Solano Transportation Authority

# SOLANO COUNTY

## Alternative Fuels & Infrastructure Plan


# Solano County Alternative Fuels & Infrastructure Plan

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# List of Acronyms

| | |
|---|---|
| A | amperes |
| AB | Assembly Bill |
| ABAG | Association of Bay Area Governments |
| AC | alternating current |
| AC Transit | Alameda-Contra Costa Transit District |
| AFDC | Alternative Fuels Data Center |
| ARB | California Air Resources Board |
| AST | aboveground storage tank |
| BAAQMD | Bay Area Air Quality Management District |
| BACT | best available control technology |
| B5 | 5% biodiesel blended with conventional diesel |
| B20 | 20% biodiesel blended with conventional diesel |
| B100 | pure biodiesel |
| BEV | battery electric vehicle |
| CAFE | corporate average fuel economy |
| Caltrans | California Department of Transportation |
| CEC | California Energy Commission |
| $CH_4$ | methane |
| CMAQ | Congestion Mitigation and Air Quality Improvement |
| CNG | compressed natural gas |
| CO | carbon monoxide |
| CPUC | California Public Utilities Commission |
| DC | direct current |
| DCFC | DC fast charge |
| DERA | Diesel Emissions Reduction Act |
| DOE | U.S. Department of Energy |
| DPM | diesel particulate matter |
| E10 | gasoline mixed with 10% ethanol |
| E85 | 85% ethanol blend |
| E100 | pure ethanol |
| EIA | U.S. Energy Information Administration |
| EPA | U.S. Environmental Protection Agency |
| EV | electric vehicle |
| EVSE | electric vehicle supply equipment |
| FCV | fuel cell vehicle |
| FFV | flexible fuel vehicle |

## List of Acronyms (continued)

| | |
|---|---|
| FHWA | Federal Highway Administration |
| FTA | Federal Transit Administration |
| FY | fiscal year |
| g/$CO_2$e/MJ | grams of carbon dioxide-equivalent per megajoule |
| GGE | gasoline gallon equivalent |
| GHG | greenhouse gas |
| HDV | heavy-duty vehicle |
| HEV | hybrid electric vehicle |
| ICE | internal combustion engine |
| kWh | kilowatt-hours |
| LCFS | Low Carbon Fuel Standard |
| LDV | light-duty vehicle |
| LEV | low emission vehicle |
| LNG | liquefied natural gas |
| LPG | liquefied petroleum gas |
| M85 | 85% methanol blended with 15% gasoline |
| MTC | Metropolitan Transportation Commission |
| NAAQS | National Ambient Air Quality Standards |
| NGV | natural gas vehicle |
| NOx | nitrogen oxides |
| NRG | NRG Energy, Inc. |
| OEM | original equipment manufacturer |
| PEV | plug-in electric vehicle |
| PG&E | Pacific Gas and Electric Company |
| PHEV | plug-in hybrid electric vehicle |
| PM | particulate matter |
| PM2.5 | fine particulate matter |
| PON | Program Opportunity Notice |
| psi | pounds per square inch |
| RFA | Request for Application |
| RFS2 | revised Renewable Fuel Standard |
| SAE | Society of Automotive Engineers |
| SMR | steam methane reformation |
| SolTrans | Solano County Transit |
| SOx | sulfur oxides |
| SPI | small paddle inductive |

# List of Acronyms (continued)

| | |
|---|---|
| STA | Solano Transportation Authority |
| STP | Surface Transportation Program |
| SUV | sport utility vehicle |
| TCRP | Transit Cooperative Research Program |
| ULSD | ultra-low sulfur diesel |
| UST | underground storage tank |
| V | volt |
| VOC | volatile organic compound |
| ZBUS | zero emission bus |
| ZEV | zero emission vehicle |

# Executive Summary

Local governments, transit agencies, and other vehicle owners are increasingly interested in using alternative transportation fuels because of their environmental benefits, ability to reduce dependency on petroleum, and potential cost savings. Although alternative fuel vehicles have been used in Solano County for more than a decade, the last several years have brought new opportunities through a wider variety of vehicle and fuel options, improvements in vehicle performance, and lower costs.

Recognizing both the potential benefits of, and obstacles to, alternative fuels for transportation, the Solano Transportation Authority (STA) Board unanimously approved the development of the first countywide plan for alternative fuels and related infrastructure for Solano County in September 2011. The STA Board identified four initial goals for the plan, which were subsequently clarified by the Alternative Fuels and Infrastructure Plan Technical Working Group. The goals are as follows:

1. Reduce greenhouse gas emissions
2. Reduce criteria pollutant emissions
3. Encourage alternative fuels and vehicle technologies that provide economic benefits to Solano County public agencies, residents, and businesses
4. Take advantage of alternative fuel funding opportunities

This plan is intended to help local government and other public agencies to increase the use of alternative fuels within their jurisdictions and achieve the four goals identified by the STA Board. The plan should be considered a starting point and not a detailed investment strategy; any fleet or agency considering major investments in new vehicles or fueling infrastructure will likely need to conduct more specific analyses of costs and engineering feasibility. It is hoped that this plan will help to elevate interest in alternative fuels, highlight the most promising options and implementation steps, and foster new collaboration among public agencies and between the government and the private sector.

## Types of Alternative Fuels

The major alternatives to gasoline and diesel include biofuels (ethanol and biodiesel), fossil fuel alternatives (natural gas and propane), and emerging transportation energy sources (hydrogen and electricity). These fuels differ widely in terms of their sources and applications.

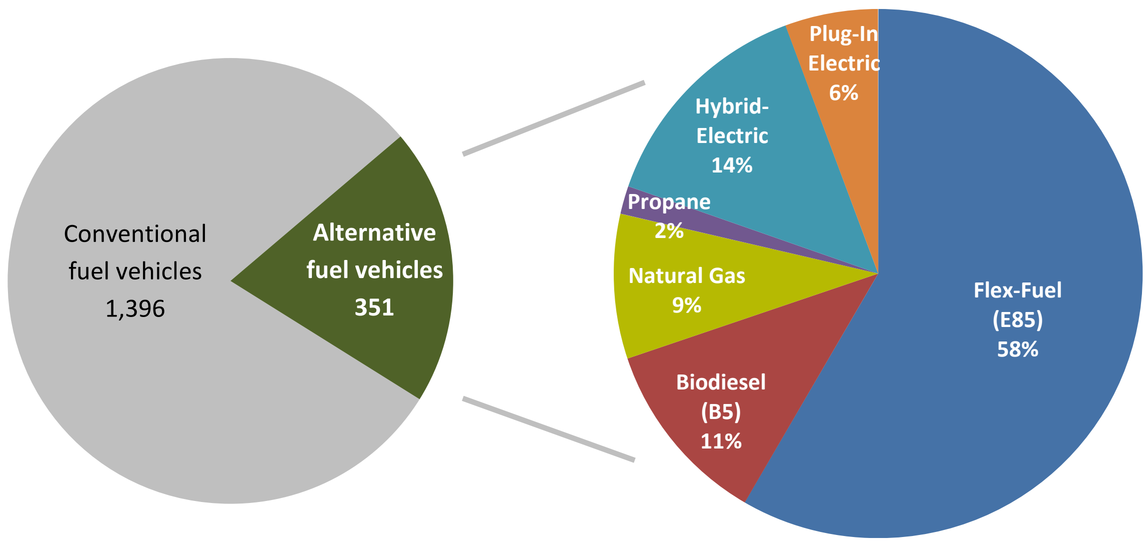
- **Ethanol** is a renewable fuel made primarily from corn. Nearly all gasoline used for transportation in the United States contains up to 10% ethanol. Flexible fuel vehicles (FFVs) can run on 85% ethanol blended with gasoline (E85). FFVs are widely available from nearly every major auto manufacturer.
- **Biodiesel** is a renewable fuel, typically made from soybean or waste oils. Most biodiesel is used in low-level blends with diesel, typically B5 or B20, and can be used in many engines without modification. Pure biodiesel (B100) often requires equipment changes.

- **Natural gas** is an odorless, gaseous mixture of hydrocarbons, predominantly methane. Vehicles can run on compressed natural gas (CNG), which is stored on-board a vehicle in pressurized cylinders. CNG models are available for light-, medium-, and heavy-duty vehicles. Liquefied natural gas (LNG) is also used as a transportation fuel, primarily for heavy-duty vehicles.
- **Propane**, or liquefied petroleum gas (LPG), is produced either as a byproduct of natural gas processing or by crude oil refining. Propane is mainly used in light-duty pickup trucks, taxis, medium-duty vans, and heavy-duty school buses. Most propane vehicles are converted from gasoline vehicle, rather than produced by an original equipment manufacturer (OEM).
- **Electricity** can be used to power all-electric vehicles (also referred to as battery electric vehicles or BEVs) and plug-in hybrid electric vehicles (PHEVs). All electric vehicles (EVs) draw electricity from the electricity grid and store the energy in batteries. In a BEV, the battery powers the motor. PHEVs also have an electric motor that uses energy stored in a battery, as well as an internal combustion engine that can run on conventional or alternative fuel. Although technically they do not use alternative fuels, hybrid electric vehicles (HEVs) are an advanced technology that can accomplish many of the same objectives as alternative fuel vehicles, including emissions reduction and fuel savings.
- **Hydrogen** is an emerging fuel and not widely used for transportation at this time. Extensive government and industry research and development are focused on hydrogen production and hydrogen fuel cell vehicles (FCVs). In FCV applications, the fuel cells generate electricity by using hydrogen as a fuel. While several transit agencies in California are operating hydrogen buses, significant challenges with respect to cost and durability of the hydrogen FCV must be resolved before mass production is possible.

## Current Alternative Fuel Vehicles and Infrastructure

Solano County and its seven incorporated cities and public transit agencies currently operate approximately 1,750 on-road vehicles, including automobiles and light-duty trucks, medium- and heavy-duty trucks, vans and minibuses, and full-size transit buses. Approximately 20% of these vehicles use, or are capable of using, alternative fuels, as shown in Figure ES-1.

**Figure ES-1. Percent of Alternative Fuel Vehicles in Solano County Municipal Fleets**




The most common type of alternative fuel vehicle in the County (and nationally) is a flexible fuel vehicle that can operate on gasoline, E85, or a mixture of the two. Other examples of current alternative fuel vehicles in the County include:

- **Biodiesel**. Solano County's 40 diesel vehicles operate on B5 (5% biodiesel blend).
- **Natural gas vehicles**. Vacaville City Coach's entire fleet of 15 transit buses runs on CNG. Vacaville also operates 8 CNG Honda Civic sedans and 7 CNG pick-up trucks and vans. Suisun City has a CNG pick-up truck.
- **Propane vehicles**. Solano County owns 6 propane pick-up trucks.
- **Hybrid-electric vehicles**. Solano County Transit (SolTrans) operates 21 diesel-hybrid buses and FAST operates 7 hybrid buses. Vallejo has 21 hybrid-electric vehicles. Benicia, Fairfield, and Rio Vista also have hybrid-electric sedans or SUVs.
- **Battery-electric vehicles**. Vacaville operates 17 Toyota RAV4 BEVs, and another BEV is operated by Rio Vista. Benicia has 2 plug-in hybrid vehicles.

In terms of alternative fuel infrastructure, Solano County is limited as compared the Sacramento region and the rest of the Bay Area. As shown in Table ES-1, most of the alternative fueling stations are located in Vacaville and Fairfield, and many are not available to the public.

**Table ES-1. Number and Location of Alternative Fuel Infrastructure in Solano County**

| Fuel Type | Public Fueling Stations | Private Fueling Stations |
|---|---|---|
| E85 | 2 (Vacaville and Fairfield) | 1 (Solano County Corporation Yard) |
| Biodiesel | none | 2 (Travis AFB and Solano County Corporation Yard) |
| Natural Gas | 1 (Vacaville) | 2 (Fairfield and Vacaville Corporation Yard) |
| Propane | 1 (Vacaville) | 1 (Solano County Corporation Yard) |
| Electric Vehicle Charging | 26+ (various locations) | 2 (Vacaville) |

## Costs and Benefits

Alternative fuel vehicles vary widely in terms of their cost implications for vehicle fleets and their environmental benefits. While it is difficult to compare costs with a high degree of precision, the following generalizations can be made:

- Among **light duty vehicles**, most alternatives to gasoline vehicles carry a higher initial purchase price, including hybrid-electric, battery electric, CNG, and propane vehicles. However, the annual fueling costs for alternative fueled light duty vehicles are often lower, especially in the case of CNG, hybrids, and EVs. Whether this fuel cost savings offsets the higher purchase price over the vehicle lifetime depends on how much the vehicle is driven, the fuel cost differential, and other factors.
- Among **transit buses**, a CNG and hybrid bus typically cost 12% and 35% more than their conventional diesel counterpart, respectively. Fueling costs for hybrid and CNG buses are lower. If the agency owns its CNG fueling facility, CNG bus fleets can enjoy fueling costs that are as much as 3-4 times lower than diesel.

Nearly all alternative fuel vehicle options will reduce air pollutant and greenhouse gas emissions to some degree. From a public health standpoint, the pollutants of greatest concern in Northern California are nitrogen oxides (NOx), volatile organic compounds (VOCs), fine particulate matter (PM2.5), and diesel particulate matter (DPM). The greatest air pollution benefits come from BEVs, which produce zero tailpipe emissions. CNG and B100 also produce large emission reductions for several pollutants; both fuels eliminate DPM. E85 and low-level biodiesel blends reduce most pollutants by 10% - 20%.

Greenhouse gas (GHG) emissions benefits depend not only the fuel and vehicle type but also on the source of the fuel. BEVs have the lowest GHG emissions – typically 65% lower than a gasoline vehicle. CNG and propane have GHG benefits in the range of 10 – 30%. The GHG benefits of E85 depend heavily on source of the ethanol. Typical corn-based ethanol has only marginal GHG benefits compared to gasoline. Ethanol made from plant waste matter can have GHG benefits as large as 60%.

## Implementation Steps

For agencies that are interested in increasing use of alternative fuels, the implementation steps listed in Table ES-2 should be considered. These recommendations are based on a high-level assessment; a more detailed assessment that considers specific sites and operating environments would be needed to fully understand the benefits and drawbacks that any one alternative fuel type offers.

**Table ES-2. Summary of Implementation Steps to Increase Use of Alternative Fuels**

| Fuel Category | Implementation Steps and Action Items |
|---|---|
| **Biofuels** | **E85**<br>• Educate vehicle operators about FFVs already in fleets that can utilize E85<br>• Investigate modifying fueling infrastructure to install E85 by either retrofitting existing or installing new storage tanks and dispensers<br>• Engage local retail fueling station owners and E85 infrastructure providers to determine the feasibility of expanding E85 to the general public<br>• Identify grant opportunities to support public and private expansion of E85<br>**Biodiesel**<br>• Check engine warranties to determine if any buses or heavy trucks are incompatible with low-level biodiesel blends (e.g., B5)<br>• When renegotiating contracts with diesel suppliers, require B5 as part of the specification (assuming no engine warranty concerns)<br>• To prepare for a future move to B20 for diesel fleets: (1) update procurement procedure to account for B20, (2) confirm engine warranties for current vehicles are covered with B20, (3) confirm existing underground storage tanks are B20 compatible and, if incompatible, (4) seek to update tanks for compatibility |

| Fuel Category | Implementation Steps and Action Items |
| --- | --- |
| **Natural Gas** | **Expanding Fueling Infrastructure**<br>• Identify potential refueling station locations<br>• Perform feasibility studies of these locations to determine station cost and proximity to current or future natural gas vehicle fleets<br>• Investigate options for new natural gas station development (station built by local agency vs. private developer)<br>**Overcoming Incremental Vehicle Costs**<br>• Pursue federal, state and regional funding sources to reduce NGV incremental costs<br>**Overcoming Unfamiliar Maintenance and Operation Procedures**<br>• Contact the local fire marshal and utility to help identify safety guidelines<br>• Contact other local fleets that have installed natural gas stations and maintain their own fleets to help identify any required upgrades or improvements and changes to maintenance practices<br>• Participate in Natural Gas Transit Users Group, which shares lessons learned and problem-solving techniques; provides a technical forum for fleet maintenance staff; and communicates safety issues, codes, and standards |
| **Electricity** | **Expanding Infrastructure Deployment**<br>• Utilize the Bay Area Plug-In Electric Vehicle Readiness Plan to identify new locations for potential public charging infrastructure<br>• Pursue identified potential EVSE deployment funding sources<br>**Ensuring EV Readiness for Local and Regional Governments**<br>• Review the checklist of recommendations from the Bay Area Plug-In Electric Vehicle Readiness Plan<br>• Identify steps to implement the prioritized items with an emphasis on (1) building codes, (2) permitting and inspection practices, and (3) zoning, parking rules and local ordinances<br>**Deploying EVs in Municipal Fleets**<br>• Identify potential fleets in the County interested in EVs<br>• Perform feasibility studies for fleets, including vehicle and infrastructure costs, infrastructure and vehicle credits and rebates, and potential LCFS revenue from the sale of credits<br>• Contact local fleets that invested in EVs and have taken advantage of federal, state, and regional credits, rebates and funding sources (such as Alameda County), to help in determine accurate costs for feasibility studies<br>• Identify opportunities to deploy hybrid-electric vehicles for municipal fleets or transit. |

# 1. Introduction and Background

This document is a plan for expanding the use of alternative transportation fuels in Solano County. Many local governments, transit agencies, and other vehicle owners are interested in alternative fuels because of their environmental benefits and potential to reduce dependency on petroleum. Although alternative fuel vehicles have been used by Solano County for more than a decade, the last several years have brought a wider variety of vehicle and fuel options, improvements in vehicle performance, and lower costs. This plan reviews the major choices for alternative fuels and vehicles, assesses their benefits and costs, and identifies implementation actions to help overcome barriers to greater use of alternative fuels.

## Challenges and Opportunities with Alternative Fuels

Alternative transportation fuels are not entirely new. Electric-powered vehicles were first introduced in the early days of the automobile. During the energy crisis of the 1970s, alternatives to petroleum began to receive serious consideration. Vehicles were introduced that could run on alcohol-based fuels such as ethanol and methanol. During the 1990s, the State and several transit agencies experimented with operating automobiles and buses running on 85% methanol blended with 15% gasoline (M85); more than 15,000 M85 flex-fuel vehicles were on the road in California in the late 1990s. Around that time, General Motors introduced the EV-1, the first mass-produced electric vehicle from a major automaker.

Despite the public and private sector efforts over the last several decades, alternative fuels have failed to make more than a small dent in the transportation fuels market, long dominated by gasoline and diesel. These conventional fuels benefit from an extensive and efficient system of fuel production, distribution, and retailing that helps to keep gasoline and diesel convenient and relatively cheap. Vehicle manufacturers reinforce the status quo by offering the greatest variety and lowest prices for vehicles that run on gasoline and diesel. Today, alternative fuel vehicles make up only approximately 0.5% of all vehicles on the road in the United States.

While the current market share is small, there are indications that alternative fuels may be poised to gain a significant toehold in the transportation sector. State and federal mandates and incentives are helping to drive private research and development, with a goal of producing alternative fuels that are cleaner and cost-competitive. Technology advances have lowered the cost of batteries and other key components of alternative fuel vehicles. The abundant supply and low price of natural gas is generating tremendous interest from private sector fleets as well as some government fleets. To cite a few examples of these recent developments:

- Consumption of biodiesel in the United States has grown from essentially zero in 2000 to nearly 900 million gallons in 2011.
- California now has 60 retail stations selling 85% ethanol blend (E85, a blend of 85% ethanol and 15% gasoline by volume), double the number available in 2009.

- More than 50,000 plug-in electric vehicles were sold in the U.S. in 2012, up from 345 vehicles in 2010. Nearly all major automobile manufacturers will offer plug-in electric vehicles within the next several years.
- Approximately 19% of buses nationwide now operate on natural gas, and natural gas buses account for fully one-third of the new buses on order by transit agencies.

The advantages of using alternative fuels can be substantial. For many, the most compelling reason to switch to alternative fuels is the environmental benefits. Most alternative fuel vehicles produce lower emissions of particulate matter, nitrogen oxides, and other pollutants that cause air pollution and adverse public health effects. Most alternative fuel vehicles also produce fewer greenhouse gas (GHG) emissions that contribute to global climate change. In some cases, using alternative fuels, particularly natural gas and electricity, can also reduce vehicle operating costs. Even if alternative fuels do not reduce operating costs, they may be less subject to the price volatility that has plagued petroleum-based fuels in recent years and creates challenges for public agencies operating on tight budgets. Buyers of alternative fuel vehicles may also be able to take advantage of incentive funding available from federal, state, and regional public agencies.

## Role of Local Governments and Other Public Agencies

Local governments and other public agencies can accelerate the transition to alternative fuels in a number of ways. By operating alternative fuel vehicles, public agencies lead by example, helping to support nascent markets and demonstrating to businesses and residents the feasibility of the vehicles. Opportunities exist to expand the use of alternative fuels among municipal fleets in Solano County, given that 85% of the county's approximately 1,400 municipal vehicles run on conventional gasoline and diesel. In some cases, limited fueling or charging infrastructure may be hindering the use of alternative fuels; in these instances, governments can help to expand the needed infrastructure through direct investment or by facilitating public and private partnerships. Local government planning and permitting actions can also encourage private sector deployment of alternative fuel infrastructure and vehicles.

While many elected officials and city staff recognize the promise of alternative fuels, the path forward is often unclear. The numerous options for alternative vehicles and fuels, and their environmental benefits, can be confusing. Further complicating the choices are the differences in fuel costs and requirements for alternative fueling infrastructure. Some options necessitate a large up-front investment, with the potential for longer-term cost savings and major environmental gains. Other options bring more modest benefits but can be achieved relatively quickly and with little capital cost.

## Plan Goals and Vision

Recognizing both the potential benefits of, and obstacles to, alternative fuels for transportation, the Solano Transportation Authority (STA) Board unanimously approved the development of the first countywide plan for alternative fuels and related infrastructure for Solano County in September 2011. The STA Board identified four initial goals for the plan, which were subsequently clarified by the Alternative Fuels and Infrastructure Plan Technical Working Group. The goals are as follows:

5. Reduce greenhouse gas emissions
6. Reduce criteria pollutant emissions
7. Encourage alternative fuels and vehicle technologies that provide economic benefits to Solano County public agencies, residents, and businesses
8. Take advantage of alternative fuel funding opportunities

The Technical Working Group also agreed on the following vision for the plan:

> ***Solano County will maximize alternative fuel use where feasible to protect public health, mitigate the effects of climate change, and capture economic benefits while continuing to serve the mobility needs of the county's residents and businesses.***

This plan is intended to help local government and other public agencies to increase the use of alternative fuels within their jurisdictions and achieve the four goals identified by the STA Board. The plan should be considered a starting point and not a detailed investment strategy; any fleet or agency considering major investments in new vehicles or fueling infrastructure will likely need to conduct more specific analyses of costs and engineering feasibility. It is hoped that this plan will help to elevate interest in alternative fuels, highlight the most promising options and implementation steps, and foster new collaboration among public agencies and between the government and the private sector.

