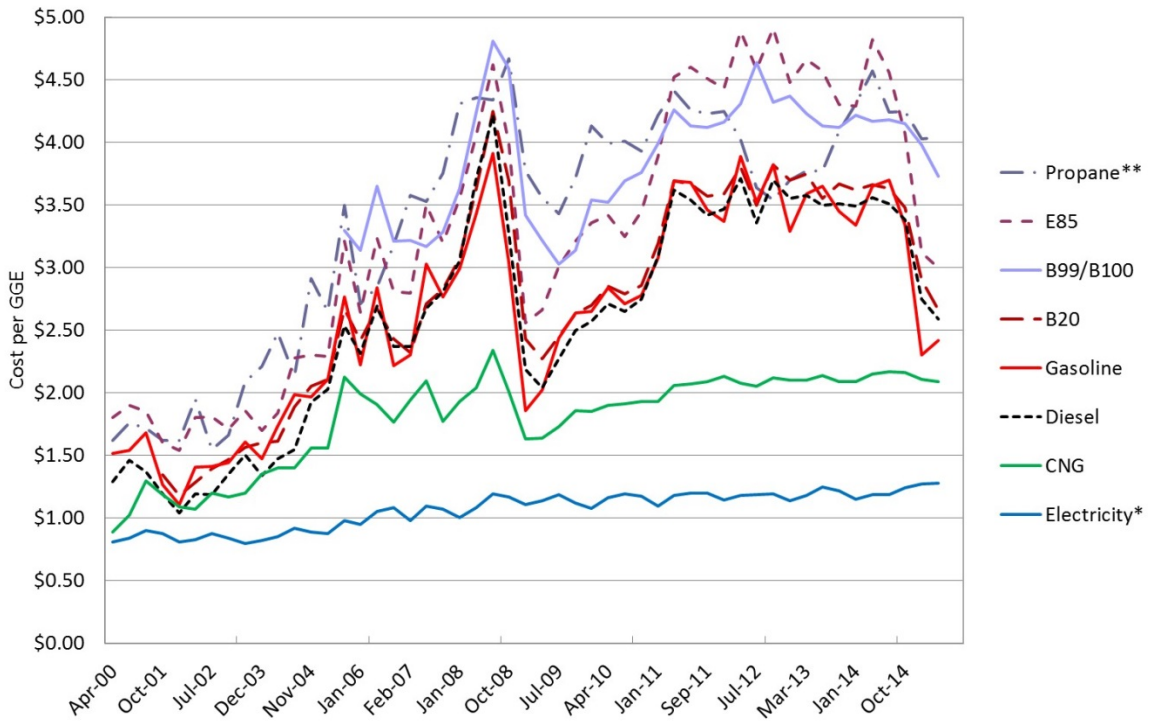



1. Fuel prices from Energy Information Administration 2015 Annual Energy Outlook.
2. Vehicle costs taken from Transitions to Alternative Vehicles and Fuels, National Academy of Sciences, 2013 and adjusted for tax credits and rebates.

## Fuel Cost

Fuel prices have proven to be highly variable over time. In the last 15 years, U.S. average gasoline prices have ranged from as little as $1.50 in 2000 to almost $4.00 in 2008. As demonstrated in Figure 12, the price of liquid alternative fuel prices is closely tied to the price of petroleum. Liquid alternative fuels are primarily used in vehicles, and petroleum options are a viable market substitute if alternative fuel prices rise too high. However, natural gas and electricity prices are more independent of the price of petroleum because transportation only accounts for a small portion of their markets, and the primary feedstock is natural gas, which has become abundant in recent years. Fuel prices have dropped in 2016 for all fuel options except electric. Incremental vehicle costs have not dropped. Alternative fuel incentives may help to compensate for lower petroleum prices.

**Figure 12. U.S. Average Retail Fuel Prices**




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

Increasing the availability of alternative fueling infrastructure is key to developing the AFV market. 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. However, in order to access the lowest electricity rates, customers may need to install a second meter. 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. Hydrogen and natural gas fueling stations, which require compressed or liquefied gas storage tanks and have a larger physical footprint, are much more expensive than gasoline stations. Table 8 shows the range of different infrastructure installation costs across fueling stations. Dispensers and tanks for a conventional gasoline and diesel station cost about $150,000. In contrast, a CNG fast-fill station can cost over $1 million and a hydrogen station can cost up to $4 million.