## Plan Organization

The remainder of this plan is organized in four main sections.

- **Chapter 2** provides an overview of the six major transportation alternative fuels: ethanol, biodiesel, natural gas, propane, hydrogen, and electricity.
- **Chapter 3** presents a summary of the vehicle fleets owned and operated by Solano County's municipal agencies, including alternative fuel vehicles. This chapter also describes the current state of infrastructure to supply alternative fuels in the county.
- **Chapter 4** reviews the benefits and costs of alternative fuel vehicles in four categories: fleet cost impacts, air pollution and health impacts, greenhouse gas emissions impacts, and funding sources.
- **Chapter 5** presents implementation steps for achieving the plan goals, with an emphasis on near-term actions that can be led by Solano County public agencies.

The information most relevant to the four plan goals established by STA and the Technical Working Group is contained in Chapter 4.

# 2. Overview of Alternative Fuels for Transportation

The major alternatives to gasoline and diesel include biofuels (ethanol and biodiesel), fossil fuel alternatives (natural gas and propane), and emerging transportation energy sources (hydrogen and electricity). These fuels differ widely in terms of their sources and applications. This section provides an overview of the six major transportation alternative fuels.

## 2.1. Ethanol

### Description

Ethanol is a renewable fuel made from various plant materials collectively referred to as *biomass*. Also known as *ethyl alcohol*, it is a clear, colorless liquid. Ethanol can be made from corn grain (typical in the United States), sugar cane (mainly in Brazil), or cellulosic feedstocks (non-food based feedstocks such as crop residues). Currently, the United States produces almost all of its ethanol from corn feedstocks, with small niche markets using other materials. Ethanol is produced largely in the Midwest, corresponding with the bulk of the nation's corn production. The U.S. ethanol industry includes more than 200 operational production facilities and a number of facilities currently under construction.[1]


Cellulosic ethanol is produced from dedicated energy crops, such as wood chips or crop residues. While it is more difficult to release the sugars in these feedstocks for ethanol production, they offer several advantages over starch and sugar crops. Cellulosic feedstocks are more abundant and can include waste products or feedstocks that can be grown on land not appropriate for other crops. In addition, less energy is required to grow, collect, and convert these feedstocks to ethanol. Researchers are currently addressing challenges associated with cellulosic ethanol production. For example, enzymes and microbes are currently under development that can accelerate deconstruction of cellulosic biomass into the sugars used for ethanol production.

Ethanol's octane number is greater than gasoline, making it ideal for blending with gasoline (octane increases vehicle power and performance). The energy content of ethanol is less than that of gasoline; 1 gallon of pure ethanol (E100) contains approximately 34% less energy than 1 gallon of gasoline.

More than 95% of gasoline used for transportation in the United States contains up to 10% ethanol to boost octane levels, meet air quality requirements, or satisfy mandates such as the U.S. Environmental Protection Agency's (EPA's) Renewable Fuel Standard. E10 (gasoline mixed with 10% ethanol) can be used in any gasoline-powered vehicle. Other low-level blends of ethanol are also available, and E15 was recently approved by EPA for use in conventional gasoline vehicles that are model years 2001 and newer.

While the use of ethanol in the California retail motor fuels market is largely dominated by E10, more ethanol is being introduced into California (and the United States in general) through the expansion of E85. The remainder of this report focuses on these higher level ethanol blends.

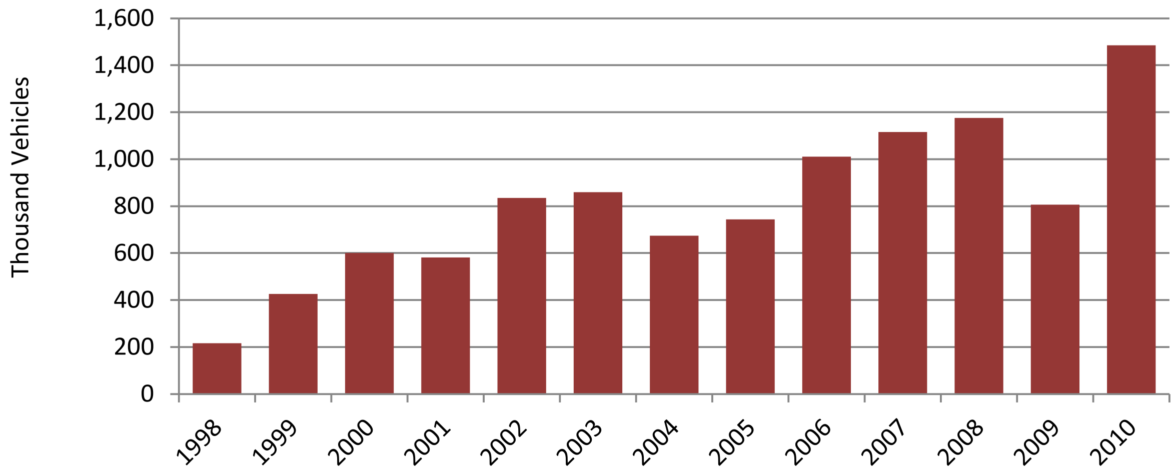
## Current Uses

Ethanol is used as a substitute for conventional gasoline in light-duty vehicle (LDV) applications.  While low-level blends can be used in gasoline-powered vehicles without alterations, E85 has different properties than gasoline. Consequently, only automobiles with compatible fuel systems and powertrain calibration can operate using the fuel. These vehicles are referred to as flexible fuel vehicles (FFVs). FFVs have an internal combustion engine (ICE) and are capable of operating on gasoline, E85, or a mixture of the two. From the driver's perspective, the only difference between FFVs and conventional gasoline-powered vehicles is the reduced fuel economy when using E85 or other mid-level blends. Gasoline-powered vehicles can be converted to FFVs, although it requires extensive modifications to the original vehicle.


FFVs are widely available from nearly every major auto manufacturer, in part because manufacturers are able to earn credits toward the federal corporate average fuel economy (CAFE) standards by selling FFVs. Ford, Chrysler, and General Motors offer the widest variety of FFVs. Most models of pickups, sport utility vehicles (SUVs), and vans, as well as many sedans, are available with an FFV option. The price of a new FFV is typically similar or identical to its gasoline counterpart.

Figure 2-1 shows the growth in the number of on-road FFVs that were sold, leased, or converted in the United States between 1998 and 2010. Presently, E85 FFVs account for two of every three alternative fuel vehicles in use nationwide. It is important to note, however, that many (perhaps most) FFVs are fueled primarily with gasoline.

**Figure 2-1. E85 Flexible Fuel Vehicles Sold, Leased, or Converted per Year in the U.S. (1998–2010)**




Source: Alternative Fuels Data Center, http://www.afdc.energy.gov/

In California, it is estimated that approximately 360,000 FFVs are currently using E85 (see Table 2-1). The FFVs are spread throughout all counties and account for 1–2% of all LDVs in each county.

**Table 2-1. E85 Flexible Fuel Vehicle Population in California**

| Vehicle Class | Flexible Fuel Vehicles | All Vehicles | % |
|---|---|---|---|
| Passenger car | 62,376 | 14,106,362 | 0.4% |
| Sport utility vehicle | 128,658 | 5,368,323 | 2.4% |
| Van | 50,884 | 1,816,770 | 2.8% |
| Pickup truck | 121,012 | 4,135,251 | 2.9% |
| **Total** | **362,930** | **25,426,706** | **1.4%** |

Source: ICF International, 2011, "Technical Analysis for Alternative and Renewable Fuel and Vehicle Technology Program, Task 2—Evaluate Alternative and Renewable Fuel Infrastructure and Distribution Development for E85." Prepared for the California Energy Commission, June

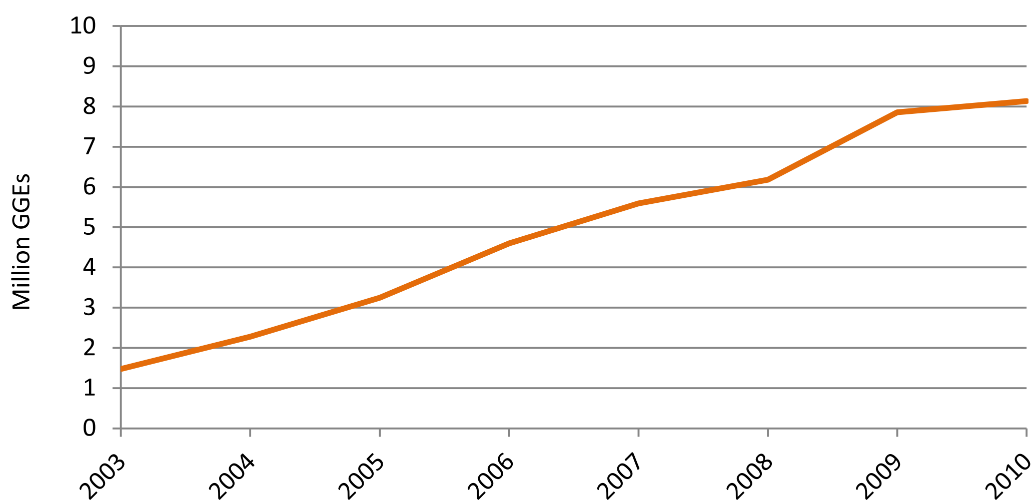
In Solano County, local governments currently operate more than 130 FFVs, including 120 FFVs owned by the County. Solano County's Corporation Yard #1 includes an E85 fueling facility (shown below).


**E85 Fueling Facility at Solano County Corporate Yard**

## Fuel Supply, Demand, and Price

In 2010, the total amount of E85 consumed in California was 8,134,000 gasoline gallon equivalents (GGE), or approximately 0.4% of total gasoline consumption.[2] Consumption of E85 in California has increased five-fold between 2003 and 2010, as illustrated in Figure 2-2. Despite the strong growth in E85 consumption, however, use of the fuel is still dwarfed by other alternative transportation fuels. E85 accounts for only 6% of total alternative transportation fuel use in California, on a GGE basis.

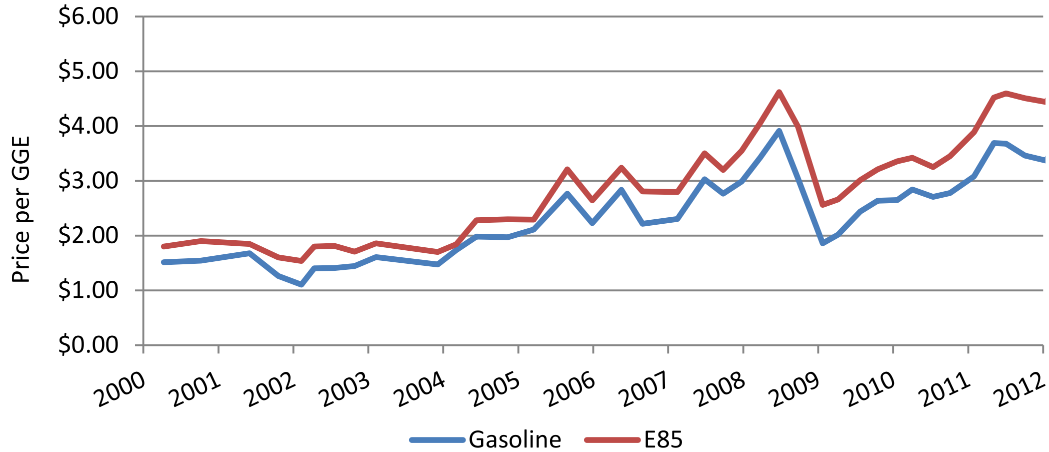
**Figure 2-2. E85 Consumption by Motor Vehicles in California (2003–2010)**




Source: Alternative Fuels Data Center, http://www.afdc.energy.gov/

As of January 2013, the average price for E85 on the West Coast was $3.34/gallon.[3] As mentioned above, 1 gallon of E85 contains less energy than 1 gallon of gasoline; therefore, using E85 results in a lower fuel economy compared to gasoline, amounting to an approximately 25% decrease in miles per gallon. Since 2000, the price of E85 has generally followed retail gasoline prices (see Figure 2-3). The prices shown for E85 have been adjusted to account for the lower energy content of ethanol. In the future, the price of E85 is expected to grow at a slower rate than gasoline, since it is derived from a renewable and domestic source. At some point, E85 may become less expensive than gasoline.

**Figure 2-3. Price of E85 and Gasoline, Nationwide (2000–2012)**




Source: Alternative Fuels Data Center, http://www.afdc.energy.gov/

## 2.2. Biodiesel

### Description

Biodiesel is a renewable fuel made by reacting animal or vegetable fats with alcohol. Approximately 70% of the nation's biodiesel is produced in the Midwest, where soybean oil is the dominant biodiesel feedstock.[4] California currently has six biodiesel producers, with total capacity of 90 million gallons per year (approximately 5% of the total U.S. production capacity). Most California plants have multi-feedstock capabilities and use a variety of feedstocks, including waste cooking oils, waste animal fats, and waste corn oil from ethanol production.[5] Currently, California' biodiesel comes primarily from waste oils.[6]

Most biodiesel is used in low-level blends, usually as 5% or 20% biodiesel blended with conventional diesel, referred to as B5 or B20, respectively. B20 is the most common blend in the United States as it provides good cold-weather performance, is generally cost effective, and can be used in most engines without modification. Pure biodiesel (B100) is available in the marketplace and can be used in some engines without modification, although equipment changes may be necessary in other engines.

Approximately 80 fueling stations are currently selling B20 or higher level blends in California. Of these, approximately 50 stations are available to the public; the remaining stations primarily are operated by federal government fleets. The only station currently dispensing B20 in Solano County is at Travis Air Force Base.

## Uses and Applications

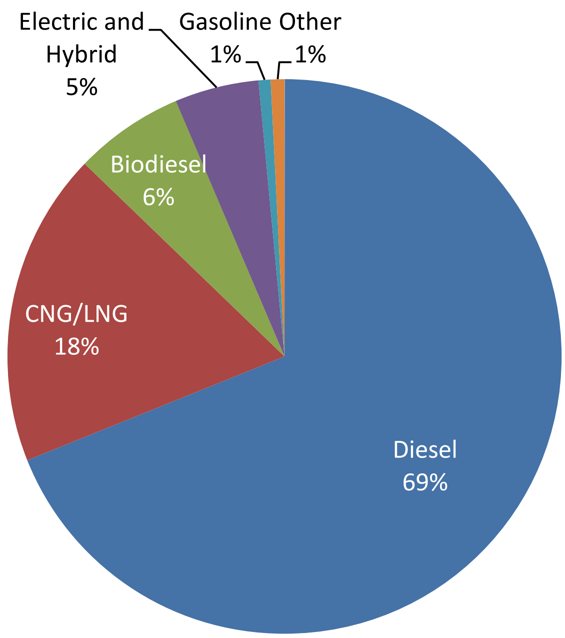
In contrast to most other alternative fuels, biodiesel does not require a specific alternative fuel vehicle. Depending on the blend level, biodiesel can be used in most conventional diesel vehicles. High-level blends tend to have a solvent effect that cleans a vehicle's fuel system and releases deposits accumulated from previous petroleum diesel use. Once released, these deposits may initially clog filters and require filter replacement in the first few tanks of high-level biodiesel blends. As such, vehicle operators should consult their vehicle and engine warranty statements before using biodiesel, particularly before using biodiesel blends higher than B5.


Biodiesel can have a limited shelf life due to factors such as contamination and exposure to air, extreme temperatures, and additives. Shelf life issues are a greater concern with higher blends. Proper fuel management can dramatically extend biodiesel's shelf-life to a year or more, which is on par with conventional diesel.

A majority of the biodiesel used in the United States is consumed by commercial fleets and government entities, including transit agencies, waste haulers, and school districts. The San Francisco Municipal Transportation Authority operates more than 500 vehicles (mostly transit buses) on biodiesel (B20), making up the largest municipal biodiesel fleet in the nation.[7] The California Department of Transportation (Caltrans) fuels most of its diesel fleet with B5, and more than 500 of the San Diego Unified School District school buses will run on biodiesel blends by 2015.[8] Figure 2-4 shows that, as of 2009, 6% of transit buses nationwide were using biodiesel in some blend. More recent information from the American Public Transportation Association suggests that this fraction is now closer to 8%.[9]

B20 is the common blend, and most heavy-duty diesel engine manufacturers state that using up to B20 will not void engine warranties. Many fleets have successfully used B50 to B99 blends for several years or more.[10] In 2008, the American Society for Testing and Materials adopted biodiesel standards for blends up to B20 and for B99.

**Figure 2-4. Alternative Fuel Transit Buses in Service, Nationwide (2009)**




Source: American Public Transportation Association, 2011, "Fact Book"

Solano County uses B5 (5% biodiesel blend) in all of its 22 diesel vehicles, which are fueled at the County Corporation Yard. The County has plans to increase biodiesel blend levels to B10 or B20 in the near future.

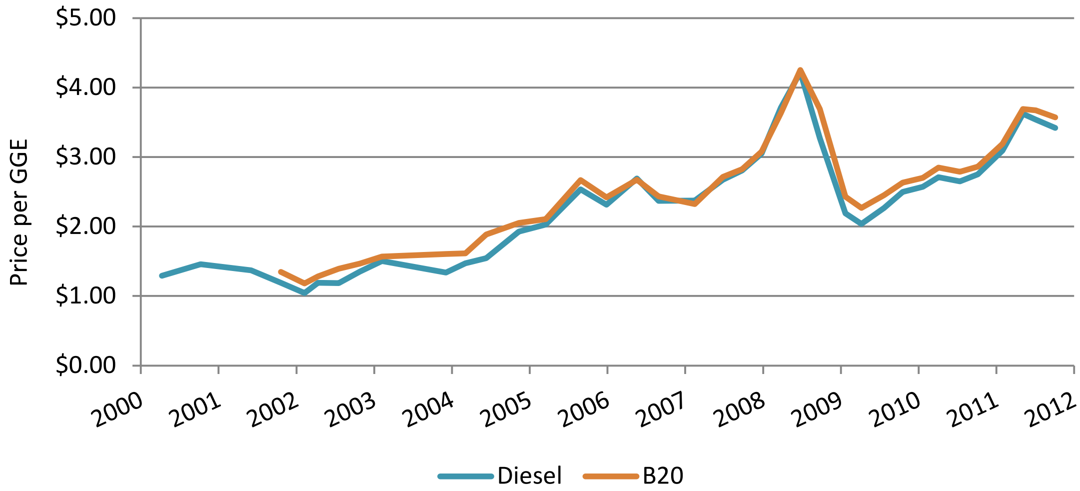
## Fuel Supply, Demand, and Price

Total U.S. biodiesel consumption in 2011 was 878 million gallons, or 1.5% of all diesel fuel consumed.[11] While biodiesel accounts for only a small fraction of all diesel used, biodiesel consumption in 2011 reflects more than a three-fold increase over 2010 levels.

Growth over the last decade has generally been strong; however, production and consumption of biodiesel has fluctuated widely in the last several years, due in part to changes in tax laws. In 2008, U.S.-based producers generated approximately 678 million gallons of biodiesel. This production level fell to 311 million gallons in 2010, largely due to the temporary expiration of the $1.00-per-gallon federal tax credit for biodiesel blenders. The credit was allowed to expire on December 31, 2009, and resulted in a 49% drop in biodiesel production between 2008 and 2010. The credit was retroactively reinstated in December 2010. In 2011, the biodiesel industry saw record-breaking biodiesel production, which was also supported by EPA's revised Renewable Fuel Standard (RFS2) volume requirements. The biodiesel tax credit was renewed again in January 2013.

On the West Coast, the average price for biodiesel (B20) as of January 2013 was $4.19/gallon, approximately 2% higher than the average West Coast price of diesel ($4.11/gallon). Since 2002, B20 prices have closely tracked diesel prices, typically with a small price premium. Figure 2-5 compares the price of B20 and diesel nationwide from 2000 to 2012. As noted above, the federal $1.00-per-gallon retailer tax credit expired on December 31, 2011. While biodiesel prices have continued to shadow conventional fuel prices in 2012, expiration of the tax credit could result in a more dramatic affect if diesel prices come down. Biodiesel does contain approximately 8% less energy than petroleum diesel, which translates to a 1–2% difference when using B20; however, most users report no noticeable difference in fuel economy.

**Figure 2-5. Price of B20 and Diesel, Nationwide (2000–2012)**




Source: Alternative Fuels Data Center, http://www.afdc.energy.gov/

Greater use of biodiesel has been constrained by California's limited distribution and local fueling infrastructure, and the current price disparity between biodiesel and ultra-low sulfur diesel (ULSD), which is required in California.[12]

## 2.3. Natural Gas

### Description

Natural gas is an odorless, gaseous mixture of hydrocarbons, predominantly composed of methane ($CH_4$). One-quarter of the energy used in the United States is produced by natural gas. With plentiful reserves bolstered by newly accessible gas in shale formations, natural gas is a reliable, primarily domestic source of clean-burning fuel. Natural gas is typically extracted from gas and oil wells, as well as from supplemental sources such as biomass and coal. Gas trapped in reservoirs is extracted through drilling. Advances in hydraulic fracturing technologies have provided access to large volumes of natural gas from shale formations. In addition, natural gas can be derived from biogas, which is produced through anaerobic digestion of organic matter in biomass waste materials.

California receives most of its natural gas supply from Arizona, Nevada, and Oregon, with approximately 15% of the natural gas supply coming from in-state sources.

Natural gas in compressed (CNG) or liquefied (LNG) form has been used as transportation fuel in California for more than 20 years. The high octane number of natural gas makes it suitable for spark ignition (gasoline) engines with some modifications. Heavy-duty natural gas vehicles are also available. Some use spark ignition natural gas systems, while others use high-pressure direct injection in a compression ignition (diesel) cycle.

CNG is stored onboard a vehicle in cylinders pressurized at 3,000–3,600 pounds per square inch (psi). A CNG-powered vehicle has a similar fuel economy to a gasoline vehicle on a GGE basis, with a GGE equal to approximately 5.66 pounds of CNG. CNG is used in light-, medium-, and heavy-duty vehicles (HDVs).

Purifying natural gas and super-cooling it to -260°F creates LNG. Because it must be kept at cold temperatures, LNG is stored in double-walled, vacuum-insulated pressure vessels. Liquid is more dense than gas (CNG), so LNG is beneficial for vehicles that require a longer driving range—as more energy can be stored by volume in an LNG tank. As such, LNG is typically used in medium- and heavy-duty vehicles. A gallon of LNG has approximately 66% of the energy in a gallon of gasoline; consequently, a GGE equals approximately 1.5 gallons of LNG.

California has been a leader in natural gas vehicles and currently accounts for approximately one-half of the nation's use of natural gas for transportation. Moreover, demand for natural gas as a transportation fuel has been growing rapidly, due in part to the price advantages (discussed below). Approximately 250 CNG stations and 12 LNG stations are located in the state. Most CNG fueling stations compress the gas on site. Only a few large-scale liquefaction facilities provide LNG fuel for transportation nationwide; otherwise, LNG must be delivered to stations by truck.

## Uses and Applications

Natural gas can be used in virtually all types of on-road vehicles. There are actually three different types of natural gas vehicles (NGVs):

- Dedicated, which run only on natural gas;
- Bi-fuel, which use natural gas or gasoline; and
- Dual-fuel, which run on natural gas and use diesel for ignition assistance.

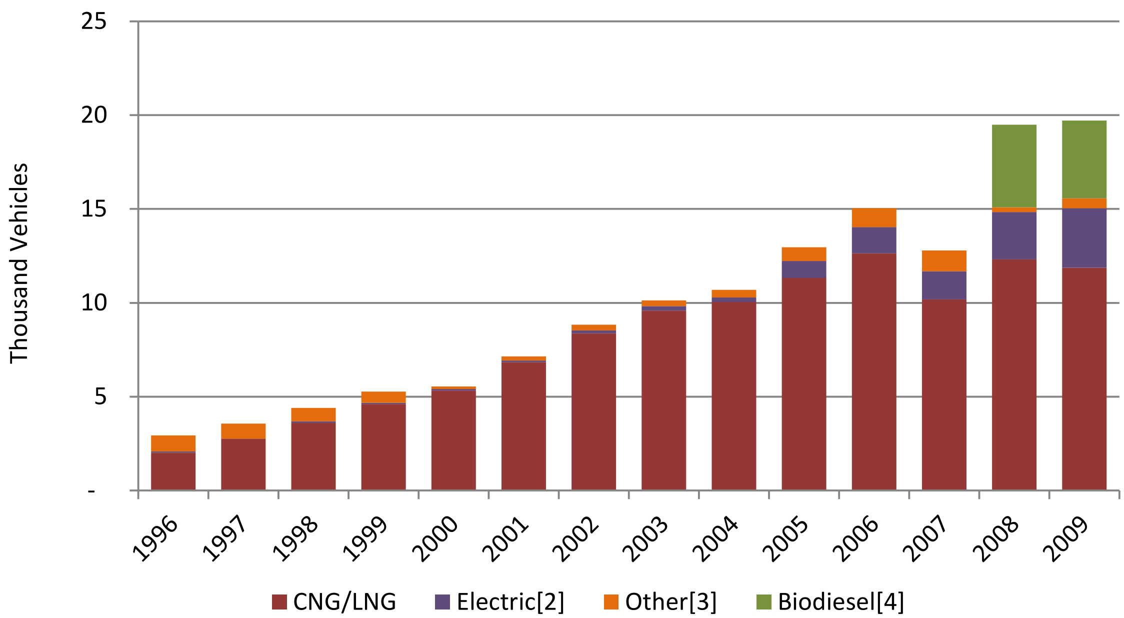
Dual-fuel vehicles are traditionally limited to HDVs. Dedicated NGVs tend to demonstrate better performance and produce lower emissions than bi-fuel vehicles. Because dedicated NGVs have only one fuel tank, they weigh less than bi-fuel NGVs and offer more cargo capacity. Although extra storage tanks can increase the range of an NGV, the additional weight may decrease the amount of cargo the vehicle can carry.

For light-duty uses, the only natural gas vehicle currently available from an original equipment manufacturer (OEM) is the CNG Honda Civic. More models are available for medium-duty truck and van applications. For example, a 2013 GMC Savana cargo van is available in a CNG version.[13] Many of the other on-road NGVs in use today are conversions.

For medium- and heavy-duty trucks, natural gas options are widely available. For example, medium-duty natural gas trucks are available from Ford, Freightliner, Kenworth, and Peterbilt, among others. Natural gas street sweepers and refuse trucks are produced by several manufacturers.

Among transit buses, natural gas has been the dominant alternative fuel. Approximately 12,000 natural gas transit buses are in operation nationwide, or 19% of the national bus fleet. As of 2010, transit agencies in California used an estimated 5,138 CNG and 327 LNG vehicles.[14] The Los Angeles County Metropolitan Transportation Authority contributes significantly to this count, with over 2,200 CNG transit buses in their fleet; these buses have logged over 1 billion miles.[15] Figure 2-6 shows the number of alternative fuel transit buses operating nationwide, from 1996 to 2009, as collected by the U.S. Energy Information Administration (EIA).

**Figure 2-6. Alternative Fuel Transit Buses, Nationwide (1996–2009)**




Notes: [1] Data not continuous between 2006 and 2007 due to new data sources and improved accuracy; [2] "Electric" includes catenary-electric, battery-electric, and hybrid-electric; [3] "Other" category includes propane, hydrogen, biodiesel (until 2008), and various blends; [4] "Biodiesel" category was counted in "Other" until 2008.

Source: American Public Transportation Association, Fact Book, 2011, http://www.apta.com/resources/statistics/Documents/FactBook/2011_Fact_Book_Appendix_A.pdf

In Solano County, Vacaville has been a leader and an award winner in the use of alternative fuels, especially natural gas, for transportation (see case study box in Section 4.2). Vacaville City Coach opted to transition to CNG for its bus fleet approximately 10 years ago, partly in response to the ARB "Fleet Rule for Transit Agencies," which required transit agencies to select a "diesel path" or "alternative fuels path" to comply with more stringent emissions standards for buses. All of the Vacaville's 15 full-size buses now run on CNG. In addition, Vacaville has been incorporating CNG sedans and pick-ups into its fleet, and currently has 15 CNG light duty vehicles. The city operates its own CNG fueling facility, and recently entered into agreement to sell CNG to Vacaville's private refuse hauling fleet. Suisun City also operates a CNG pick-up truck.

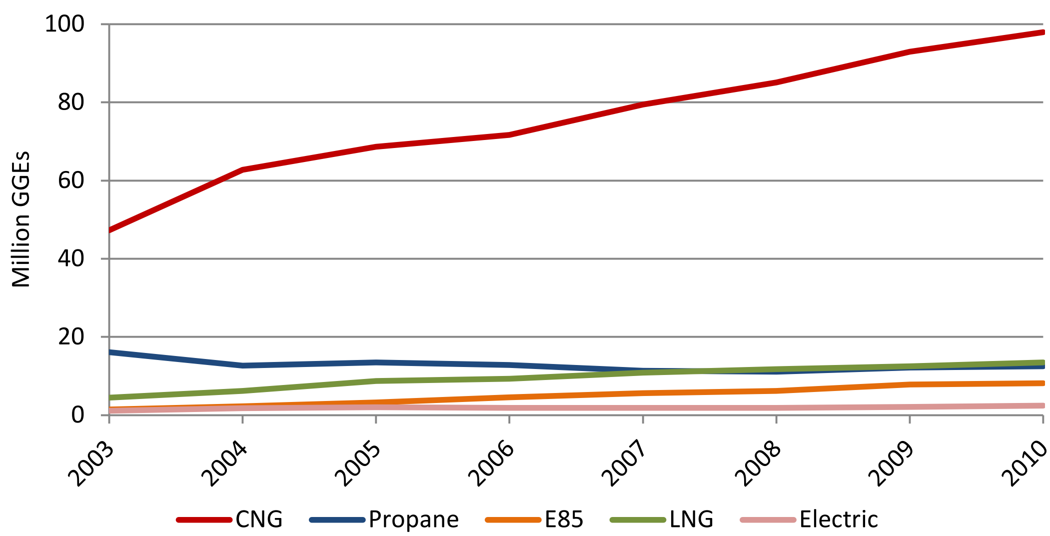

**Vacaville City Coach CNG Bus**

**Vacaville CNG Honda Civic**

## Fuel Supply, Demand, and Price

Over the last decade, use of natural gas for transportation has grown significantly and continues to do so. Figure 2-7 shows that transportation natural gas consumption has doubled since 2003.

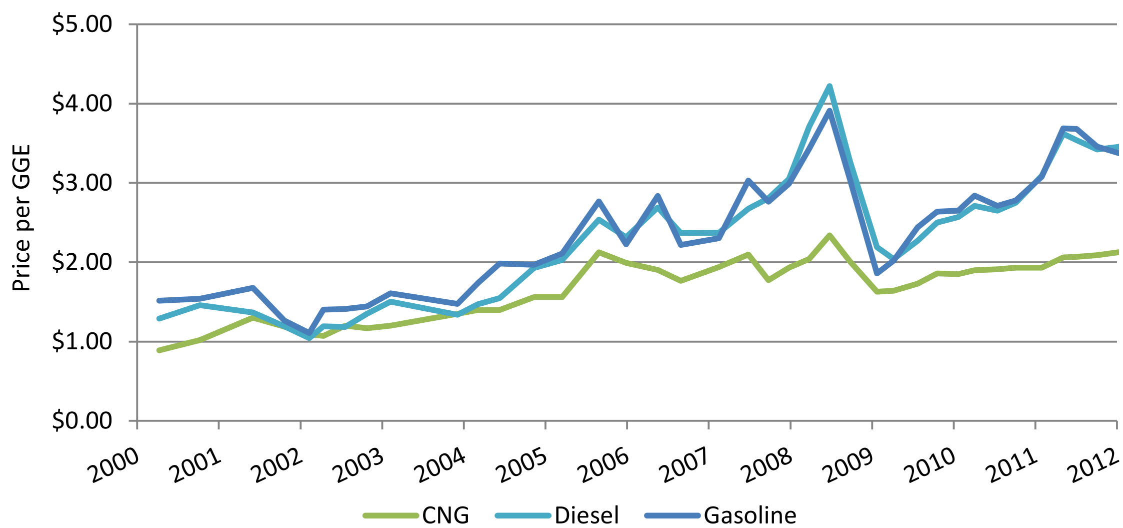
**Figure 2-7. Consumption of Alternative Fuels in the Transportation Sector in California (2003–2010)**




The strong interest in natural gas is due primarily to its price advantage over gasoline and diesel. As of January 2013, the average retail price for CNG on the West Coast was $2.39/GGE, compared to $3.54/gallon for gasoline and $4.11/gallon for diesel. A CNG-powered vehicle has approximately the same fuel economy as a conventional gasoline-powered vehicle on a GGE basis. Figure 2-8 shows that the price of CNG has remained relatively steady since 2000, while conventional fuel prices have fluctuated dramatically at times and increased overall.

For a fleet with its own CNG fueling station, natural gas prices are often much lower than retail. The station operator typically purchases bulk natural gas from the utility (e.g., Pacific Gas and Electric Company [PG&E]) and compresses the gas on site. The bulk purchase price for natural gas is in the range of $0.80–$0.90 per GGE, or approximately one-quarter the price of gasoline.

**Figure 2-8. Retail Price of Natural Gas, Diesel, and Gasoline, Nationwide (2000–2012)**




Source: Alternative Fuels Data Center, http://www.afdc.energy.gov/

## 2.4. Propane

### Description

Liquefied petroleum gas (LPG) is commonly referred to as *propane. Autogas* is another term specific to propane used in transportation. Propane turns into a colorless, odorless liquid when stored under pressure inside a tank. As pressure is released, the liquid propane vaporizes and turns into a gas, which is used for combustion. Propane presents no threat to soil, surface water, or groundwater. Additionally, propane has a high octane rating, which allows for increased vehicle power and performance.

Nearly all U.S. propane supply is produced in North America either as a byproduct of natural gas processing or by crude oil refining. Pipelines, railroads, barges, trucks, and tanker ships are used to ship propane from its points of production to bulk distribution terminals. Trucks are filled at the terminals, and propane dealers then distribute propane to end users, which include retail fuel sites. Currently, approximately 230 propane stations are found in California, the majority of which are available to the public. Public propane fueling locations in California are located at large propane distributor facilities such as AmeriGas, Ferrellgas, and Suburban Propane; smaller propane distributor locations; U-Haul facilities; and conventional fueling locations.

## Uses and Applications

Propane is mainly used in light-duty pickup trucks, taxis, medium-duty vans, and heavy-duty school buses. Propane is well suited for spark ignition engines, and gasoline engines can be converted relatively easily to use propane. The high octane rating of propane (104–112 compared to 87–92 for gasoline), combined with low carbon and oil contamination characteristics, results in engine life that can last up to two times longer than a gasoline engine. Propane can be stored onboard a vehicle as a liquid at a low pressure—between 100 and 200 psi, allowing for refueling times comparable to gasoline refueling.

The cruising speed, power, and acceleration of propane vehicles are similar to those of gasoline-powered vehicles. Propane has approximately 73% the energy content of gasoline per gallon; therefore, the typical range of an LDV equipped with a 20-gallon tank is approximately 250 miles. Driving range can be increased by adding additional storage tanks; however, the added weight displaces payload capacity.


Because few propane vehicles are offered by OEMs, propane normally requires conversion of a gasoline vehicle. Companies providing propane conversions include Baytech Corporation, Bi-Phase Technologies, CleanFuel USA, Emissions Solutions, Inc., and Roush CleanTech.

Propane has a small niche among transit fleets. As of 2010, an estimated 742 propane buses were in use in California. California transit agencies operate a total of 18 propane vehicles; the remaining buses are operated by school districts, other local government agencies, and private fleets.[16] For example, in addition to their extensive CNG bus fleet, Los Angeles County Unified School District operates 126 propane school buses.[17]

Propane can also be well suited to off-road applications such as fork lifts, commercial mowers and other grounds maintenance equipment, and airport ground support equipment.

Solano County owns and operates 6 propane pick-up trucks. The County's Corporation Yard includes a propane refueling facility (shown below).


**Solano County's Propane Fueling Station**

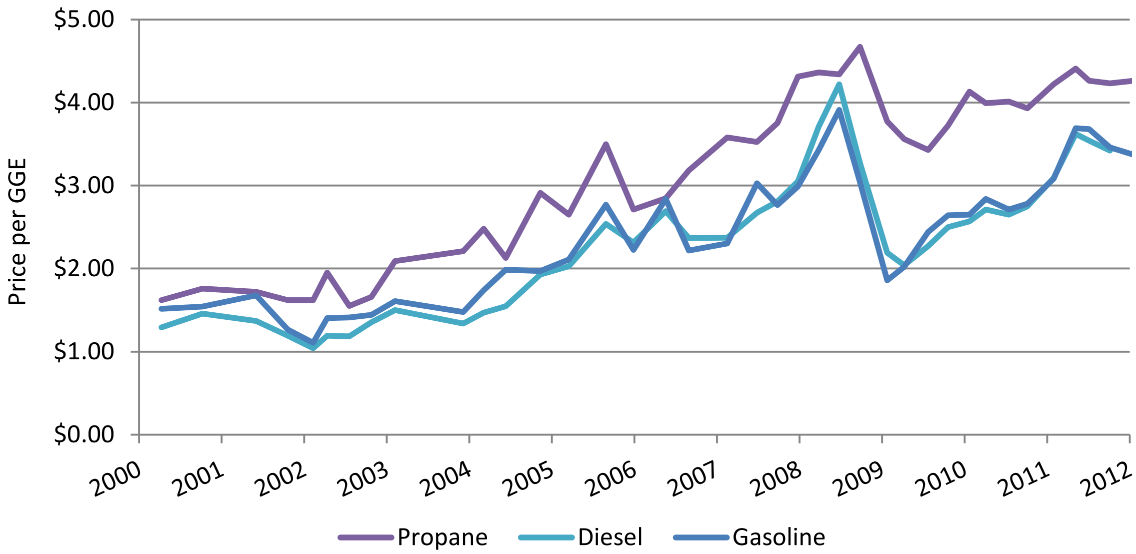
## Fuel Supply, Demand, and Price

Motor vehicles in California used 12 million GGEs of propane in 2010, or 0.1% of total gasoline use in the state. Propane consumption for transportation has steadily declined in recent years, due in part to limited vehicle offerings, limited fueling stations, and heightened interest in other alternative fuels. Nationwide, 2010 propane consumption for transportation was 44% lower than in 2003.

As of January 2013, the average price for propane on the West Coast was $2.93/gallon, compared to $3.54/gallon for gasoline. Note that these propane prices are reflective primarily of public stations reporting to the U.S. Department of Energy's (DOE's) Clean Cities Program. Private refueling station prices are generally lower, and a dedicated transportation fleet using propane could likely secure lower prices. In January 2013, the price for propane at private fueling stations was 20% lower than at public fueling stations.

As noted above, the energy content of propane fuel is approximately 73% of that of gasoline. This energy content difference is reflected in vehicle fuel economy. Propane vehicle providers report that the new liquid injection technologies appear to have only a 10–15% fuel efficiency disadvantage in practice, although there is currently no independent verification of these claims. Over the last several years, the price gap between propane and gasoline has narrowed; on a GGE basis, the two fuels are now quite similar in price, as shown in Figure 2-9.[18]

**Figure 2-9. Price of Propane, Diesel, and Gasoline, Nationwide (2000–2012)**




Source: Alternative Fuels Data Center, http://www.afdc.energy.gov/

## 2.5. Hydrogen

### Description

Hydrogen ($H_2$) is a colorless, odorless gas at earth-surface temperatures; however, it is rarely found in nature alone and is usually bonded with other elements. Hydrogen is found in large quantities in water ($H_2O$), hydrocarbons (such as methane), and other organic matter.

Presently, hydrogen is not widely used as a transportation fuel. Extensive government and industry research and development are focused on hydrogen production and hydrogen fuel cell vehicles (FCVs). The energy content in 2.2 pounds (1 kilogram) of hydrogen gas is approximately the same as the energy content in 1 gallon of gasoline. To ensure that FCVs have a driving range comparable to conventional vehicles, it is essential that an FCV store enough fuel on board to make up for hydrogen's low volumetric energy density. While some hydrogen storage technologies are currently undergoing additional research and demonstration, the majority of storage technologies are still under development—including bonding of hydrogen chemically with a material such as metal hydride. Hydrogen storage technologies currently undergoing demonstration include compressing gaseous hydrogen in high-pressure tanks at up to 10,000 psi and cooling liquid hydrogen cryogenically to -423°F (-253°C) in insulated tanks.

Most hydrogen used in the United States is produced near its end use location, typically at large industrial sites. Because there is no widespread demand for hydrogen as a transportation fuel, an effective hydrogen distribution system (e.g., a pipeline) has yet to be created for widespread use of FCVs. Of the approximately 50 hydrogen fueling stations in the United States, 23 are in California, and few are open to the public.[19] Hydrogen infrastructure development in California was bolstered by the California Hydrogen Highway Network Project, an effort introduced in 2004 to develop public hydrogen fueling stations in the state. The project has focused on cluster areas, including Los Angeles County, Orange County, Sacramento, and the San Francisco Bay Area. Currently, eight public hydrogen stations are located in the state—one in Emeryville and seven in Southern California.[20]

Most of the existing stations produce hydrogen using on-site electrolysis, with several using "green" electricity to power the electrolyzer. Several stations produce hydrogen using on-site solar arrays to power the electrolyzer. In addition, several stations plan to generate hydrogen in the future using on-site steam methane reformation. This development will largely depend on the stations transitioning toward a mass market opportunity, rather than a niche market that serves fewer than 10 vehicles.

## Uses and Applications

Hydrogen can be used as a fuel in both LDV and HDV applications. For years, hydrogen in FCVs has been considered attractive because of its zero tailpipe emissions, high efficiency, and fuel source diversity. For transportation, hydrogen is currently used primarily as a compressed gas, stored at 5,000 psi in both passenger car and transit bus applications. Although hydrogen FCVs have been under development since the 1970s, efforts to develop a pathway to commercialization took off in the late 1990s with investments from automakers, European and Japanese governments, and DOE.

The two main vehicle strategies are use of hydrogen fuel in an ICE vehicle or in an FCV. The main benefit of the ICE is the relatively low cost of converting a gasoline or diesel engine to use hydrogen. However, the amount of hydrogen that can be carried onboard an ICE vehicle in terms of energy content is quite small, equivalent to approximately only 4–5 gallons of gasoline. This makes the range of a hydrogen-fueled ICE vehicle quite low. Consequently, there has not been much interest in the hydrogen ICE vehicle. Nevertheless, it may be a bridging technology for FCVs.


In FCV applications, the fuel cells generate electricity by using hydrogen as a fuel in an electrochemical process. This electricity generated by a stack of cells is then used to drive an electric motor, which drives the vehicle. In some cases, the electric motors driving the vehicle are powered solely by a fuel cell, while others use a hybrid drive system that includes a battery pack or other power source for peaking requirements. This results in a zero emission vehicle, where the only exhaust products are water and heat.

Significant challenges with respect to cost and durability of the hydrogen FCV must be resolved before mass production is possible. While no light-duty hydrogen FCVs are commercially available on a nationwide basis at this time, Honda has begun leasing its FCX Clarity sedan to residents in Southern California (Torrance, Santa Monica, and Irvine). The company plans to lease 200 of the vehicles in the first 3 years of its program. In addition, Mercedes-Benz is planning a limited leasing program for their B-Class F-Cell vehicle in the Los Angeles and San Francisco Bay areas.[21]

Hydrogen buses are currently being tested in transit applications in California. A fuel cell bus demonstration project funded by DOE placed buses into revenue service at the Alameda-Contra Costa Transit District (AC Transit), Santa Clara Valley Transportation Authority, and SunLine Transit Agency in the Coachella Valley. Data collected from the buses involved in this effort have helped to evaluate FCV performance, emissions, costs, and operating characteristics.[22] AC Transit is now taking delivery of 12 new fuel cell buses with more sophisticated power systems.

### Fuel Supply, Demand, and Price

Hydrogen is an emerging fuel, and little is currently used in the transportation sector. Thus, fuel supply, demand, and price information are not comparable to information available for other fuels. The outlook for hydrogen vehicles is a long-term vision based on low carbon production options, zero tailpipe emissions, and the benefits of an electric drive system.