**Table 8. 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-$200,000 |
| 1 Fueling Island | Biodiesel/Renewable Diesel[7,8,9] | $50,000-$200,000 |
| 1 Fueling Island | Gasoline/Diesel[7,8,9] | $50,000-$200,000 |

[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] T. 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 Center. 2014. Hydrogen Fueling Station Infrastructure. http://evtc.fsec.ucf.edu/reports/EVTC-RR- 02-14.pdf.

High costs and distant returns discourage investment in alternative fuel infrastructure by traditional investors. Local governments have a role to play in connecting private developers with funding or creating public-private partnerships to encourage AFI development. Government agencies can help to identify incentives, grants, or other funding opportunities to partially cover the cost of construction or support private installations of AFV infrastructure. Once funding has been identified, a site must be located and construction permits and inspections will be required. Streamlined permitting and inspection processes also help to make infrastructure development more appealing to investors.

Some government fleets are already operating on alternative fuels and may have their own refueling station. If these stations are made available for public fueling as well as fleet needs, this increases the intensity of their use, reducing the return on investment time for infrastructure construction, and also helps serve the demand of alternative fuel vehicle drivers in the area.

The following list summarizes some potential ways to fund public AFI development:

- Engage in public/private partnerships where government funding covers cost of construction but independent contractors construct, manage, and maintain station.
- Take advantage of government grants, funding, and incentive programs.

- Create a coalition of stakeholders who benefit from the existence of AFI, such as government entities, local businesses, environmental groups, and car manufacturers

## Technical Challenges

AFVs use new technologies and run on non-conventional fuel sources. As such, these vehicles require an adjustment in consumer habits and expectations due to their 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 compatible rate in each geographic area. Currently, station density for most alternative fuels is low. Manufacturers typically will not sell vehicles in a given market 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 9 summarizes the technical challenges inherent to AFVs, which are discussed in detail in the following section.

## Regulatory Challenges

Regulatory challenges include any aspect of alternative vehicle fueling and operation that must be regulated or permitted by government agencies. Zoning laws, fire and safety codes, permitting, and parking regulation are all areas of regulatory concern. 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 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.

## Educational Challenges

Current understanding of AFVs and alternative fuels by the public is limited and may include uninformed 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.

**Table 9. Technical Challenges**

| Issue | AFV Impacts | Local Challenge | Solutions |
|---|---|---|---|
| Low 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. |
| Low EVSE Density | BEV drivers need public stations for emergency charging, long trips, and commutes. | Free charging at businesses or public stations is inefficient. 12% of residents live in multi-unit dwellings. | Charge at least a nominal fee for EV charging. Support policies to increase public charging. |
| 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 demand will support driver access and minimize 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. | 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. | 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. |

# 6. Increased Procurement Strategies

Existing policies and incentives are already having a large effect on the growth of alternative fuel vehicles in California and San Mateo County as car manufacturers, fuel providers, and consumers take advantage of various 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 may also consider incentivizing the purchase of AFVs and installation of AF charging infrastructure in local communities. A range of solutions can be employed to address the various challenges described above.

## Cost Strategies

Economic challenges are one 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 the purchase price of a PEV, diesel, or CNG vehicle is higher than a conventional gasoline vehicle but the fuel price is lower. The vehicle operators may incur lower life cycle costs. However, the upfront cost remains a barrier.

Governments, businesses, and consumers interested in purchasing AFVs can employ a variety of financing and procurement strategies to make AFVs more affordable. Each strategy's pros and cons should be evaluated by the purchasing entity, be it a government agency, private fleet manager, or individual. Some strategies to consider for making vehicles more affordable are summarized in Table 8. These approaches are explained in more detail in San Mateo County's Alternative Fuel Readiness Plan: Full Report.