The market penetration of FCVs is affected by California's zero emission vehicles (ZEV) mandate, since battery electric vehicles (BEVs) and FCVs are the only technologies able to receive pure ZEV credits. In the near term (2012), the number of hydrogen LDVs being leased and tested in California is expected to reach approximately 200–300. Several auto manufacturers anticipate a 2015–2018 timeframe for FCV commercialization but, because of the underdeveloped fueling infrastructure, it is unclear how accepting consumers will be of these offerings.

In addition, California's zero emission bus (ZBus) regulation may affect market penetration, particularly in urban bus fleets. Under this regulation, beginning in 2011, transit agencies with a fleet of 200 or more urban buses must ensure that 15% of their new annual bus purchases are zero emission buses. In January 2010, the California Air Resources Board (ARB) postponed implementation of this regulation until the agency develops and approves new purchase requirements.

The DOE and others, including the California Fuel Cell Partnership and the California Energy Commission (CEC), have examined the long-term cost targets, with projections of $3–$6 per kilogram as a retail price. DOE's target price is $2–$4 per GGE, delivered and untaxed—a value at which hydrogen is competitive with gasoline.

## 2.6. Electricity

### Description

Electricity can be used to power all-electric vehicles (also referred to as battery electric vehicles or BEVs) and plug-in hybrid electric vehicles (PHEVs), collectively known as electric vehicles (EVs). All EVs draw electricity from off-board electrical power sources (i.e., the electricity grid) and store the energy in batteries. In a BEV, the battery powers the motor. PHEVs also have an electric motor that uses energy stored in a battery, as well as an ICE that can run on conventional or alternative fuel.

Although technically they do not use alternative fuels, hybrid electric vehicles (HEVs) are an advanced technology that can accomplish many of the same objectives as alternative fuel vehicles, including emissions reduction and fuel savings. Hybrid electric technology increases vehicle efficiency by introducing an electric motor and generator, an energy storage device (e.g., a battery), and power electronics. The electric motor and generator absorb energy via regenerative braking and store that energy in a battery to offset the acceleration and power demands of the vehicle. HEVs reduce petroleum consumption but do not utilize grid electricity to offset addition petroleum fuel consumption.

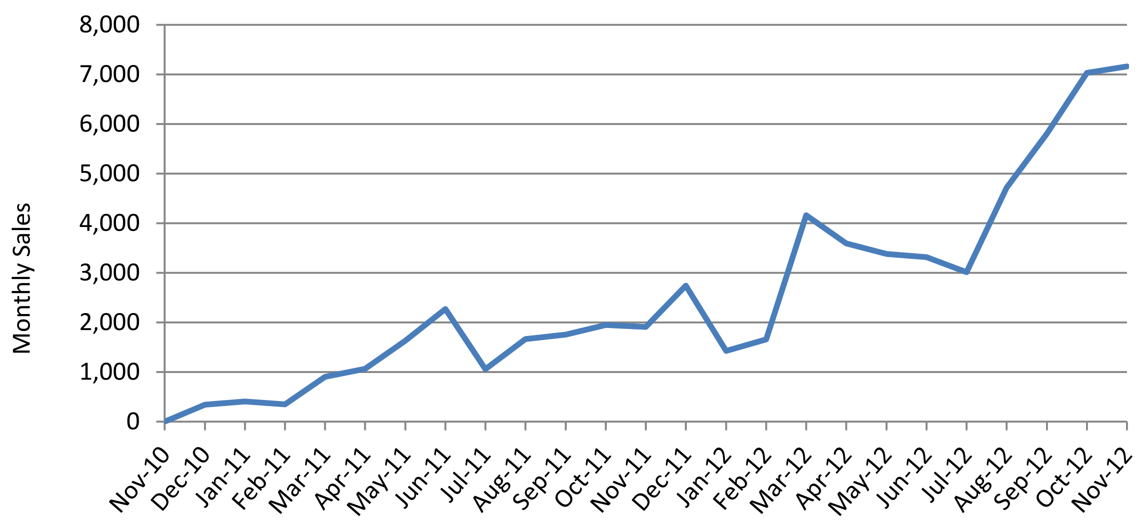
EVs are charged by plugging into EV-charging infrastructure. This equipment is classified by the rate or speed at which the batteries are charged. Charging times vary and can range from 15 minutes to 20 hours or more, depending on factors such as battery size and type, and the type of charging equipment used. Today, three types of equipment are in use, with others under development. Level 1 chargers use a 120-volt (V) alternating current (AC) plug. Level 2 chargers are rated at less than or equal to 240-V AC. Direct current (DC) fast charging has a 480-V input. In addition, inductive charging uses an electromagnetic field to transfer electricity to an EV without a cord; this is still being used in certain areas where it was installed for EVs in the 1990s.

Currently, more than 12,000 EV charging outlets are located across the country, and at least 2,800 are in California (not including residential infrastructure).[23] Infrastructure expansion is occurring rapidly, a trend that is expected to continue.

## Uses and Applications

Both heavy-duty and light-duty EVs are commercially available, although the current focus is on the light-duty market. Since 2010, several manufacturers have begun to introduce light-duty BEV and PHEV models, and more vehicle models are expected to be released in 2013 and 2014. Figure 2-10 shows the number of EVs that were sold in the United States between November 2010 and November 2012, not including low-speed or neighborhood electric vehicles. As manufacturers increase their model year offerings, sales are expected to increase. EVs currently make up 0.6% of all U.S. light-duty vehicle sales.

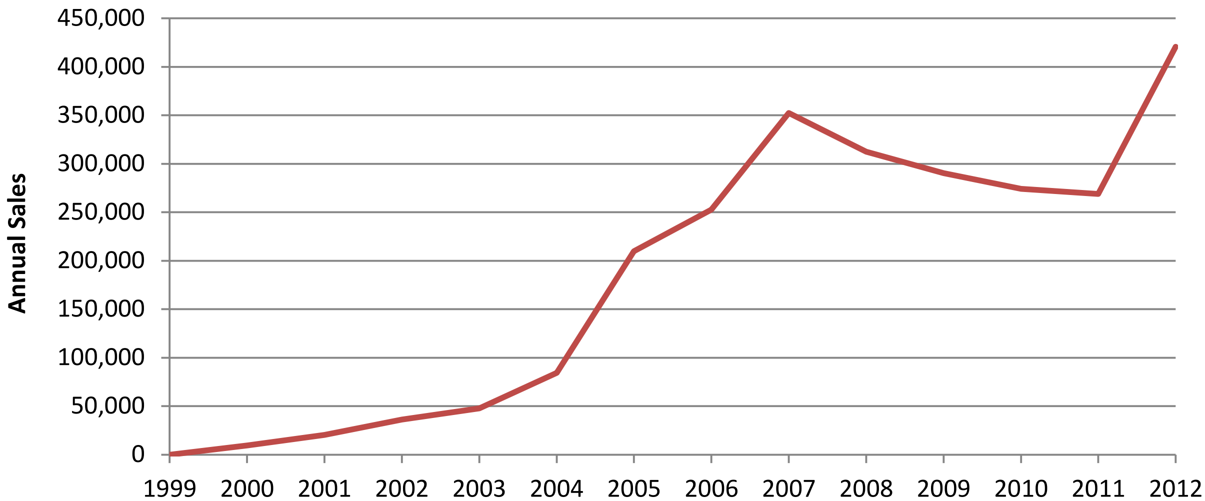
**Figure 2-10. Monthly Electric Vehicle Sales in the United States (November 2010 – November 2012)**




Source: www.hybridcars.com, Hybrid Market Dashboard

HEVs were first sold in the United States in 2000, when the Toyota Prius and Honda Insight were introduced into the U.S. market. HEV sales grew rapidly between 2003 and 2007, topping 350,000 vehicles in 2007, and then declined somewhat along with the broader U.S. automobile market, as shown in Figure 2-11. HEV sales picked up in 2012, topping 400,000 vehicle sales. HEVs currently make up approximately 3% of all U.S. light-duty vehicle sales.

**Figure 2-11. Annual Hybrid Electric Vehicle Sales in the United States (1999–2012)**




Source: Alternative Fuels Data Center, http://www.afdc.energy.gov; www.hybridcars.com

Hybrid electric medium- and heavy-duty trucks have been introduced only in the last several years, although all major truck makers now offer HEVs. Nationwide, approximately 4,000 HEV medium- and heavy-duty trucks are in use. Many of these are in California, due in part to ARB's Hybrid Truck and Bus Voucher Incentive Project (HVIP).

Electric buses are currently being used by a number of transit agencies in California. Trolley buses powered by electricity from overhead wires have been used in San Francisco for several decades. These buses have auxiliary power units allowing them to travel off-wire for several blocks.[24] In addition, as of 2010, an estimated 28 BEVs operating independently of overhead wires were in use by transit agencies in California. In Bakersfield, for example, an electric bus refurbished to look like the historic Bakersfield electric trolley offers free rides along a 1-mile loop in the city. Foothill Transit (Los Angeles County) operates three 35-foot electric buses made by Proterra, purchased using federal stimulus funds. The San Joaquin Regional Transit District (Stockton) is now adding two of the same Proterra electric buses to its fleet.

Hybrid electric buses are widely used in transit service. First introduced in the late 1990s, hybrid buses have been gaining market share and now account for approximately 9% of buses nationwide. More than 60 transit agencies now operate gasoline-electric or diesel-electric hybrid buses.[25]

Hybrid-electric technology can also be used to provide auxiliary power for vehicles such as utility trucks. For example, the "JEMS" technology offered by Altec uses stored electrical energy to power truck aerial device, tool,s and exportable power. The energy storage system can be recharged by plugging into grid power or by the truck's internal combustion engine.

In Solano County, a number of municipal agencies operate hybrid and battery electric vehicles. Vacaville was one of the first local governments in the nation to operate BEVs. The city obtained 24 Toyota RAV4 BEVs approximately 10 years ago, a "first generation" electric vehicle that uses an inductive charging paddle rather than the current SAE J1772 charging standard. The city still operates many of these vehicles, although their production has since been discontinued in favor of "second generation" EVs. Solano County Transit (SolTrans) operates 21 diesel-hybrid buses, and Fairfield and Suisun Transit (FAST) operates 7 hybrid buses. The City of Benicia operates 6 HEVs and 2 PHEVs. Rio Vista's fleet includes a hybrid-electric SUV and battery-electric vehicle. Fairfield also operates 2 HEVs.


**Vacaville Toyota RAV4 Electric Vehicle**


**SolTrans Diesel-Hybrid Bus**

## Fuel Supply, Demand, and Price

Because only in the last 2 years have there been significant OEM offerings of EVs, available statistics on electricity use for transportation are not meaningful. EIA estimates that electricity demand in the transportation sector in 2020 will be approximately 0.03 quadrillion British thermal units, reflecting 3.5% annual growth.[26] For perspective, to keep up with this demand, it is estimated that the number of Level 2 chargers in 2020 would need to be as high as 1,250,000 for residential and 3,200,000 for non-residential, as illustrated in Table 2-2.

**Table 2-2. Forecasted Electric Vehicle Charger Population, Nationwide (2020)**

| Scenario | Vehicle Population (millions) | Residential Chargers (thousands) | | Non-Residential Chargers (thousands) | |
|---|---|---|---|---|---|
| | | L-1 | L-2 | L-2 | DC Fast Charging |
| Low | 0.56 | 448 | 112 | 280 | 28 |
| Moderate | 1.25 | 812 | 438 | 1,070 | 180 |
| High | 2.5 | 1,250 | 1,250 | 3,200 | 550 |

Notes: Level 1 (L-1) chargers use a 120-volt (V) alternating current plug; Level 2 (L-2) chargers are rated at less than or equal to 240-V AC. Direct-current (DC) fast charging has a 480-V input.

The price of electricity varies widely depending on the rate schedule and the time of day of use (peak, partial-peak, off-peak). PG&E rates can vary from as low as $0.10 per kilowatt-hour (kWh) to as high as $0.24 per kWh. For sake of comparison, a light duty vehicle that pays $4.00 per gallon of gasoline is equivalent to about $0.45 per kWh.

# 3. Solano County Government Fleets and Alternative Fueling Infrastructure

This chapter presents a summary of the vehicle fleets owned and operated by Solano County's municipal agencies, including alternative fuel vehicles. The chapter also describes the current state of infrastructure to supply alternative fuels in the county.

## 3.1. Municipal Fleets

Based on a survey conducted for this study in 2012, Solano County and its seven incorporated cities and public transit agencies currently operate approximately 1,400 on-road vehicles. These vehicles include automobiles and light-duty trucks, medium- and heavy-duty trucks, vans and minibuses, and full-size transit buses.

Table 3-1 summarizes the number of vehicles operated by type and by agency. The county's municipal fleets operate more than 1,300 light-duty vehicles and nearly 250 medium- and heavy-duty trucks. The largest fleets are operated by Solano County, Vacaville, and Fairfield. The county's five transit agencies collectively operate 126 full-size transit buses and 54 minibuses and paratransit vans.

**Table 3-1. Municipal Fleet Vehicles in Solano County by Vehicle Type (2012)**

| Agency | Passenger Cars and Light-Duty Trucks | Medium- and Heavy-Duty Trucks | Minibuses and Paratransit Vans | Transit Buses (35+ feet) | Total |
|---|---|---|---|---|---|
| Solano County | 447 | 46 | - | - | 493 |
| City of Benicia | 8 | 27 | - | - | 35 |
| City of Dixon | 44 | 11 | 9 | - | 64 |
| City of Fairfield | 243 | 43 | 4 | - | 290 |
| FAST | 6 | - | 11 | 44 | 61 |
| City of Rio Vista | 10 | 13 | 4 | - | 27 |
| Suisun City | 16 | 9 | - | - | 25 |
| City of Vacaville | 283 | 52 | - | - | 335 |
| Vacaville City Coach | - | - | 6 | 15 | 21 |
| City of Vallejo | 238 | 48 | - | - | 286 |
| SolTrans | 23 | - | 20 | 67 | 110 |
| **Total** | **1,318** | **249** | **54** | **126** | **1,747** |

Table 3-2 shows the same municipal fleet vehicles organized by fuel type. Gasoline and diesel fuel are used by the vast majority (80%) of the municipal vehicles; the remainder are capable of operating on some type of alternative fuel, as discussed below.

**Table 3-2. Municipal Fleet Vehicles in Solano County by Fuel Type (2012)**

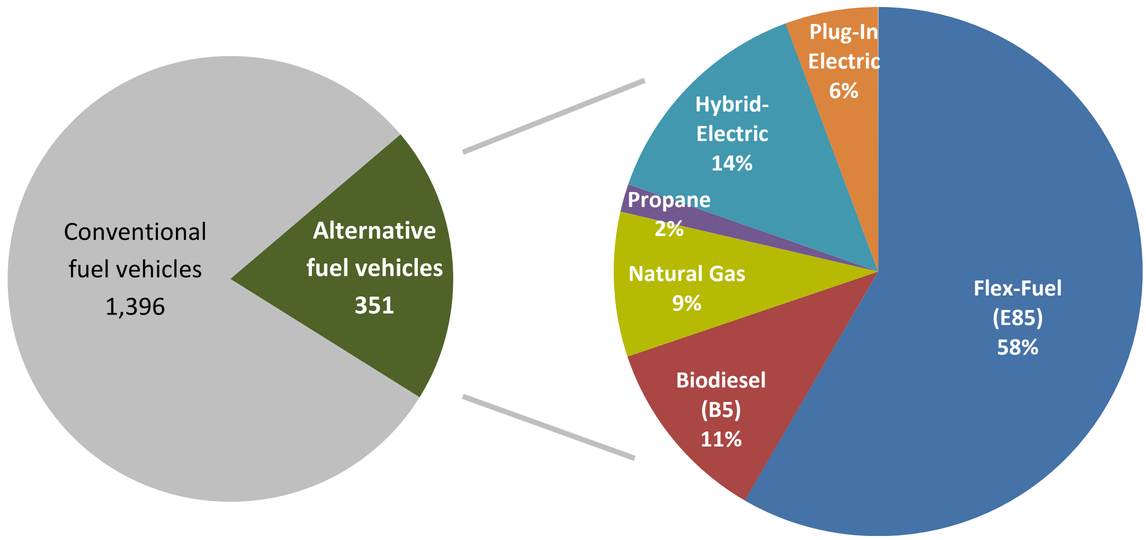
| Agency | Fuel Type: Gasoline | Diesel | Flex-Fuel (E85) | Biodiesel (B5) | Natural Gas | Propane | Hybrid-Electric | Plug-In Electric | Total |
|---|---|---|---|---|---|---|---|---|---|
| Solano County | 327 | - | 120 | 40 | - | 6 | - | - | 493 |
| City of Benicia | 7 | 20 | - | - | - | - | 6 | 2 | 35 |
| City of Dixon | 40 | 11 | 13 | - | - | - | - | - | 64 |
| City of Fairfield | 252 | 22 | 14 | - | - | - | 2 | - | 290 |
| FAST | 8 | 44 | 2 | - | - | - | 7 | - | 61 |
| City of Rio Vista | 23 | 2 | - | - | - | - | 1 | 1 | 27 |
| Suisun City | 18 | 6 | - | - | 1 | - | - | - | 25 |
| City of Vacaville | 252 | 51 | - | - | 15 | - | - | 17 | 335 |
| Vacaville City Coach | 2 | 4 | - | - | 15 | - | - | - | 21 |
| City of Vallejo | 170 | 48 | 56 | - | - | - | 12 | - | 286 |
| SolTrans | 43 | 46 | - | - | - | - | 21 | - | 110 |
| **Total** | **1,142** | **254** | **205** | **40** | **31** | **6** | **49** | **20** | **1,747** |

The AFVs operated by Solano County public agencies in 2012 include the following:

- **Flex-fuel (E85) vehicles**. These are light-duty vehicles that can fuel with gasoline or E85. They include 120 FFVs owned by Solano County, 56 owned by Vallejo, 14 owned by Fairfield, and 13 FFVs leased by the Dixon Police Department.
- **Biodiesel**. All 40 Solano County diesel vehicles operate on B5 (5% biodiesel blend).
- **Natural gas vehicles**. Vacaville City Coach's entire fleet of 15 transit buses runs on CNG. Vacaville also operates 8 CNG Honda Civic sedans and 7 CNG pick-up trucks and vans. Suisun City has a CNG pick-up truck.
- **Propane vehicles**. Solano County owns 6 propane pick-up trucks.
- **Hybrid-electric vehicles**. Solano County Transit (SolTrans) operates 21 diesel-hybrid buses and FAST operates 7 hybrid buses. Vallejo has 21 hybrid-electric vehicles. Benicia, Fairfield, and Rio Vista also have hybrid-electric sedans or SUVs.
- **Battery-electric vehicles**. Vacaville operates 17 Toyota RAV4 BEVs, and another BEV is operated by Rio Vista. Benicia has 2 plug-in hybrid vehicles.

Figure 3-1 illustrates the percentages of alternative fuel vehicles currently in use among Solano County municipal and transit agency fleets.

**Figure 3-1. Percent of Alternative Fuel Vehicles in Solano County Municipal Fleets**




## 3.2. Alternative Fuel Stations

Alternative fuel infrastructure is available throughout Solano County and in the greater Northern California region. Data on alternative fuel facilities were collected through a survey of fleet managers and from the U.S. Department of Energy, Alternative Fuels Data Center (www.afdc.energy.gov).

Approximately 35 alternative fueling sites were identified within Solano County. More than 80% of these sites are EV charging stations, concentrated in Vacaville and Fairfield. Of the remaining sites, only two or three locations were identified for biodiesel, E85, natural gas, and propane. The information presented here includes a mix of both publicly available and private fueling stations.

In the remainder of this section, maps show the location and distribution of different fueling stations; several tables follow that provide more information on each station.

### Ethanol

As illustrated in Figure 3-2, ethanol (E85) is widely available in Northern California. The Sacramento area alone hosts 29 stations that provide E85. The fuel is not widely available in Solano County, however, as only three stations in the county provide it. Two of these stations offer public access: one in Vacaville and one in Fairfield. The third station providing E85 is the Solano County Corporation Yard #1 in Fairfield, which does not offer public access. Table 3-3 lists the stations in Solano County that provide E85 fuel.

**Figure 3-2. E85 Fueling Infrastructure in and around Solano County (2013)**

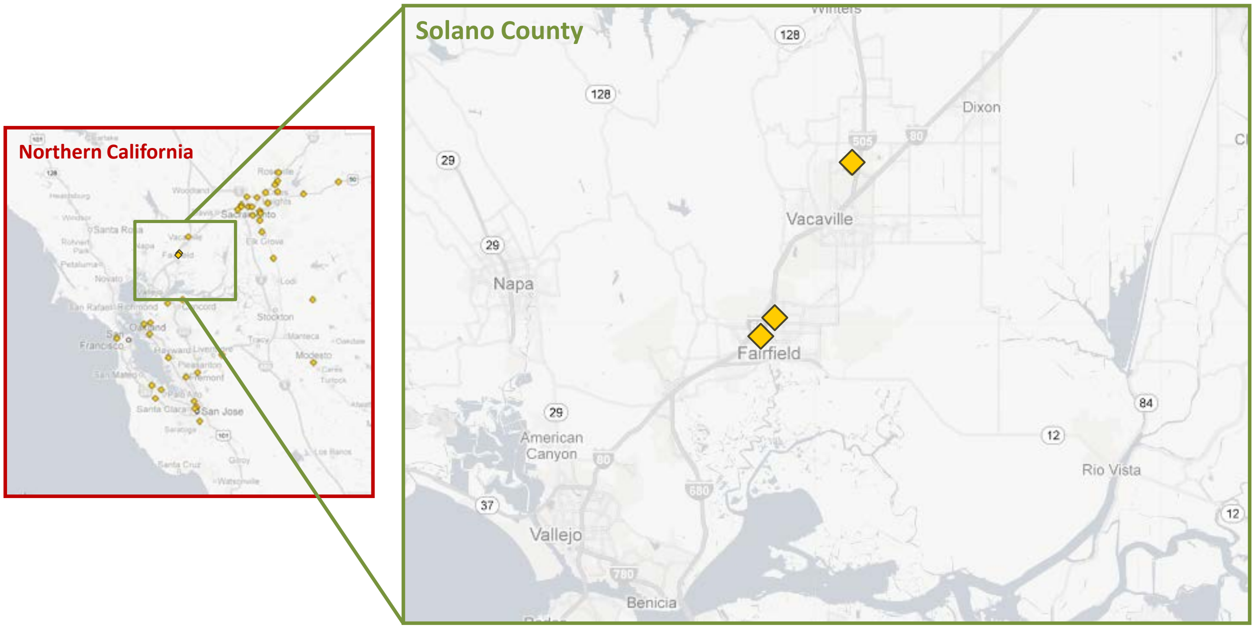



**Table 3-3. E85 Fueling Infrastructure in Solano County (2013)**

| Station Name | Street Address | City | Access |
|---|---|---|---|
| Solano County Corporation Yard #1 | 3255 North Texas Street | Fairfield | Private |
| Pacific Pride – Interstate Oil Co | 917 Cotting Lane | Vacaville | Public |
| Plaza Oliver Valero | 1009 Oliver Road | Fairfield | Public |

## Biodiesel

The County has two biodiesel fueling stations: Solano County's Corporation Yard #1 (located in Fairfield) and a facility at Travis Air Force Base. Neither station offers public access. As illustrated in Figure 3-3, the Sacramento region has 7 biodiesel fueling stations; 18 stations are located throughout the remainder of Northern California. Table 3-4 lists the stations in Solano County that provide biodiesel fuel.

Figure 3-3. Biodiesel Fueling Infrastructure in and around Solano County (2013)

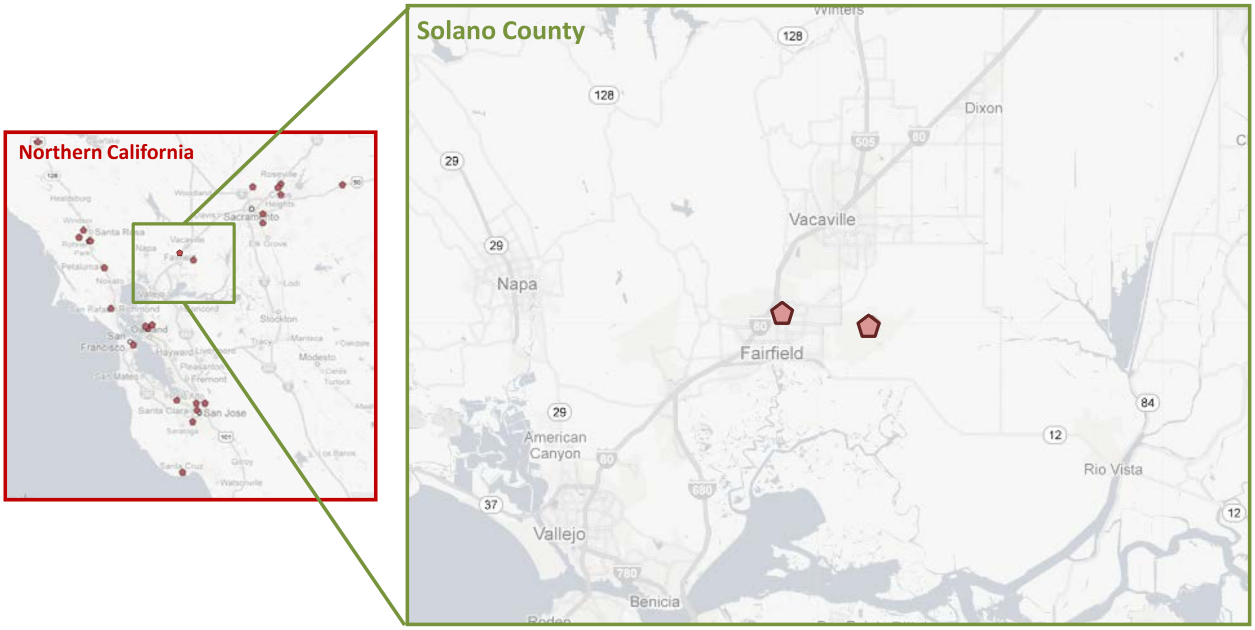



**Table 3-4. Biodiesel Fueling Infrastructure in Solano County (2013)**

| Station Name | Street Address | City | Access | Biodiesel Blends Available |
|---|---|---|---|---|
| Solano County Corporation Yard #1 | 3255 North Texas Street | Fairfield | Private | B5 (B10 planned in 2014) |
| Travis Air Force Base | 430 Hangar Avenue | Fairfield | Private | B20 |

## Natural Gas

As shown in Figure 3-4, natural gas fueling infrastructure is distributed widely throughout Northern California. CNG is more common than LNG and is found at many public, utility, and private locations. Three CNG stations are located in Solano County, including a PG&E facility in Vacaville with public access; the City of Vacaville Corporation Yard; and an LNG/CNG facility in Fairfield, which is one of only four LNG facilities in Northern California. The two CNG facilities located in nearby Davis are outside Solano County; one of these stations serves the Davis transit agency, Unitrans, while the other offers public access. Table 3-5 lists the stations in Solano County that provide natural gas fuel.

A current study is assessing the feasibility of installing a CNG fueling facility at two locations in Vallejo and one location in Benicia. The study will provide a conceptual layout and preliminary cost estimate to construct each fueling facility, determine the cost/benefit for each, and provide an estimate for retrofitting existing maintenance facilities to accommodate CNG buses and other vehicles.

**Figure 3-4. Natural Gas Fueling Infrastructure in and around Solano County (2013)**

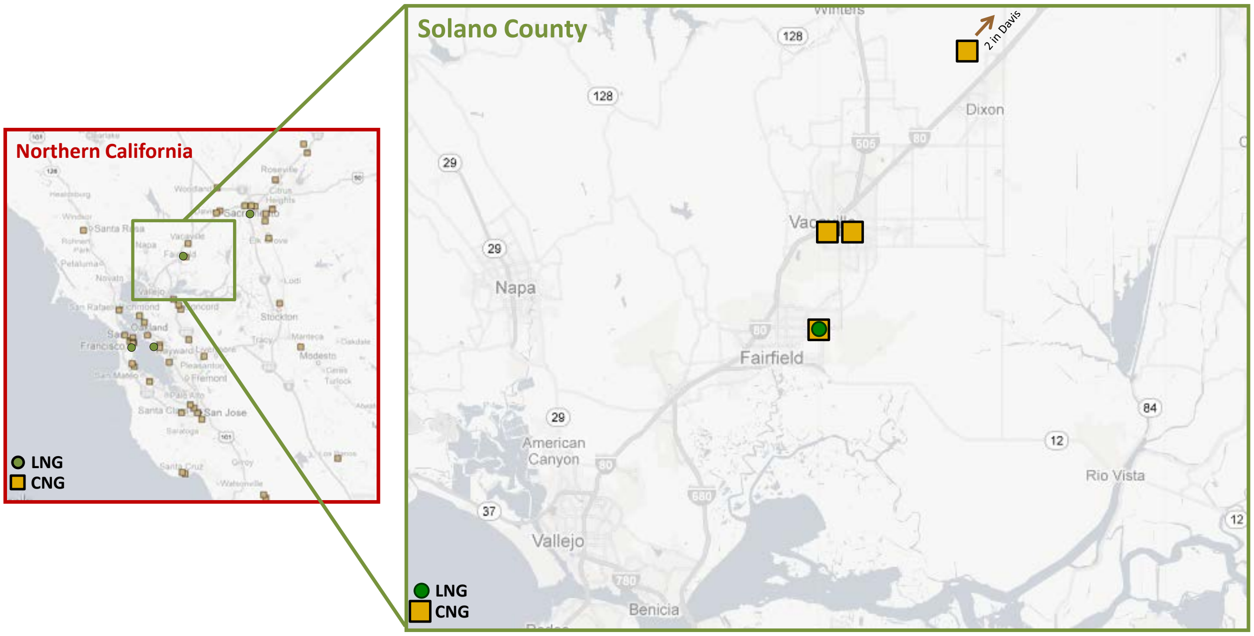



**Table 3-5. Natural Gas Fueling Infrastructure in Solano County (2013)**

| Fuel Type | Station Name | Street Address | City | Access | Details |
|---|---|---|---|---|---|
| LNG/CNG | Solano Garbage | 1930 Walters Court | Fairfield | Private | Quick fill; 3000 and 3600 psi |
| CNG | PG&E Vacaville Service Center | 158 Peabody Road | Vacaville | Public | Quick fill; 3000 psi |
| CNG | City of Vacaville Corporation Yard | 1001 Allison Drive | Vacaville | Private | N/A |

## Propane

Propane fuel (for transportation uses) is available throughout Northern California, with large clusters in Alameda County and Sacramento County (Figure 3-5). In Solano County, the fuel is less common, found at only two stations. One station, located in Vacaville, offers public access. The other station is located in the Solano County Corporation Yard #1, with no public access. Several public-access stations offer propane near Rio Vista, just outside Solano County. Table 3-6 lists the stations in Solano County that provide propane fuel.

Figure 3-5. Propane Fueling Infrastructure in and around Solano County (2013)

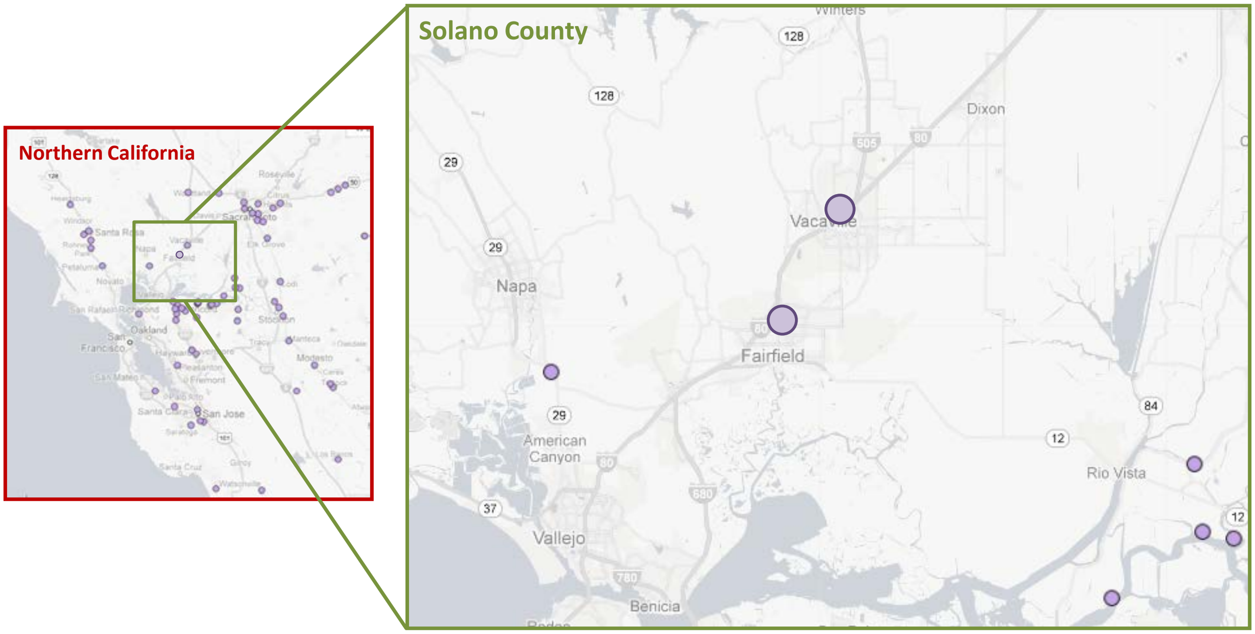



**Table 3-6. Propane Fueling Infrastructure in Solano County (2013)**

| Station Name | Street Address | City | Access |
|---|---|---|---|
| Solano County Corporation Yard #1 | 3255 N. Texas Street | Fairfield | Private |
| U-Haul | 1240 E Monte Vista Avenue | Vacaville | Public |

## Electric Vehicle Charging Stations

Approximately 28 electric vehicle charging stations are located throughout Solano County (Figure 3-6). The current charging station standards established by the Society of Automotive Engineers (SAE) differentiate between three levels:

- Level 1 AC – These use standard 120-volt (V), single-phase service with a three-prong electrical outlet at 15–20 amperage (A).
- Level 2 AC – These are used specifically for EV charging and are rated at less than or equal to 240 V AC, and less than or equal to 80 A.
- DC fast-charging (DCFC) units – These provide power much faster than the AC counterparts, with a 480 V input.

In addition, some older charging stations are built to the small paddle inductive (SPI) charging standard. Vehicle support for SPI was phased out starting in 2001, when ARB adopted the current conductive charging standards. In Solano County, the majority of sites host multiple charging stations, and one-half provide at least two types of equipment—current Level 2 charging equipment and the older SPI standard. Fourteen charging stations are built on municipal sites, and 14 are on private property (Table 3-7). Vacaville in particular has been a leader in the installation of EV charging infrastructure.

**Figure 3-6. Electric Vehicle Charging Infrastructure in and around Solano County (2013)**


Notes: Maps accessed September 17, 2012; includes public and private stations; does not include planned and residential charging stations; each triangle represents one charging location, which may include more than one port; refer to Table 3-7 for a full list of infrastructure.

**Table 3-7. Electric Vehicle Charging Infrastructure in Solano County (2013)**

| Station Name | Street Address | City | Access | Charging Infrastructure Available |
|---|---|---|---|---|
| Benicia City Hall | 250 East L Street | Benicia | Public | 2 Level 2 and 1 DCFC station* |
| Pitt School Plaza | 1440 Ary Lane | Dixon | Public | 1 Level 1; 1 SPI; 1 Tesla conductive |
| Fairfield City Hall | 1000 Webster Street | Fairfield | Public | 2 Level 2 |
| Fairfield Transportation Center | 2000 Cadenasso Drive | Fairfield | Public | 2 Tesla conductive |
| Momentum Nissan | 2545 Auto Mall Parkway | Fairfield | Public (dealer) & private (service center) | 2 Level 2 |
| Solano Community College | 4000 Suisun Valley Road | Fairfield | Public | 3 Level 2; 1 SPI |
| Solano County Government Center Parking Structure | 501 Union Avenue | Fairfield | Public | 1 SPI; 4 Level 2 |
| Rio Vista City Hall | 1 Main Street | Rio Vista | Public | 1 Level 1; 1 Level 2; 1 SPI |
| Suisun Amtrak Station Park & Ride Lot | 650 Lotz Way | Suisun City | Public | 1 Level 2; 1 SPI |
| Suisun City Civic Center | 701 Civic Center Boulevard | Suisun City | Public | 1 Level 2; 1 SPI |

| Station Name | Street Address | City | Access | Charging Infrastructure Available |
|---|---|---|---|---|
| Kaiser Permanente – Vacaville | 1 Quality Drive | Vacaville | Public | 3 SPI; 1 Avcon conductive |
| Leisure Town Center | 100 Sequoia Drive | Vacaville | Public | 1 Level 2; 1 SPI |
| Vacaville Cultural Center | 1000 Ulatis Drive | Vacaville | Public | 1 Level 2; 1 SPI |
| Stars Recreation Center | 155 Browns Valley Parkway | Vacaville | Public | 3 Level 2; 1 SPI |
| Nut Tree Village | 1651 East Monte Vista Avenue | Vacaville | Public | 1 Level 1; 1 SPI |
| Vacaville Regional Transport Center | 190 Hickory Lane | Vacaville | Public | 3 Level 2; 1 SPI |
| Vacaville Premium Outlets | 321 Nut Tree Road | Vacaville | Public | 2 Level 2 |
| Office of Housing & Redevelopment | 40 Eldridge Avenue | Vacaville | Public | 2 SPI |
| KUIC Parking Lot – Lot 9 | 500 Catherine Street | Vacaville | Public | 1 Level 2; 1 SPI |
| Kohl's | 570 Orange Drive | Vacaville | Public | 1 Level 1; 1 Level 2 |
| Vacaville City Hall | 650 Merchant Street | Vacaville | Private | 2 Level 2; 7 SPI |
| Vacaville Police Headquarters | 660 Merchant Street | Vacaville | Private | 2 SPI |
| Nissan of Vacaville | 671 Orange Drive | Vacaville | Public (dealership) & private (service center) | 2 Level 2 |
| Bella Vista Road Park & Ride Lot | 782 Davis Court | Vacaville | Public | 3 Level 1; 4 Level 2; 1 SPI |
| Leisure Town Road Park & Ride Lot | Leisure Town Road & Orange Drive | Vacaville | Public | 1 Level 2; 1 SPI |
| Vallejo City Hall | 555 Santa Clara Street | Vallejo | Public | 2 Level 2 |
| Vallejo Nissan | 3287 Sonoma Boulevard | Vallejo | Public (dealership) & private (service center) | 2 Level 2 |
| Vallejo Ferry Terminal | 495 Mare Island Way | Vallejo | Public | 2 SPI; 1 Avcon conductive; 1 Tesla conductive |

Notes: Information accessed September 17, 2012; includes public and private stations; does not include planned and residential charging stations; each row represents one charging location, which may include more than one port.

Tesla conductive chargers are used for Tesla EVs only. Avcon conductive chargers are a predecessor to the current SAE J1772 standard for chargers and require an adaptor box to be used with most EVs currently in production.

Benicia's DCFC will be operational in November 2013.

Source: U.S. Department of Energy, Alternative Fuels Data Center, http://www.afdc.energy.gov/

# 4. Benefits and Costs of Alternative Fuel Vehicles

Local governments in Solano County may be interested in alternative fuels for different reasons. Some communities may be primarily concerned about climate change and looking for opportunities to reduce GHG emissions. Another city may be considering alternative fuels primarily as a way to minimize fleet operating costs and petroleum dependence, or to satisfy regulatory requirements. And others could be seeking funding opportunities. This chapter reviews the benefits and costs of alternative fuel vehicles in four main areas:

- Regulatory requirements
- Fleet cost impacts
- Air pollution and health impacts
- Greenhouse gas emissions impacts
- Funding sources

## 4.1. Regulatory Requirements

The California Air Resources Board (ARB) has authority to adopt regulations that apply to California vehicles and fuels. In the past, some fleets have switched to alternative fuels as a way to comply with ARB regulations. Table 4-1 summarizes current and recent regulations that could affect public transit and municipal fleets; a brief discussion of each regulation follows. At present, there are no regulations that would necessitate use of alternative fuels by municipal or transit fleets.

**Table 4-1: Summary of ARB Regulations and their Impact on Transit or Municipal Fleets**

| Regulation | Impact on Transit or Municipal Fleets |
|---|---|
| **Transit Fleets** | |
| Fleet Rule for Transit Agencies | Required agencies to upgrade buses to cleaner standards by 2011. Currently, no additional upgrade requirements. Annual reporting required. |
| Zero Emission Buses | Would require large transit agencies to purchase battery or fuel cell buses for 15% of its annual purchases. Currently suspended by ARB, pending further review. |
| On-Road Heavy-Duty Diesel Vehicles Regulation | Requires agencies to replace or upgrade heavy-duty trucks to meet 2010 engine standards. Transit fleets are exempt. |
| **Municipal fleets** | |
| Fleet Rule for Public Agencies and Utilities | Required agencies to upgrade trucks to cleaner standards by 2011. Currently, no additional upgrade requirements. No annual reporting is needed, but there are recordkeeping requirements. |
| In-Use Off-Road Diesel | Requires agencies to upgrade or retrofit their off-road equipment fleets to meet |

| Regulation | Impact on Transit or Municipal Fleets |
| --- | --- |
| Vehicle Regulation | cleaner standards, starting in 2014 through 2023. Deadlines are extended for medium and small fleets. |
| **Other Regulations** | |
| Low Emission / Zero Emission Vehicles | No requirements for transit or municipal fleets. Cleaner passenger cars will be available for purchase. |
| Low Carbon Fuel Standard | No requirements for transit or municipal fleets. The rule will accelerate introduction of low carbon fuels for transportation. |

## Fleet Rule for Transit Agencies

In February 2000, ARB adopted the Fleet Rule for Transit Agencies, which includes several provisions designed to reduce harmful criteria pollutant and air toxic emissions from urban buses and other transit vehicles. These requirements were designed to be phased in between 2002 and 2010, and are largely in-place as of 2012. The Transit Fleet Rule requires transit agencies to upgrade its urban bus fleet to meet more stringent emissions standards, phased in gradually through 2009. The rate of this phase-in depended on the "fuel path" that fleet managers chose to meet the standards. Under the "diesel path," transit agencies were to meet emission reductions of 85% in 2007 (compared to 2002 baseline) through a combination of retrofitting existing diesel buses and purchasing new diesel buses. In the "alternative fuel path," transit agencies were given two additional years to meet the standards but were required to adopt alternative fuel buses as the majority of new bus purchases or leases. Also included in this regulation is the Zero Emission Bus mandate, discussed below.

Solano County transit agencies already comply with this rule. ARB still requires annual reporting of each agency's transit fleet, which can be done using the agency's online reporting tool.

## Zero Emission Bus Rule

The Zero Emission Bus (ZBus) mandate was enacted as part of the Transit Fleet Regulation in 2000. This ambitious program was designed to jump-start research, development, and deployment of new bus technologies, which were not available at the time the rule was introduced. ARB's goal was that by the time the ZBus requirement would become binding, the advanced bus market would have sufficiently matured to reduce the burden of compliance. The original ZBus rule required large transit agencies (those with more than 200 buses in their fleets) to meet a minimum purchase requirement for zero emission buses. The regulation originally required transit agencies to acquire 15% of all new annual bus purchases as ZBuses, beginning in year 2011.

Due to agency feedback and the delays in market-ready ZBus technologies, ARB has delayed components of the regulation. In January 2010, the agency postponed the ZBus requirement until a feasibility study determines that the technology is sufficiently matured. As an indicator of market readiness, ARB has informally set a threshold of 125% for the cost of a ZBus compared to a conventional bus. As of 2009, the agency estimated the cost premium as 275%.

If implemented, the ZBus regulation has the potential for significant impacts to transit agencies, in that it would require purchase of hydrogen fuel cell or battery electric buses. However, there is no certainty when or even if the rule will be implemented. Moreover, as currently written, the regulation only applies to large transit agencies (with more than 200 buses). The largest Solano County transit fleet (SolTrans) currently has approximately 60 buses. For more information about the Zero Emission Bus rule, visit www.arb.ca.gov/msprog/bus/zeb/zeb.htm .

## On-Road Heavy-Duty Diesel Vehicles (In-Use) Regulation

In 2007, ARB adopted the On-Road Heavy-Duty Diesel Vehicles (In-Use) Regulation, known as the "Truck and Bus Rule." This regulation requires that older heavy-duty trucks must be upgraded with cleaner equipment starting January 2012, and replaced starting January 2015. By full project phase-in in 2023, nearly all trucks and buses must meet emission standards for model year 2010 engines.

This rule does not apply to public transit agencies or local governments, so has no direct impact on Solano County government fleets.