With the anticipated increase in number of alternative fuel vehicles, County of San Mateo government agencies will need to plan for an increase in the number of alternative fueling stations, both public and private. With high station infrastructure costs and distant returns that may discourage investment, local governments can play a role to in connecting private developers with funding opportunities as well as creating public-private partnerships. The following list summarizes some ways stakeholders can collaborate to provide funds for 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 providing funds or other resources to support infrastructure development.
- Create a coalition of stakeholders who may benefit from the existence of AFI, such as government entities, local businesses, and automobile manufacturers.

**Table 8. 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)

## Regulatory Strategies

Regulation is an area where San Mateo County jurisdictions have an opportunity to positively influence the growth of AFVs. Local governments have jurisdiction over zoning, permitting, and building regulations. This role is important, because the highest growth rates for technology

market share are associated with the presence of clear standards. The next most important factors are the price of gasoline and government subsidies for the purchase of green vehicles (Plotkin, 2013; Zoepf, 2011). 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
- Government owned vehicles

## 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. Creating a local sustainability department is another important option to increase access to alternative fuels. The available grants and incentives are constantly changing. A sustainability department could assume the responsibility of organizing local outreach programs and seeking out 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 contractors working on municipal contracts meet certain environmental standards, such as the use of alternative fuels in their fleets. Including sustainability and environmental performance in evaluation criteria provides significant motivation for companies to be environmentally responsible.

Setting specific goals and targets for local city and county vehicle procurement is a more targeted way to encourage the transformation to a lower emission vehicle population. For instance, the County of San Mateo established a 30mpg target for the county sedan fleet, which has prompted the purchase of hybrid vehicles in the last few years. 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 County fleets can expand their use of BEVs.

## Zoning & Building Codes

San Mateo County cities and the County may consider revising zoning and building codes to accommodate or encourage the installation of EV charging stations or the construction of other AFI. Building codes in California are divided into codes for residential and nonresidential buildings. Residential buildings are classified as either 1) homes of one to four units, or 2) multi-unit dwellings (MUDs) of five units or more. Nonresidential buildings include buildings for business, industrial, institutional, and retail uses. Although cities and the County are obligated by law to enforce the building codes outlined in California's Codes and Regulations, Title 24, Chapter 3, 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 percent 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 EVSE" (Title 24: Part 11, Supplement, 2015). Nonresidential standards include a requirement that businesses designate a percentage of their parking spaces for low-emitting vehicles or have wiring capable of supporting EVSE as described in Table 10.

**Table 10. Nonresidential EV Parking Standard: Required EV Charging Spaces**

| Current Mandatory | Current Voluntary | Proposed Mandatory[1] |
|---|---|---|
| 3% of spots in lots with 51 spaces or more | 4-6% of spots, regardless of number of spaces | 6% of spaces in lots with 10 spaces or more |

Source: (California Building Standards Commission, 2015)
1. Effective January, 2017 if adopted.

Building codes and standards exist for all of the different alternative fuels. However, only some are mandatory and many local jurisdictions have not adopted all of the possible standards. National and state standards provide guidance on how to handle each alternative fuel, as shown in Table 11. Ensuring that building and construction codes and standards have been adopted for all alternative fuels and are well-understood is a helpful step towards creating an AFI friendly culture.

**Table 11. Nonresidential EV Parking Standard: Required EV Charging Spaces**

| Fuel | Public Stations | 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 planning. |
| Hydrogen | Integrated 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. May require large sites. |
| CNG | Integrated 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 | | | |

## Permitting

The permitting process can result in large costs for a developer if it invites delays or involves unpredictable fees. Therefore, permitting for AFI development should be streamlined to the

greatest extent possible. The streamlining mechanism itself will vary by fuel type since the requirements of different infrastructure and construction processes 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.

### Signage

Local signs are used to advertise the location of fueling station, the availability different fuels, and the current prices. 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.

### 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, more PEV owners are 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. However, a number of unique challenges face MUD residents who want to install charging stations in their building, allowing them to access the convenience and cheaper rates of nighttime off-peak home charging.

A recent California law, Assembly Bill (AB) 2565, confirms the legal right of drivers to install EVSE in rental properties, ensuring that drivers will be able to charge at home even if they don't own their home. The law is primarily aimed at renters in MUDs and includes a number of restrictions to this effect; 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.