## Fleet Rule for Public Agencies and Utilities

The Fleet Rule for Public Agencies and Utilities was enacted in 2005 to reduce emissions from older heavy-duty trucks operated by municipalities or utilities. The regulation excludes vehicle types covered under other mandates, including transit buses, as well as trucks newer than model year 2007, which already meet the emission standard. Depending on the truck model year, municipalities must phase-in "Best Available Control Technology" (BACT) to reduce particulate matter emissions. This can be achieved by installing Diesel Particulate Filters to remove particulates from a truck's exhaust stream.

For most public agencies, including those in Solano County, this rule required updates to municipal fleets by 2011. For Solano County agencies, these updates have likely been completed and there are no further compliance requirements.

## In-Use Off-Road Diesel Vehicle Regulation

In July 2007, ARB approved the In-Use Off-Road Diesel Vehicle Regulation, structured with similar requirements as the On-Road Heavy-Duty Diesel Vehicles (In-Use) Regulation. All existing off-road vehicles (including construction equipment, street sweepers, landscaping vehicles, and others) would need to meet strict pollution standards, through upgrades, retrofits, or replacement. In 2010 the agency delayed the implementation date for cleaner emission standards, due to effects of the recession on the industry and a delay in obtaining a necessary waiver from EPA. Under amendments to the ruling in December 2010, the emission standards will begin to take effect in 2014 for large fleets, 2017 for medium fleets, and 2019 for small fleets. The new standards will be fully phased in by 2023 for large and medium fleets and 2028 for small fleets.

This regulation may have significant impact on Solano County municipalities, depending on the size and age of its off-road fleet. The new standards phase in starting in 2014 for large fleets (more than 5,000 combined horsepower) and finishing in 2023. This schedule is delayed for medium (more than 2,500 combined horsepower) and small fleets. The regulation also includes requirements for reporting and labeling off-road equipment. In addition, fleets must limit equipment idling. ARB designed this regulation so fleets could comply with the standards by upgrading current diesel vehicles or replacing old trucks with new diesel vehicles. A fleet does not need to introduce alternative fuel equipment in order to meet the regulation's emission standard. For more information about the Off-road Equipment Rule, visit www.arb.ca.gov/msprog/ordiesel/ordiesel.htm .

## Low-Emission Vehicle / Zero-Emission Vehicle Regulations

For more than 20 years, ARB has regulated emissions from passenger cars through increasingly stringent emission standards. The first Low-Emission Vehicle (LEV) regulations were enacted in 1990, followed by tighter LEV II standards in 1998 and LEV III in 2011, applied to new cars sold between 2015 and 2025. LEV III standards will reduce smog-forming emissions by 75% and GHG emissions by 34%. In tandem with LEV III, CARB enacted a Zero-Emission Vehicle (ZEV) program to accelerate the sales and use of electric and fuel cell vehicles. ZEV mandates require manufacturers to meet ZEV sales targets as a portion of their overall new vehicle sales within California. In total, the regulation will result in 1.4 million ZEVs sold in 2025, accounting for 15.4% of all sales.

LEV III and ZEV regulations have been combined into ARB's Advanced Clean Car Rules. These regulations do not contain any provisions that specifically apply to transit or municipal fleets. As manufacturers upgrade their vehicles to meet the LEV/ZEV rules, fleet owners will have more choices available if they choose to purchase low-emission or zero-emission passenger cars

## Low Carbon Fuel Standard

In 2010 ARB enacted the Low Carbon Fuel Standard (LCFS), which requires a 10% reduction in the carbon intensity of transportation fuels in 2020. LCFS is designed as a framework to encourage the use of alternative fuels in place of gasoline or diesel. The regulation places mandates on "regulated parties," primarily the refiners and blenders of gasoline, diesel, and their substitutes, to meet a schedule for reducing the carbon intensity of their fuel through 2020.

One goal of LCFS is to encourage the availability of alternative fuels in the marketplace, specifically the availability of ethanol, biodiesel, bio-natural gas, and other low-carbon substitutes. Like the ZEV standards, in most cases LCFS does not impose restrictions directly on transit or municipal fleets; however, LCFS should ease barriers to introducing alternative-fuel vehicles and infrastructure by making the fuels more readily accessible.

In some cases, LCFS directly may apply to transit or municipal fleets, due to the definition of a "regulated party." For conventional natural gas fuel (as opposed to biogas), LCFS defines the regulated party as the entity that owns the natural gas fueling equipment. In these cases, a transit or municipal agency may choose to opt-in to LCFS requirements in order to be eligible to earn credits from using low-carbon fuels, although this is not required.

## 4.2. Fleet Cost Impacts

Fleets considering the purchase of new vehicles often compare choices based on *lifecycle* costs, which include all the costs associated with a vehicle during its lifetime in the fleet, such as the purchase price, resale value, fuel costs, maintenance costs, and any fueling infrastructure costs. It is difficult to estimate and compare lifecycle costs with a high degree of precision because they vary from fleet to fleet depending on factors such vehicle annual mileage, usage and duty cycle, fleet size, existing maintenance facilities and staff experience, existing fueling infrastructure, and financing mechanisms. This section does not perform a full lifecycle analysis; rather, it presents information on vehicle purchase price, fuel costs, and (for some vehicle types) maintenance costs, comparing each alternative fuel to its conventional fuel counterpart.

Information is also presented on fueling infrastructure costs, although these costs are not factored into the cost examples because the differences in infrastructure costs can make side-by-side comparisons misleading. Any agency making decisions about fleet purchasing and infrastructure investment will need to perform a more detailed and agency-specific calculation of lifecycle cost and return on investment. The following sections provide examples of generalized purchase price, operations and maintenance, and fuel costs for light-duty sedans, light-duty trucks, medium- and heavy-duty trucks, and transit buses. A summary discussion of fueling infrastructure costs is found at the end of the section.

### Light-Duty Vehicle Costs

#### Vehicle Purchase Price

The alternative fuels currently available to light-duty vehicles for fleet purchases are E85, CNG, propane, and electricity. No light-duty hydrogen fuel cell vehicles currently are commercially available for purchase, although Mercedes Benz (B-Class F-CELL) and Honda (Clarity) offer a fuel cell vehicle for lease in California. Table 4-2 shows sample incremental vehicle prices for light-duty sedans. These values represent the additional purchase price when compared to a conventional gasoline vehicle. The Honda Civic and Ford Focus were chosen for the comparison because together they can illustrate the alternative fuels for light-duty sedans. Table 4-3 shows sample incremental vehicle prices for light-duty trucks compared to conventional gasoline trucks.

**Table 4-2. Sample Incremental Vehicle Prices for Alternative Fuel Light-Duty Sedans Compared to Gasoline Vehicles**

| Honda Civic | | | | Ford Focus | | |
|---|---|---|---|---|---|---|
| Gasoline | HEV | CNG | Propane | Gasoline | E85 | BEV |
| Baseline | $5,195 | $7,500 | $6,000 | Baseline | $0 | $11,749 |

**Table 4-3. Sample Incremental Vehicle Prices for Alternative Fuel Light-Duty Trucks Compared to Gasoline Vehicles**

| Chevrolet Silverado 1500 | | | Chevrolet Silverado 2500 | | GMC Sierra 2500 | |
|---|---|---|---|---|---|---|
| Gasoline | E85 | HEV | Gasoline | Propane | Gasoline | CNG Bi-Fuel |
| Baseline | $0 | $17,445 | Baseline | $6,500 | Baseline | $17,445 |

The price differences of alternative fuel vehicles are driven by several factors, including the following.

- The retail price for an **E85 flex fuel vehicle** is usually identical to its conventional gasoline counterpart. Although the cost to produce an FFV is slightly higher than for a comparable gasoline vehicle, manufacturers have typically set identical prices as a way to encourage FFV sales, which can earn federal CAFE credits for auto makers.[27] For several models, most of the available light-truck configurations are designated as FFV.
- **CNG vehicles** carry a price premium over their conventional fuel counterparts. The primary reason for the price premium is the cost of CNG fuel tanks, as well as the lower production volumes.
- **EVs and HEVs** carry a higher price than their conventional fuel counterparts, mainly because of the cost of the batteries. Both BEV and PHEV sedans are eligible for the current federal tax credit of up to $7,500, as well as a state incentive up to $2,500 (the Clean Vehicle Rebate Project). BEV and PHEV light-duty trucks are eligible for up to $30,000 of incentives through the HVIP. These incentives can significantly reduce the purchase price of EVs and, when combined with the fuel cost savings, make these sedans competitive with gasoline vehicles over the life of the vehicle. HEVs, while cheaper than EVs, do not achieve the same level of petroleum reduction and use no low cost grid electricity as a fuel source.
- Because few **propane vehicles** are offered by OEMs, propane usually requires conversion of a gasoline vehicle. The current price of a bi-fuel conversion that enables a conventional fueled vehicle to operate on both propane and gasoline is approximately $5,500–$6,500 ; the incremental costs of converting to a dedicated propane light-duty vehicle is approximately $11,600.

## Operations and Maintenance Costs

The overwhelming component of operations costs for all vehicles is fueling costs. Owners of alternative fuels fleets need to weigh the following factors related to the costs of alternative fuels.

- While **E85** is typically cheaper per gallon at the pump, vehicle operating costs are often higher because of the lower mileage per GGE of FFV vehicles. Based on current prices, the annual cost of fuel for an FFV running on E85 will be 25% greater than for a comparable gasoline vehicle.

- At the current low natural gas prices, **natural gas** vehicles achieve a significant fuel savings compared to their conventional fuel versions. Natural gas fuel prices at public retail stations are higher than at private stations, which are usually owned and operated by private fleets or transit agencies.
- The impacts of **propane** on operating costs depend heavily on its price differential with gasoline. The average retail price of propane is currently slightly higher than gasoline on a GGE basis (i.e., accounting for the lower energy content of propane). However, private propane stations typically offer significantly lower prices than public stations, which can result in a lower effective fuel price.
- Because **electric drive** vehicles have significantly better mileage than their gasoline and diesel counterparts, their annual fueling costs are lower. With many light-duty vehicle models now available, the fuel economy advantage of EVs and HEVs depends on the specific model, as well as the amount of highway vs. city driving. In the case of electric vehicles, fleets should also account for the costs of maintaining charging stations. In many cases, there may also be networking fees associated with "smart" charging equipment, particularly for Level 2 EVSE and DCFC. ICF estimates maintenance costs of about $20 per month and networking fees of approximately $20 per month for both Level 2 EVSE and DCFC. For fleets using Level 1 charging, maintenance costs will be very low or zero.

Table 4-4 and Table 4-5 show the lifetime fueling costs of light-duty sedans and trucks, respectively, assuming 10,000 miles per year, 50% highway and 50% city operation, and a 10-year vehicle life.

**Table 4-4. Sample Light-Duty Sedan Lifetime Fueling Costs**

| Honda Civic | | | | | | Ford Focus | | |
|---|---|---|---|---|---|---|---|---|
| Gasoline | Hybrid | CNG Public | CNG Private | Propane Public | Propane Private | Gasoline | E85 | BEV |
| $11,100 | $8,500 | $7,200 | $3,000 | $16,700 | $12,800 | $11,500 | $14,500 | $3,600 |

**Table 4-5. Sample Light-Duty Truck Lifetime Fueling Costs**

| Chevrolet Silverado 1500 | | | Chevrolet Silverado 2500 | | | GMC Sierra 2500 | | |
|---|---|---|---|---|---|---|---|---|
| Gasoline | E85 | HEV | Gasoline | Propane Public | Propane Private | Gasoline | CNG Bi-Fuel Public | CNG Bi-Fuel Private |
| $21,900 | $27,300 | $17,800 | $27,800 | $31,400 | $24,000 | $33,700 | $24,900 | $10,600 |

In terms of maintenance costs, some fleets report that FFVs have higher overall maintenance costs than their gasoline counterparts; others report no significant difference in FFV maintenance costs. The caustic nature of alcohol found in E85 fuel creates more wear on (non-synthetic) rubber components such as gaskets or seals. However, modern FFVs have been designed with synthetic rubber components to avoid this outcome.

CNG and propane vehicles burn cleaner than conventionally fueled vehicles, and field reports indicate that engine life is extended and general engine maintenance may be less than required for gasoline vehicles. On the other hand, most propane vehicles use engines that were originally designed for gasoline (e.g., lacking hardened valves) and therefore may require additional maintenance. Additional training requirements and lack of certified maintenance facilities also can increase costs for propane fleets. The net impact on maintenance costs related to the use of alternative fuels will depend on a variety of factors and is difficult to generalize.

Because the EVs currently available to consumers have been introduced only in the last 3 years, information is limited related to their maintenance costs. Most researchers assume that BEVs will cost less to maintain than ICE vehicles because their engines have fewer moving parts and maintenance needs. For example, BEVs will not need oil changes, air filter replacements, spark plug replacements, or timing chain adjustments. Because they use regenerative braking, both HEVS and EVs will experience less brake wear.

Because current maintenance cost information is not extensive and the differences are expected to be small, maintenance costs are not included in the cost comparisons below.

## Purchase and Fuel Cost Comparison

Based on the purchase price and operations cost assumptions described above and in the preceding tables, Figure 4-1 and Figure 4-2 present a sample cost comparison for light-duty sedans and light-duty trucks, respectively.

**Figure 4-1. Sample Light-Duty Sedan Purchase and Lifetime Fuel Cost Comparison**

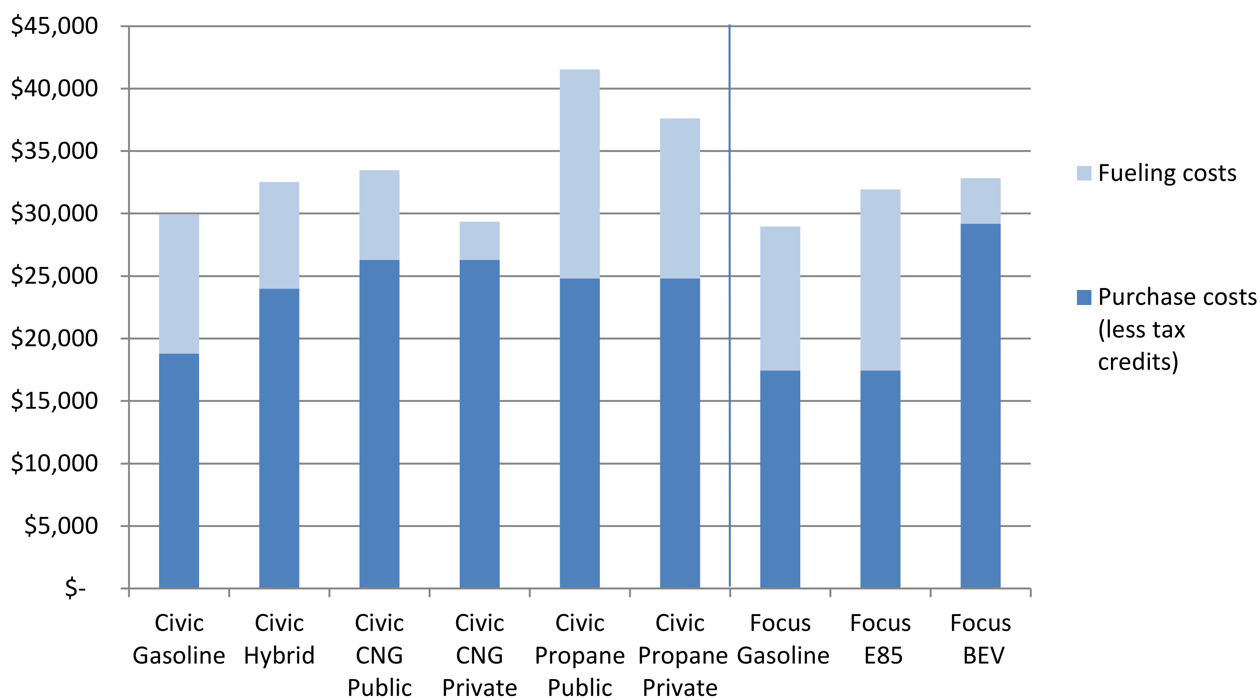
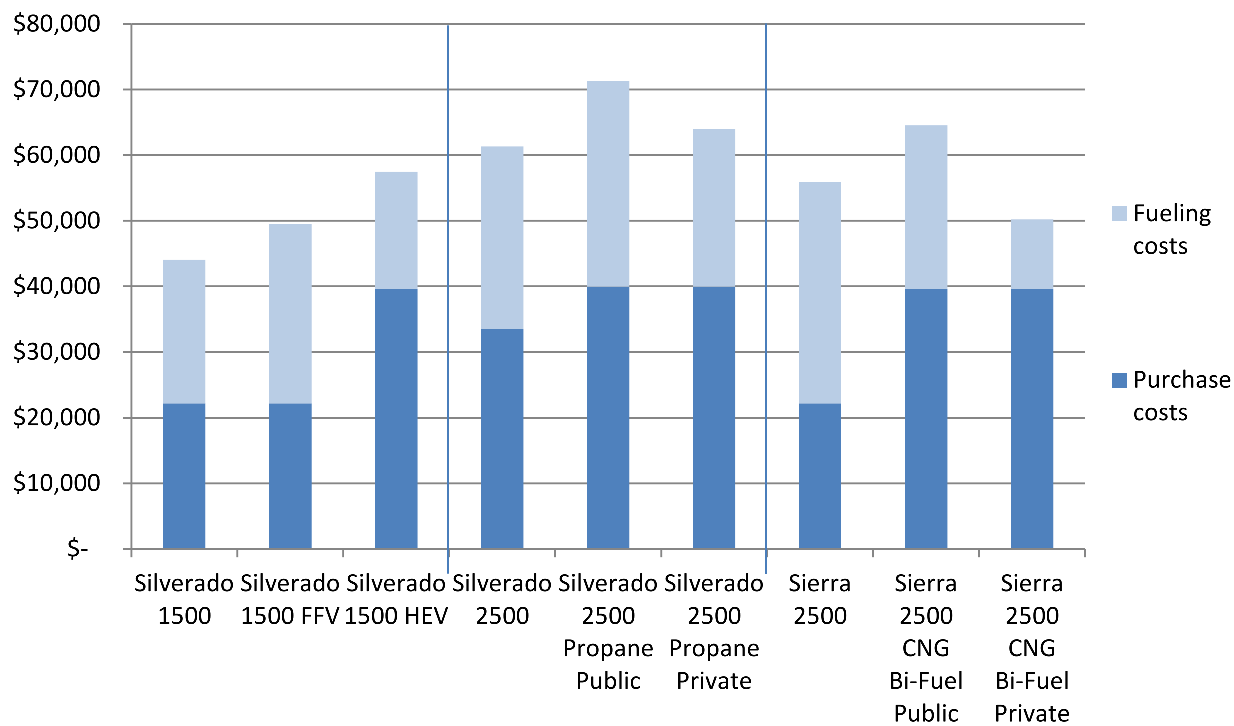


**Figure 4-2. Sample Light-Duty Truck Purchase and Lifetime Fuel Cost Comparison**




For most of the sample light-duty vehicles included in the preceding figures, alternative fuels result in an increase in purchase plus fuel costs over the baseline gasoline vehicle. The exceptions are the CNG vehicles (Civic sedan and GMC Sierra 2500) fueled at a private (fleet-owned) facility. For many other options, the lifetime cost increase is modest. For example, the E85 and BEV Ford Focus cost 10% and 13% more, respectively, than a gasoline Focus over the vehicle lifetime. Also note that these are sample vehicle models; other HEV and BEV options may result in lifetime cost savings.

## Medium- and Heavy-Duty Truck and Transit Bus Costs

### Vehicle Purchase Price

Because biodiesel can act as a drop-in replacement for diesel fuel, costs for biodiesel vehicles are comparable to those for conventional diesel vehicles. Biodiesel will run in most diesel vehicles without need for retrofit or conversion. B5 is approved by manufacturers in all diesel engines. B20 has been shown to perform well in diesel vehicles, even in cold weather and in older vehicles.[28] Based on bus price assumptions supplied by the Metropolitan Transportation Commission (MTC) for fiscal year 2013-2014, the total purchase price for 40 foot diesel, diesel HEV, and CNG buses are $544,000, $733,000, and $607,000, respectively. MTC guidance notes that the federal government covers, on average, 80.64% of the bus purchase price, and the local government pays the remaining 19.38%. Using these assumptions, a local government would typical pay $105,416, $142,041, and $117,624 for a diesel, diesel HEV, and CNG bus, respectively.

The price differential for purchase of natural gas buses is smaller in percentage terms compared to the difference in purchase price for natural gas light-duty sedans and trucks. The purchase price of a CNG bus is approximately 12% higher than that of a diesel bus, compared to a 40–75% purchase price increase for natural gas light-duty sedans and trucks.

**Table 4-6. Sample Incremental Vehicle Prices for Alternative Fuel Medium-Duty Trucks and Transit Buses Compared to Diesel Vehicles**

| Medium-Duty Truck | | Transit Bus (Local Portion) | | | |
|---|---|---|---|---|---|
| Diesel | B20 | Diesel | B20 | Diesel HEV | CNG |
| Baseline | $0 | Baseline | $0 | $36,625 | $12,208 |

## Maintenance and Operations Costs

Biodiesel has a solvent quality that will clean the fuel delivery system. Even at low-level blends, initial use of biodiesel will require changing fuel filters more often as the fuel accumulates contaminants in the fuel system. After the fuel system is clean, fuel filter service intervals return to normal.[29]

Once any initial maintenance costs associated with a transition to biodiesel have been incurred, regular maintenance costs should be similar to those for conventional diesel vehicles. A study for the Federal Transit Administration (FTA) reported that maintenance costs for a fleet of 100 buses using B20 would be slightly lower than for using ULSD ($0.14 vs. $0.15 per mile).[30] In a study examining transit buses running on B20 for 100,000 miles, the National Renewable Energy Laboratory found no difference in fuel economy, engine maintenance costs, or road calls between buses operating on B20 and those operating on diesel.[31]

Maintenance costs for CNG buses are reported to be higher than for diesel buses based on a survey of transit agencies.[32] While maintenance costs varied across surveyed agencies, the median cost was found to be 15% higher, at $0.68 per mile compared to $0.59 per mile for diesel. Note that some of these reports of higher CNG maintenance costs may be based on experiences with “first generation” CNG buses, as was the case with Vacaville. Some agencies report that newer CNG buses have no significant maintenance cost differences compared to diesel. Also note that fleets introducing natural gas for the first time will face significant costs associated with constructing or retrofitting a maintenance facility that can service CNG vehicles.

In terms of fueling costs, biodiesel in B20 blend currently costs approximately 2% more than conventional diesel, and the fuel has slightly lower energy content. Switching to B20 would increase annual fueling costs by 3–4%. Thus, for medium-duty trucks, sample lifetime fuel costs would be $39,200 for diesel and $40,400 for B20.

The fuel savings from hybrid electric buses depends on factors such as the number of stops per mile, average speed, and topography. Since the electric battery is recharged through braking, hybrids can be much more fuel efficient than their conventional counterparts in stop-and-go traffic, while their fuel economy advantages are less in freeway traffic. The San Francisco Municipal Transportation Agency

(SFMTA) has seen a 25% improvement in fuel economy with its hybrids. New York City MTA (which has the nation's largest hybrid bus fleet) has experienced a 10% to 30% fuel economy improvement, and one study found a 27% improvement for King County Metro Transit in the Seattle. Fairfield has observed a 35% - 50% fuel economy improvement compared to diesel buses of similar model year. Note that the fuel economy of hybrid buses has improved nearly 50% over the last seven years, due mainly to technology improvements.[33] So the newest hybrid buses will likely achieve greater fuel savings than older models.

Table 4-7 shows sample lifetime operations and maintenance costs for diesel and several transit bus alternative fuel options. These calculations assume a transit bus life of 12 years.[34]

**Table 4-7. Sample Transit Bus Lifetime Operations and Maintenance Costs**

| Cost Type | Diesel | B20 | Diesel HEV | CNG Public | CNG Private |
|---|---|---|---|---|---|
| Fuel costs | $487,500 | $502,400 | $390,000 | $367,000 | $163,400 |
| Maintenance costs | $283,200 | $283,200 | $283,200 | $326,400 | $326,400 |

## Purchase and Fuel Costs

Using the purchase price and maintenance and operations costs discussed above, Figure 4-3 and Figure 4-4 show a sample cost comparison for medium-duty trucks and transit buses, respectively.

**Figure 4-3. Sample Medium-Duty Truck Purchase and Lifetime Fuel Cost Comparison**

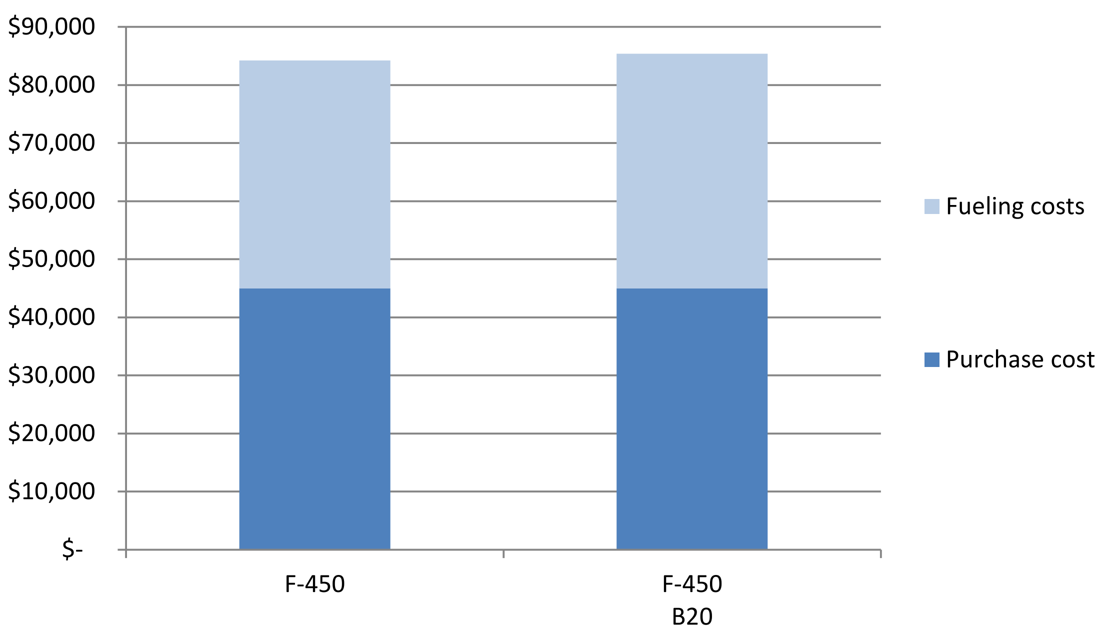
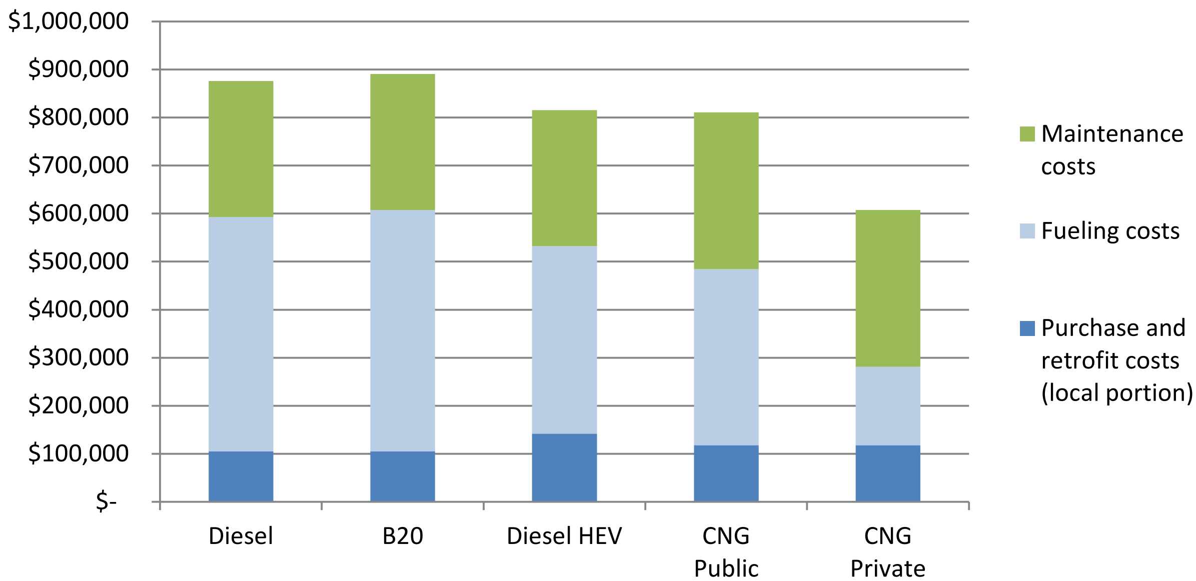


**Figure 4-4. Sample Transit Bus Purchase and Lifetime Maintenance and Fuel Cost Comparison**




As shown in these figures, biodiesel for medium-duty trucks and transit buses have slightly higher costs due to increased fuel costs. The lower fuel costs for the diesel HEV over the 12-year life offsets the higher purchase cost of the diesel HEV compared to the diesel bus. CNG buses have a lower cost due to the much lower fuel costs of CNG compared to diesel, particularly in the case of CNG purchased from private stations.

When considering costs associated with heavy-duty vehicles, it should be recognized that vehicles that have an axle weight of over 16,000 lbs can significantly affect pavement on non-arterial roads. If a certain type of bus (CNG, Diesel, Hybrid, etc.) is heavier on one or both axles, it can cause more damage to a road. It is possible that a cost savings to a transit agency could result in premature and costly repairs for a local public works agency if there is a significant increase in weight on the bus axles.

## Fueling Infrastructure Costs

E85 vehicles require dedicated infrastructure for fuel storage and refueling. E85 fuel is delivered as a blend to the station. A fleet with E85 vehicles can choose to “fill up” at public stations or install dedicated infrastructure alongside conventional gasoline tanks. A typical cost for a new E85 station is $150,000.[35] If a single ethanol pump and new fuel tank are added to an existing station, a typical cost is $60,000; adding E85 capacity by converting an existing tank costs approximately $11,000.[36] Currently, only three E85 fueling stations are located in Solano County: the Solano County Corporation Yard #1 facility in Fairfield and publicly available stations in Vacaville and Fairfield.

CNG vehicle fleets require a dedicated on-site natural gas station or accessible public facilities. For small CNG fleets, especially those consisting of passenger cars and light-duty trucks, public infrastructure would likely be sufficient if a source is nearby. Large CNG fleets and bus fleets would likely require on-site infrastructure. The CEC estimates that the cost of a new CNG fueling station would range from

$600,000 to $5 million, depending on the size of the facility and other factors.[37] CNG fueling infrastructure also involves maintenance costs that are likely to be higher than for conventional fuel infrastructure. A Transportation Research Board study found the annual maintenance cost of CNG fueling infrastructure to be 6.8% of the infrastructure capital cost.[38] The cost of LNG infrastructure fits within the range above.

The cost of building a propane fueling station is similar to that for a comparably sized gasoline dispensing system, and propane refueling infrastructure can often be added to existing service station infrastructure. The cost of a typical fleet fueling facility capable of serving 10–30 vehicles would range from $25,000 for a 500-gallon tank with a non-electronic turnkey dispenser skid system up to $60,000 for a fully integrated electronic fuel dispenser system with a 2,000-gallon tank.[39]

The per-vehicle refueling station cost depends on the number of vehicles served by the facility. Because of the relatively low facility costs and the quick fill capability of a propane station, most private fleet facilities operate well below their vehicle capacity. Based on a typical fleet size of 10–20 vehicles, the cost of a dedicated fleet propane refueling station would be approximately $2,000–$3,000 per vehicle. The per-vehicle costs drop quickly for facilities serving larger fleets.

Similar to operations and maintenance costs, there is relatively little experience with installation of hydrogen fueling infrastructure. The examples to date have likely incurred much higher costs than will future hydrogen fueling stations. AC Transit opened a hydrogen fueling facility in April 2012 to serve its fleet of 12 demonstration fuel cell buses.[40] The total cost of the facility was approximately $6 million, funded in part by a state grant.[41] The agency is building another hydrogen fueling station in Oakland.

Use of EVs by public agencies requires the availability of charging infrastructure, sometimes referred to as electric vehicle supply equipment (EVSE). The cost of EVSE depends heavily on the type of charger, as well the extent of any trenching and concrete work needed to bring electrical service to the charger. Costs typically range from $3,800 to $11,000 for Level 1 EVSE, from $5,600 to $14,000 for Level 2, and from $100,000 to $150,000 for DC fast charging (including all power infrastructure, equipment, and installation costs).

Table 4-8 shows a summary of the estimated costs for alternative fuels infrastructure. In addition to the equipment costs for infrastructure, there are potential increases in costs for additions to the Fleet Management Information System (FMIS) that would need to be included.

**Table 4-8. Estimated Infrastructure Costs for Alternative Fuels**

| E85 | | CNG | Propane | Hydrogen | EV | | |
|---|---|---|---|---|---|---|---|
| Existing Station | New Station | New Station | New Station | New Station | Level 1 | Level 2 | DC Fast Charging |
| $60,000 | $150,000 | $600,000 – $5 million | $60,000 | $6 million | $3,800 – $11,000 | $5,600 – $14,000 | $100,000 – $150,000 |

## Vacaville's Experience with Natural Gas


Among Solano county agencies, Vacaville has the most experience with using natural gas for transportation. In 2001, Vacaville built an on-site CNG compression station and retrofitted its bus maintenance facility to handle CNG. The cost of the compression station was approximately $800,000. Vacaville City Coach then began operating five 30-foot CNG buses. These vehicles were among the first generation of CNG buses and suffered from maintenance problems, mostly because of the undersized bus body rather than the fuel. In 2009 and 2010, the agency switched to 35-foot New Flyer low-floor CNG buses, following successful operation of this model by Golden Gate Transit. Vacaville's 15 CNG buses have performed well, with maintenance costs comparable to a conventional diesel bus. On the general fleet side, the city now has approximately 15 CNG cars and trucks in its fleet. The CNG Honda Civic has become the sedan of choice as gasoline-powered sedans are replaced.


Because of the low cost of CNG, Vacaville's fleet now enjoys significantly lower operating costs. While the price of natural gas fluctuates, the city has typically paid $0.90 - $1.00 per diesel gallon equivalent (DGE) for gas delivered to city's yard via pipeline. Compressing the gas adds about 10% to the cost. Vacaville can also take advantage of a federal tax rebate for natural gas. The net cost to the city is approximately $0.80 - $0.90 per DGE, as compared to recent diesel prices of $4.00 per gallon and higher. These substantial cost savings allow Vacaville City Coach to achieve a higher farebox recovery ratio (the portion of operating costs covered by bus fares).

Vacaville is currently investigating the prospect of providing CNG for the city's refuse hauling contractor. Within a few years, the refuse hauler will operate 38 CNG vehicles in Vacaville, all of which could be potentially fueled at the city's corporate yard CNG station. This arrangement has the potential to provide additional revenue for the city, while also providing discounted CNG to the refuse hauler and reducing diesel emissions in the city's neighborhoods.

## 4.3. Air Pollution and Health Impacts

The air pollutants of greatest concern in Northern California are nitrogen oxides (NOx), volatile organic compounds (VOCs), fine particulate matter, and diesel particulate matter (DPM). These are termed *criteria pollutants*. NOx and VOCs are the two major components in the formation of ground level ozone, or smog. Ground level ozone can trigger a variety of health problems including aggravated asthma, reduced lung capacity, and increased susceptibility to respiratory illnesses like pneumonia and bronchitis. The EPA has designated the San Francisco Bay Area as a marginal nonattainment area for ozone, indicating some exceedances of the National Ambient Air Quality Standard (NAAQS).

Particulate matter (PM) is directly emitted from engines and is produced by motor vehicle tire and brake wear. PM is also created when emissions of NOx or sulfur oxides (SOx) react with other compounds in the atmosphere to form particles. Many scientific studies have linked breathing PM to significant health problems, including aggravated asthma, chronic bronchitis, and heart attacks. The most significant health impacts are caused by fine particulate matter (PM2.5), which consists of particles less than 2.5 microns in diameter. The San Francisco Bay Area is designated as a nonattainment area for PM2.5, indicating an unacceptable air pollution level for this finer particular matter.

DPM is of particular concern because it is widely believed to be a human carcinogen when inhaled. DPM carries heavy metals and toxic hydrocarbons into the body, and is the primary cancer-causing agent in vehicle exhaust. Studies in Southern California have found that 70% of the air pollution inhalation cancer risk in the region was caused by DPM, most of which comes from goods movement sources.[42]

### Biofuels and Blends

Unlike GHGs, which are measured on a lifecycle basis, criteria pollutant emissions focus exclusively on the vehicle—including both vehicle tailpipe exhaust or evaporations from the fueling system. Vehicle criteria pollutant emissions are a significant source of air quality problems within urban areas, including smog and cancer-causing chemicals. E85 emissions of NOx (a precursor to smog) are 27% lower than those for gasoline, while VOCs show a small decrease.[43] NOx emission benefits are due to the lower combustion temperature for E85. Notably, NOx emissions for the lower-ethanol content E10 blend are slightly higher than those for gasoline. It is important to note that FFVs meet the same emissions standards as conventional vehicles, regardless of their using gasoline or E85.

B20 biodiesel shows small emission benefits across most criteria pollutants. VOCs and carbon monoxide (CO) are reduced by approximately 20% and 10%, respectively. These values are relatively small compared to emissions for diesel, as the B20 blend is primarily diesel fuel. Biodiesel has been show to slightly increase and decrease NOx emissions, depending on the study. The change in NOx emissions varied between plus and minus 2% for B20 in EPA testing.[44] When considering diesel emissions, the most significant pollutant is DPM, primarily in the form of soot emitted from the tailpipe. As noted, DPM carries heavy metals and toxic hydrocarbons into the body, and is the primary cancer-causing agent in diesel vehicle exhaust. B20 reduces DPM by approximately 10%.[45] However, because new diesel vehicles have pollution controls such as diesel particulate filters, DPM emissions are low in new vehicles even without the use of B20. B100 reduces DPM by 100%. Figure 4-5 shows the percent change in emissions for E85, B20, and B100 compared to petroleum-based fuels.

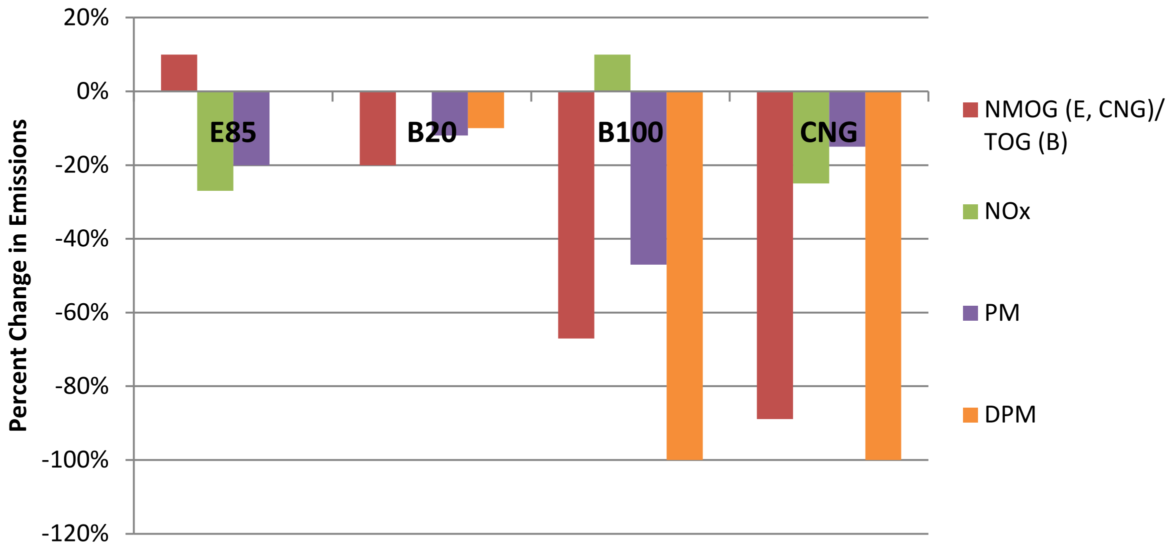
## Natural Gas and Propane

In passenger cars, EPA reports that the criteria pollutant emissions benefits of CNG are small compared to gasoline vehicles with modern emission controls. EPA's emission standards do not differentiate among fuel types, and CNG vehicles are held to the same standard as gasoline vehicles. Nevertheless, NGVs offer emissions benefits compared to gasoline vehicles, especially when replacing older vehicles.[46] Emissions certifications for light-duty trucks (both original engine manufacturer and after-market conversion) show a range of lower and slightly higher emissions for criteria pollutants but always below the emissions standard.[47]

In bus transit fleets, CNG historically has produced significant emissions reductions compared to diesel. However, with the introduction of low-emission diesel buses that meet the EPA 2007/2010 emissions standards, the benefits of CNG are more modest because both diesel and CNG heavy-duty engines must meet the same stringent emissions standards. There has been little in-use testing of emissions from new CNG buses for comparison to diesel. Based on natural gas engines certified for HDVs, NOx emissions reductions appear to be in the range of 20–30%, with 25% represented in the chart below.[48] [49] The effect on PM emissions is less certain. New natural gas engines for trucks have been certified at PM emissions levels significantly lower than diesel. However, natural gas trucks operated at the Port of Los Angeles have shown greatly increased ammonia emissions relative to diesel trucks.[50] Ammonia can produce secondary particulates that could offset the PM benefits of natural gas. Newer natural gas vehicles may eliminate this problem. The effect of natural gas vehicles on PM emissions is an area of on-going research. For this report, PM benefits were assumed in the range of 10–20% (15% represented in the chart below) in comparison to conventional diesel. In CNG applications that displace 100% of diesel, DPM is also decreased by 100%.

Propane burns cleaner than gasoline or diesel. However, compared to modern gasoline and diesel vehicles, propane does not offer significant criteria pollutant emissions benefits. Emissions certification data for propane conversions of gasoline engines show both slight increases and decreases in criteria pollutant emissions, depending on the size of the engine and vehicle converted.[51] The emissions control systems of conventional vehicles have improved to the extent that gasoline or diesel emissions are already at a very low level. As with natural gas vehicles, EPA emissions standards apply equally to all fuel types.[52] Also, similar to CNG, propane shows a 100% reduction of DPM. Figure 4-5 shows the percent change in emissions for CNG compared to petroleum-based fuels.

**Figure 4-5. Emissions Reductions of Biofuels, Biofuel Blends, and CNG Compared to Petroleum-Based Fuels**




Note: NMOG is non-methane organic gases (presented for E85 and CNG). TOG is total organic gases (presented for B20 and B100).

### Hydrogen and Electricity

Hydrogen and electricity are considered the two main advanced fuels. From a tailpipe perspective, the criteria pollutant and air toxic benefits of hydrogen depend on the vehicle technology used. For FCVs, vehicles emit only water vapor with trace amounts of hydrogen, eliminating all tailpipe pollutants. A major benefit of BEVs is the total elimination of tailpipe emissions. Consequently, BEVs can greatly contribute to improving local air quality.

The benefits of PHEVs and HEVs are less because these vehicles burn gasoline during a portion of operation. However, with emission control technology in place, criteria pollutant emissions from PHEVs and HEVs are equivalent to or less than those from conventional gasoline and diesel vehicles. In contrast, hydrogen ICE vehicles produce quantities of NOx in the combustion process. Hydrogen's higher flame temperature compared to gasoline drives higher NOx emissions, although these emissions can be greatly reduced in an after-treatment process.