Governments, property managers, and residents can employ different strategies to overcome some of the logistical challenges of installing EVSE in a communal parking area. The question of electricity payment is often a sensitive one. Ideally, a separate meter allows the electricity used for PEV charging to be directly billed to the driver. In the case of multiple users, MUDs can select a flexible billing system so that 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. Providing residents with access to an impartial mediator or a public registry of PEV ready buildings can also help drivers to easily identify buildings that will make charging easy and negotiate MUD EVSE challenges.

Table 12 summarizes the local policies that can help to address the range of AF, AFV, and AFI challenges and incentivize the use and purchase of alternative fuels. These are divided into policies that address fuel production, vehicle purchase, and infrastructure development, and confront the four categories of challenges that these technologies face.

**Table 12. Summary of Local Policy Options**

| | Fuel | Vehicles | Infrastructure |
|---|---|---|---|
| **Economics** | Sell LCFS credits and RINs from fuel production.<br><br>Offer reduced price PEV charging in public locations. | Take advantage of and advertise state and local rebate opportunities.<br><br>Lease instead of purchase vehicles to defray cost and capture federal tax credits.<br><br>Aggregate AFV purchase orders with other agencies to reduce cost of manufacturing.<br><br>Restructure fleet vehicle budgets to account for lower fuel costs over time.<br><br>Join a Clean Cities Coalition. | Apply for grants and educate investors about available incentives.<br><br>Obtain funds for low- interest loan programs.<br><br>Make city fueling stations open-access.<br><br>Engage in public-private AFI partnerships.<br><br>Identify pre-permitted sites that can be easily converted for AFI retail.<br><br>Require new buildings have EVSE ready wiring. |
| **Technology** | Encourage utilities to upgrade grid and smart grid capacity.<br><br>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.<br><br>Create public fleet AFV goals or emissions targets. | Have dedicated Sustainability department.<br><br>Adopt AFI friendly building codes.<br><br>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.<br><br>Outreach to technicians about training opportunities. | Educate indirect AFI beneficiaries.<br><br>Include AFVs in first responder emergency training curricula. |

# 7. Education and Outreach

AFVs will be most successful in San Mateo County if all of the potential stakeholders are informed and involved. Therefore, ensuring that educational opportunities exist for consumers, investors, government officials, safety personnel, and support staff, such as technicians and mechanics remains a priority. Local agencies and businesses may also want to consider converting organic waste from municipal collection or waste water treatment into renewable fuels such as bio-methane once they are aware of the potential for savings and environmental benefits.

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 full report for the Plan, and further details on this can be found in Chapter 7. 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.

Several entities in San Mateo County are already demonstrating the feasibility of turning organic waste products into energy. South San Francisco Scavenger waste management 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 (Scavenger facilities are shown in Figure 13). The City of San Mateo is capturing the bio-methane produced from its waste water treatment facility and scrubbing it to produce natural gas to fuel its 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 13. SSF Scavenger Company CNG Fueling Infrastructure**

## Communication Strategy

This 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 AFVs. This requires active marketing, communication, and educational outreach to three main target audiences: County of San Mateo government agencies and fleets; businesses and private fleets; and consumers. Communication efforts are aimed at creating awareness of the existence of the Alternative Fuel Readiness Plan and conveying the benefits of alternative fuel production usage. The following list outlines specific recommendations for communication efforts that should take place in San Mateo County:

- Make the AFRP report accessible on the C/CAG and city websites.
- Conduct face-to-face presentations and workshops informing key stakeholders about the Plan, its goals, and alternative fuel opportunities.
- Develop a multi-stage email campaign to make each city and jurisdiction in San Mateo County aware of the Plan and encourage them to facilitate alternative fuel usage in their area.
- Create a website section about alternative fuels on the C/CAG homepage, including links to background information, grant opportunities, incentives, case studies and other resources.
- Use the video produced during this project to showcase AFV usage in San Mateo County.

- Conduct community events showcasing AFVs and participate in other local events by setting up an information booth and/or passing out informational brochures.
- Conduct school events that educate children in K-12 about alternative fuels.

## Training Resources

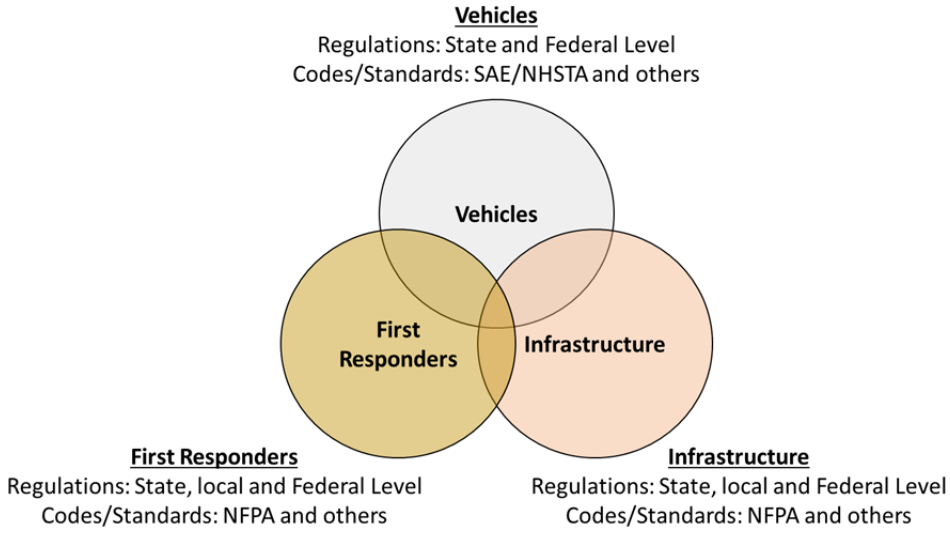
Many stakeholders and obligated parties, such as operators, first responders, and government officials, remain unfamiliar with the specific techniques and practices needed for safe vehicle operation, maintenance, and refueling. It is important for them to understand:

- Alternative Fuel Properties
- 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

### Alternative Fuels Regulations

Aspects of alternative fuel use and storage are addressed in a standardized manner in a range of federal, state and local safety and hazard regulations. The codes and standards for AF and AFV use and deployment can be categories into three groups. These are: (1) vehicles; (2) built infrastructure; and (3) emergency responders. Each of these categories has different regulatory and consensus codes and standards. This is illustrated in Figure 14 (Blake, 2010; Durso, 2010; Farr, 2010; Grant, 2010).

**Figure 14. Basic Groups of AFV Related Codes and Standards**




**Source:** Adapted from U.S. National Electric Vehicle Safety Standards Summit Summary Report (Grant, 2010).

### *Vehicles*

Vehicle safety concerns relating to the 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 at the state, local and federal levels. Regulations are based on numerous model consensus codes and standards from the National Fire Protection Association (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.

## Safety Considerations

Regulations and first responder experience do not encompass all of the risks and hazards associated with alternative fuels. Training is needed to address potential hazards, labelling concerns, operating practices, and other factors (DOE, 2015a, 2015b, 2013; 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:** U.S. 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.

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.

## 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. 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 12 shows a list of AF training resources available online. 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 National Alternative Fuels Training Consortium (NAFTC) is the only nationwide alternative fuel vehicle and advanced technology vehicle training organization in the U.S. 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.

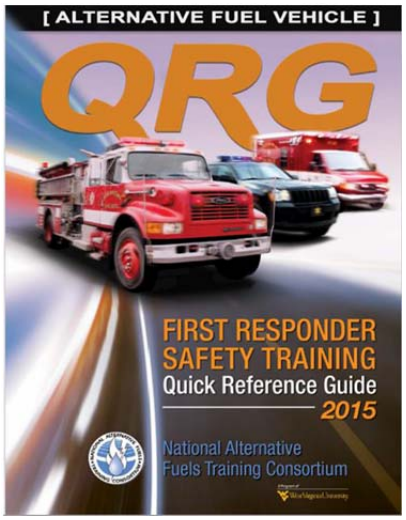
The first responder stakeholders in San Mateo County are in discussions with NAFTC to hold a series of training seminars in the County. Participants of the NAFTC training receive access to state-of-the art curricula, unsurpassed train-the-trainer courses and workshops, timely instructor updates, and 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) for Emergency Responders shown in Figure 15, which has now been distributed to every fire truck in San Mateo County. The QRG 100-page guidebook covering all alternative fuel vehicles and includes

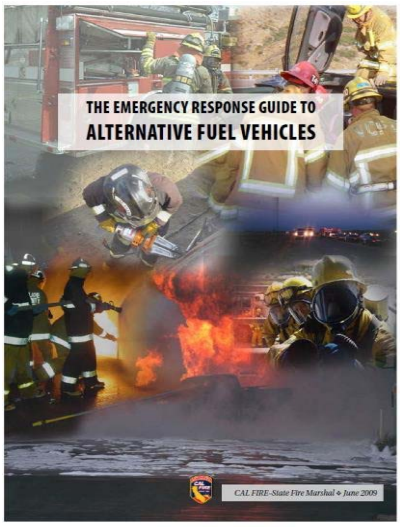
identifying photos of each make and model. Each section includes detailed diagrams of the vehicles, switches, and valves, with additional photos and diagrams of the under hood components. This guide is also available as a mobile app. Another noteworthy resource for first responders is the Emergency Response Guide for Alternative Fuel Vehicles produced by CAL FIRE State Fire Marshal, shown in Figure 16.

**Figure 15: Alternative Fuel Vehicle Quick Reference Guide**




Source: http://afvsafetytraining.com/qrg.html

**Figure 16: Alternative Fuel Vehicle Emergency Response Guide**




Source: http://osfm.fire.ca.gov/training/pdf/alternativefuelvehicles/Altfuelintroduction.pdf

As part of the development of this Alternative Fuels Readiness Plan, fire officials from San Mateo County were consulted for their insight into current level of alternative fuel training for first responders. Upon learning of the existence of a freely available Emergency Responder Guide for Alternative Fuel Vehicles, the San Mateo County Office of Emergency Management added it to the resources fire fighters keep in every vehicle, either in hard copy or electronically.

Table 13 provides an overview of open access training resources for safety and emergency personnel and includes reading materials, in person trainings, and mobile applications.

**Table 13. 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 |
| Ethanol Emergency Response Resources | Ethanol Emergency Response Coalition | http://www.ethanolresponse.com/pages/resources |
| 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://phmsa.dot.gov/portal/site/PHMSA/menuitem.6f23687cf7b00b0f22e4c6962d9c8789/?vgnextoid=f6db5aaa0581d310VgnVCM1000001ecb7898RCRD&vgnextchannel=c8e71dec94973110VgnVCM1000009ed07898RCRD&vgnextfmt=print |
| Clean Transportation Education Project, U.S. 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 |

# 8. Conclusions & Next Steps

San Mateo County will experience significant growth in alternative fuel demand in the years to come. Cities will be far more prepared for this increase in alternative fuels if they consider possible new requirements and potential 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. 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. With this knowledge, cities can collaborate to develop siting and zoning plans that 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 implementing the Plan may include:

1. **Educate and train government staff on issues related to alternative fuels regulation.**
   - Review guidelines for streamlined permitting, such as developing permitting 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 the 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 the maximum number of allowable signs at stations and surrounding areas. Legally approved signs can be found in the CA Department of Transit Traffic Operations Policy Directive 13-01.

2. **Implement the outreach and marketing strategies specified in the Plan.**
   - Create a webpage on city or county websites with information and useful resources about alternative fuels. Include background information, grant and 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.
   - Hold educational events at K-12 schools to introduce children to alternative fuels.
   - Distribute brochures about alternative fuels at relevant gatherings.

3. **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, and other agencies for building refueling infrastructure, purchasing vehicles, or converting organic feedstocks into bio-methane.
- Perform environmental cost benefit analyses for different AFV options based on individual fleet needs (range, capacity, overnight storage, maintenance, etc.).
- Include green procurement requirements in contracting evaluation.

**4. 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 the 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 building 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.

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