## 4.4. Greenhouse Gas Emissions Impacts

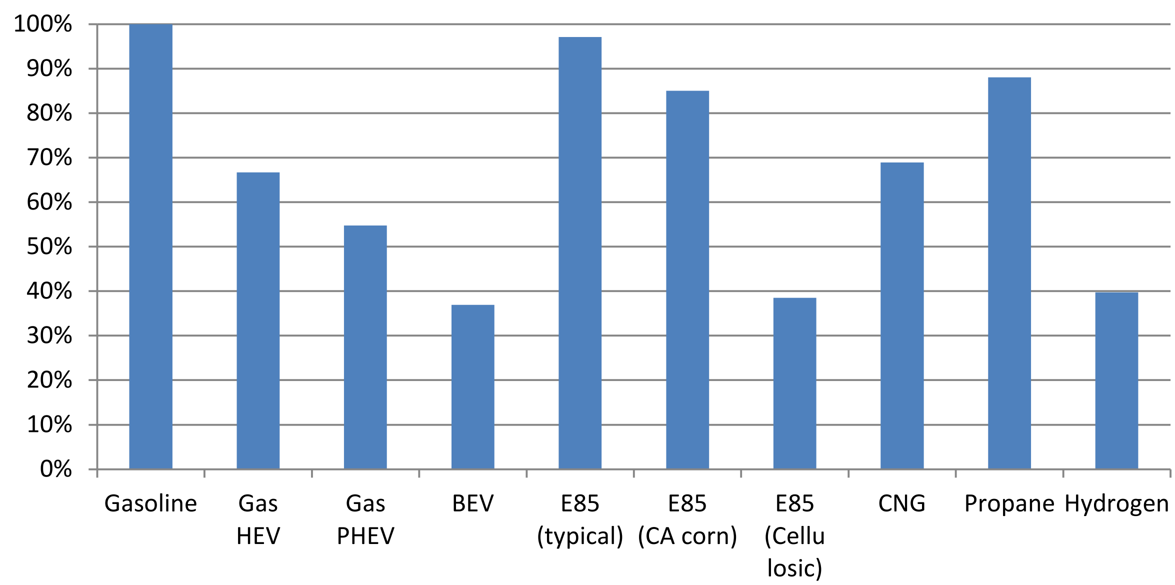
This section discusses the GHG benefits of alternative fuels and technologies for the gasoline/light-duty sector and the diesel/medium- and heavy-duty sector.

### Gasoline/Light-Duty Vehicles

For gasoline/light-duty vehicles, the alternative fuels and technologies to reduce GHGs are hybridization, electricity, ethanol, natural gas, propane, and hydrogen. Figure 4-6 compares the GHG emissions of alternative technologies and fuels to the emissions of conventional gasoline vehicles. These emissions estimates are based on fuel-specific carbon intensity values published by ARB and thus reflect fuel and electricity typical for the state.

The GHG emissions benefits of ethanol vary considerably, depending on the feedstock that is used and the method of refining the fuel. The most common feedstock in use for ethanol in California today is a blend of Midwest corn and California feedstock. Because relatively high GHG emissions are associated with crop production, the net GHG emissions resulting from typical ethanol are just 4% less than those of gasoline.[53] If ethanol is produced exclusively in California, there is a potential for a 19% carbon intensity reduction due to the increased efficiency of California ethanol plants. This translates to a 15% carbon intensity reduction for E85 using California corn ethanol. Ethanol produced from sugar cane is cleaner, with GHGs that are on average 23% less than those from gasoline. Cellulosic ethanol produced from forest waste would reduce greenhouse gas emissions by 78% compared to gasoline. Note that the GHG emissions benefits of various ethanol blends will be less than the benefits of pure ethanol, depending on the ratio of ethanol to gasoline.

**Figure 4-6. GHG Emissions Benefits of Alternative Technologies and Fuels for Light-Duty Vehicles Compared to Conventional Gasoline**




Natural gas has GHG emission benefits when used as an alternative to gasoline. The most prevalent form of natural gas compressed to CNG has a lifecycle carbon intensity of 31% less than gasoline. The benefits of LNG are smaller, primarily due to the energy needed to liquefy the fuel. When natural gas is delivered from overseas sources, the carbon intensity is higher due to transportation needs. While the carbon intensity of propane is lower than conventional fuels, it is among the highest of alternative fuels listed in this report. With a carbon intensity of 86.9 grams of carbon dioxide-equivalent per megajoule (g CO2e/MJ), GHG emissions from propane are 12% less than those of gasoline.[54]

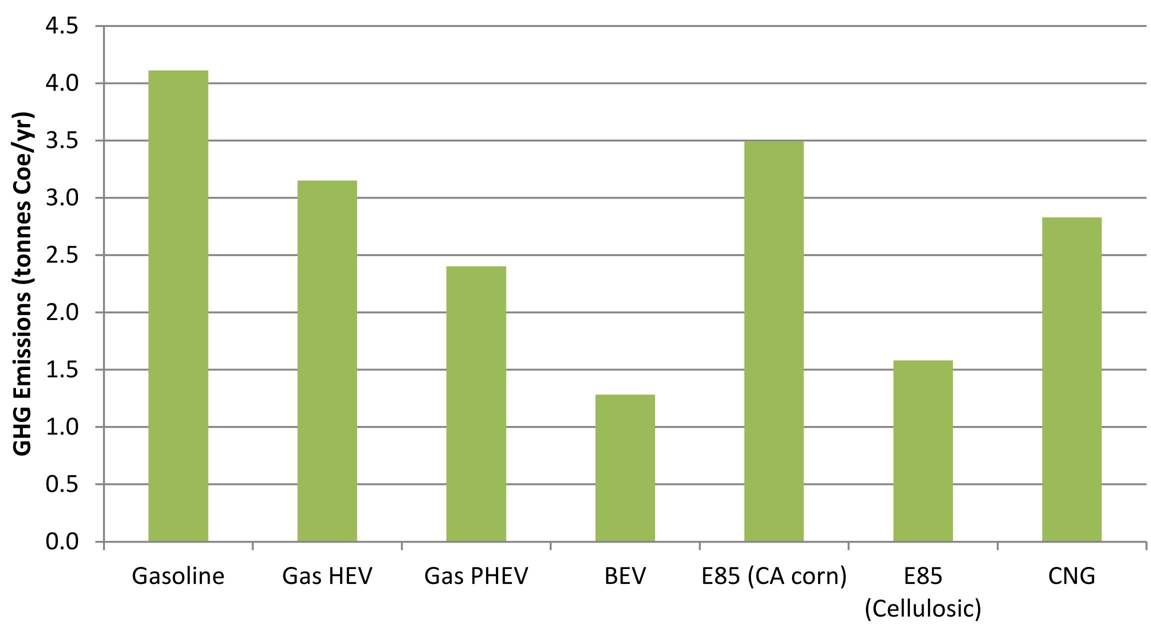
Although hydrogen FCVs can produce significantly lower GHG emissions than gasoline on a lifecycle basis, the benefits depend heavily on how the hydrogen is produced. The difference lies in the feedstock source—whether hydrogen is produced from natural gas (using steam methane reformation [SMR] technology), produced from water using "dirty" electricity with a high-carbon intensity, or produced from "clean" electricity from renewable sources. SMR-produced hydrogen has higher carbon intensity than conventional gasoline, at 95.86 g CO2e/MJ; when the efficiency of a FCV is taking into account, however, hydrogen has 60% lower GHG emissions than gasoline.[55,56]

Hybridization does not change the type of fuel consumed but lessens the amount of fuel used by increasing the fuel economy. Reviewing newer EPA-rated fuel economies of hybrid vehicles compared to their gasoline counterparts, hybridization increases fuel economy by an estimated 50%. HEVs typically see a 33% reduction in GHG emissions compared to a comparable gasoline ICE vehicle.

The GHG emissions of EVs depend on fuel mix and vehicle type. For purposes of the Low Carbon Fuel Standard (LCFS), ARB estimated that EVs are three times more energy efficient than conventional gasoline ICE vehicles. For a typical BEV, the net effect is a 71% reduction in GHG emissions per mile, compared to a gasoline ICE vehicle. The emissions benefits of PHEVs are less because they are designed to operate on a mix of electricity and gasoline. A typical PHEV produces 48% fewer GHG emissions per mile. Note that increased usage of EVs will increase demand for electricity. The effects of EVs on the electric grid are minimized if EVs can be charged during off-peak times (e.g., night time).

For cities wishing to estimate the GHG benefit of alternative fuel vehicles on a tonnage basis, Figure 4-7 shows annual GHG emissions per vehicle across the various fuel and technology options. These estimates use the same assumptions for annual mileage and fuel economy as discussed in Section 4.2. The emissions benefits can be multiplied by the number of alternative fuel vehicles in a fleet to estimate the total GHG impact.

**Figure 4-7. Annual GHG Emissions of Alternative Technologies and Fuels for a Light-Duty Vehicle Compared to Conventional Gasoline**



## Diesel/Medium- and Heavy-Duty Vehicles

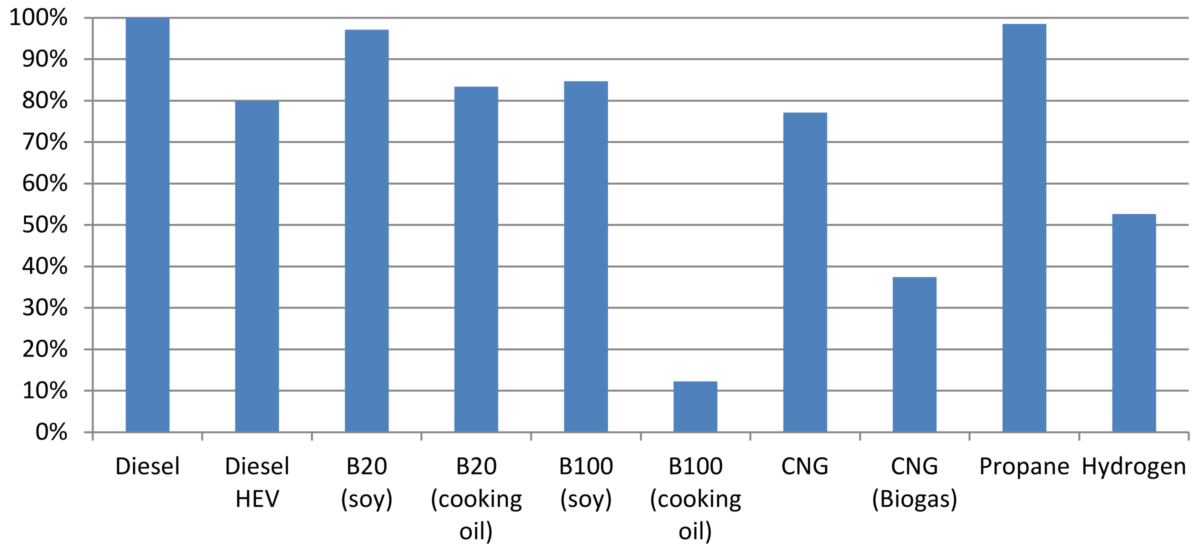
For diesel/medium- and heavy-duty vehicles, the alternative fuels and technologies to reduce GHGs are hybridization, biodiesel, natural gas, propane, and hydrogen. Figure 4-7shows the GHG emissions of these technologies and fuels compared to conventional diesel vehicles.

Similar to ethanol, the $CO_2$ emissions at the tailpipe from a vehicle running on biodiesel are roughly equivalent to those from a vehicle running on conventional diesel. The GHG emission benefits of biodiesel are apparent only when viewed on a lifecycle basis that considers fuel production.

Biodiesel is currently produced from several feedstocks, in three main categories: waste oils such as used cooking oil, plant oils such as corn or palm oil, and crops such as Midwest soybeans. In the case of waste cooking oil and other waste streams (such as corn oil when extracted from distillers grains), the total biodiesel GHG emissions are very low. For example, when produced from used cooking oil, biodiesel reduces GHG emissions by approximately 85%.[57] When produced from soybeans, however, the reductions are only 12%, due to emissions related to cultivation of the soybeans.[58] The land use effects similarly reduce the GHG emissions benefits of using virgin corn oil and palm oil as a biofuel feedstock. These GHG emissions benefit figures apply to pure biodiesel. When blended with conventional diesel, the emission benefits would be reduced, depending on the ratio of the blend.

Natural gas, in compressed or liquid form, has GHG emissions benefits when used as an alternative to diesel. The most prevalent form of natural gas has a lifecycle carbon intensity of 23% less than diesel when taking into account the 10% efficiency loss of natural gas compared to diesel. The benefits of LNG are smaller, primarily due to the energy needed to liquefy the fuel. Natural gas produced from biogenic sources produces much less $CO_2$ (on a lifecycle basis) than conventional natural gas or diesel. No crop production emissions are associated with gases collected from waste streams. CNG produced from landfill gas (biomethane) has a lifecycle carbon intensity that is 63% less than conventional diesel when taking into account the 10% efficiency loss of natural gas compared to diesel. While the carbon intensity of propane is lower than conventional fuels, it is among the highest of alternative fuels listed in this report.[59]

**Figure 4-8. GHG Emissions Benefits of Alternative Technologies and Fuels for Medium- and Heavy-Duty Vehicles Compared to Diesel**

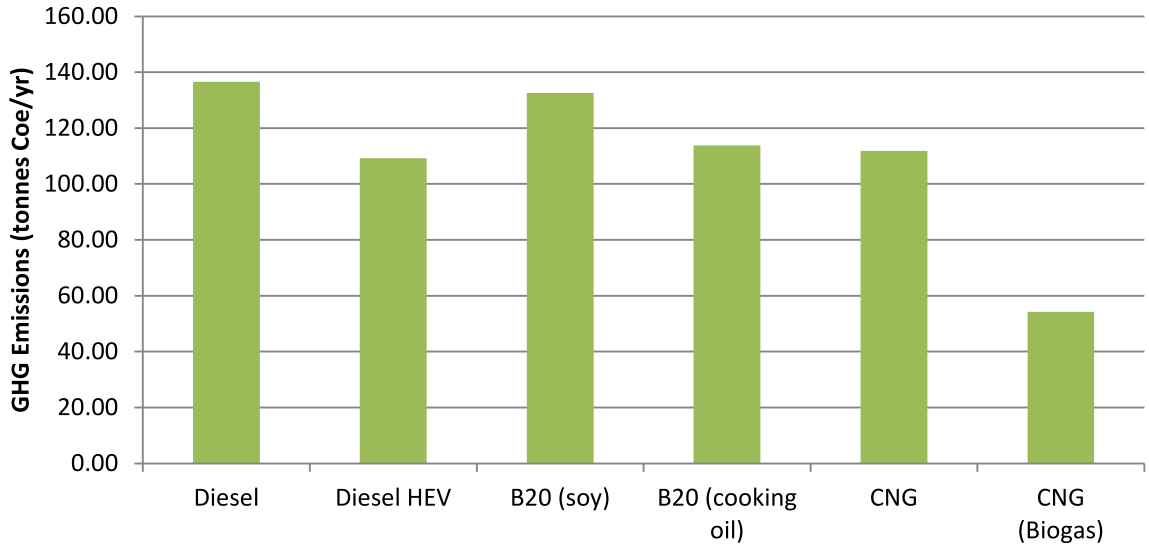



Similar to gasoline, hydrogen FCVs can produce significantly lower GHG emissions than diesel on a lifecycle basis; reduced GHG emissions depend heavily on how the hydrogen is produced. SMR-produced hydrogen has higher carbon intensity than diesel, at 95.86 g CO2e/MJ; when the efficiency of an FCV is taking into account, however, hydrogen has 60% lower GHG emissions than diesel.[60,61]

When compared to diesel, the most prevalent electrification technology is hybridization and not pure battery electric technologies. This is due to the extremely high incremental cost of battery electric medium- and heavy-duty vehicles. Hybrid-electric diesel vehicles, including transit buses, have an estimated increased efficiency of 25%, resulting in a 20% decrease in fuel consumption and GHG emissions. Hybrid-electric diesel vehicles using biodiesel blends would result in additional GHG emissions reductions.

Figure 4-9 below, using the same assumptions in Section 4.2 for annual fuel consumption, shows the estimated annual GHG emissions for a selection of alternative fuels for a transit bus. For cities wishing to estimate the GHG benefit of alternative fuel buses on a tonnage basis, the emissions benefits can be multiplied by the number of alternative fuel vehicles in a fleet to estimate the total GHG impact.

**Figure 4-9. Annual GHG Emissions of Alternative Technologies and Fuels for a Transit Bus Compared to Diesel**




## 4.5. Funding Sources

A variety of federal, state, and regional funds are available to fleets for alternative vehicles and infrastructure. Described below are available sources of funding starting at the federal level and working down to the regional level.

### Federal Funding

The main sources of funding for fleets and transit agencies at the federal level are Congestion Mitigation and Air Quality Improvement (CMAQ) funds; FTA Grants, including the Transit Investments for Greenhouse Gas and Energy Reduction (TIGGER) Program and the Clean Fuels Grants Program; Diesel Emissions Reduction Act (DERA) funding; and federal vehicle and infrastructure tax credit.

**Congestion Mitigation and Air Quality Improvement Program.** The CMAQ Program funds transit improvements, travel demand management strategies, traffic flow improvements, and public fleet conversions to cleaner fuels. The federal share for most CMAQ-eligible projects is 80%. Establishment of alternative fuel refueling facilities and related other infrastructure is eligible for funding if the facility is publicly owned or leased. However, if private alternative fuel stations are reasonably accessible, CMAQ funds may not be used to fund publicly owned refueling stations. Grants from this program can pay for the incremental cost of purchasing natural gas vehicles and can be used to fund alternative fuel refueling projects, although the projects must have 20% local or regional co-funding, and funding is allowed for private/public partnerships.

**Federal Transit Administration Grants.** The FTA provides grants to help fund transit buses for local and regional public transit systems. FTA helps communities support public transportation by issuing grants to eligible recipients for planning, vehicle purchases, facility construction, operations, and other purposes. Two of FTA's programs are described below.

***Transit Investments for Greenhouse Gas and Energy Reduction Program*.** The TIGGER Program is managed by FTA's Office of Research, Demonstration and Innovation in coordination with the Office of Program Management and FTA regional offices. The TIGGER Program works directly with public transportation agencies to implement new strategies for reducing GHG emissions and for reducing energy use within transit operations. These strategies can be implemented through operational or technological enhancements or innovations. To align the TIGGER Program with other strategic initiatives, FTA encourages project implementation that will enhance operational efficiencies, demonstrate innovative electric drive strategies, and create an environment prioritizing public transportation through intelligent transportation systems or other related technology approaches to achieve efficiency and sustainability goals. Eligible recipients include public transportation agencies, federally recognized tribes, and state departments of transportation. Eligible activities include capital investments that assist in reducing the energy consumption of a transit agency and capital investments that reduce greenhouse gas emissions of a transit agency.

***Clean Fuels Grants Program.*** The Clean Fuels Grants Program has a two-fold purpose. First, the program was developed to assist nonattainment and maintenance areas in achieving or maintaining the NAAQS for ozone and CO. Second, the program supports emerging clean fuel and advanced propulsion technologies for transit buses and markets for those technologies. Eligible recipients include entities authorized to receive federal urbanized formula funds and located in areas that are designated as maintenance or non-attainment for ozone or CO. Eligible activities include assisting recipients to purchase or lease clean fuel buses and to construct or lease clean fuel bus facilities or electrical recharging facilities and related equipment; and projects relating to clean fuel, biodiesel, hybrid electric, or zero emissions technology buses that exhibit equivalent or superior emissions reductions to existing clean fuel or hybrid electric technologies. Facilities and related equipment for clean diesel buses are not eligible for these grants.

**Examples of Federal Transit Administrations' Transit Investments for Greenhouse Gas and Energy Reduction (TIGGER) and Clean Fuels Grants Programs**

The fiscal year 2011 Sustainability Awards for the TIGGER and Clean Fuels Programs granted a total of $13.7 million to California recipients. These included the following grants:

- TIGGER Program grant of $6.7 million to Long Beach Public Transportation Company to replace diesel buses with all electric buses for a pilot program
- TIGGER Program grant of $4.9 million to Sunline Transit Agency to assist in building two fuel cell hybrid buses
- Clean Fuels grant of $2 million to Long Beach Public Transportation Company to replace aging diesel buses with gasoline/electric hybrid buses
- Clean Fuels grant of $700,000 to Monterey-Salinas Transit to replace gas minibuses with diesel hybrid electric buses

**Diesel Emissions Reduction Act Program.** The DERA Act of 2010, or DERA 2, reauthorizes the DERA grant program to award up to $100 million per year for fiscal year (FY) 2012–2016. DERA 2 removes the requirement that 50% of funds be used for public fleets and removes restrictions on using funds for programs mandated by state or local law. DERA funds will continue to support projects that strategically reduce diesel emissions. EPA distributes DERA funds through seven regional collaboratives, with 70% of funds awarded on a nationally competitive basis and 30% allocated for state programs. The collaboratives issue regional Requests for Applications (RFAs). New natural gas vehicles and natural gas conversion systems certified by EPA or ARB are eligible for all categories for which the collaboratives issue an RFA.

**Federal Tax Credits.** The last main federal funding source is federal tax credits. Three main federal tax credits are available to transit districts and fleets:

- Fueling equipment for natural gas, liquefied petroleum gas (propane), electricity, E85, or diesel fuel blends containing a minimum of 20% biodiesel installed between January 1, 2006, and December 31, 2013, is eligible for a tax credit of 30% of the cost, not to exceed $30,000. Fueling station owners who install qualified equipment at multiple sites are allowed to use the credit toward each location.
- A fuel cell vehicle tax credit of up to $4,000 is available for the purchase of qualified light-duty FCVs. Tax credits are also available for medium- and heavy-duty FCVs ($10,000 – $40,000, depending on vehicle weight). This tax credit expires on December 31, 2014.
- PHEVs purchased in or after 2010 may be eligible for a federal income tax credit of up to $7,500. The credit amount varies based on the capacity of the battery used to fuel the vehicle.

## State Funding

The three main state funding opportunities are the Alternative and Renewable Fuel and Vehicle Technology Program (Assembly Bill [AB] 118), the California Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP) and the Light-Duty Clean Vehicle Rebate Project.

**Alternative and Renewable Fuel and Vehicle Technology Program.** AB 118 authorizes the California Energy Commission (CEC) to develop and deploy alternative and renewable fuels and advanced transportation technologies to help attain the state's climate change policies. The CEC has an annual program budget of approximately $100 million to support renewable and alternative transportation fuel projects. The statute allows the CEC to use grants, loans, loan guarantees, revolving loans, and other appropriate measures. Eligible recipients include public agencies, private businesses, public/private partnerships, vehicle and technology consortia, workforce training partnerships and collaboratives, fleet owners, consumers, recreational boaters, and academic institutions. The 2013–2014 program funding proposes infrastructure funding for EV charging ($7 million), hydrogen fueling ($20 million), and natural gas fueling ($1.5 million). There is also $12 million of proposed funding for NGV deployment. The CEC releases Program Opportunity Notices (PONs) for available funding that involves submitting competitive applications.

**AB 118 Natural Gas Funding Opportunities**

The California Energy Commission, through PON-12-605 Natural Gas Fueling Infrastructure, awarded funding on March 18, 2013, of almost $4 million, with a significant share going to cities and school districts. Most of this funding was to assist building new CNG stations or upgrading existing stations. Applicants receiving grants included the City of Sacramento; County of Santa Clara; City of Santa Clarita; City of Anaheim; and the Lodi, Murrieta Valley, and Poway Unified School Districts. For example, the City of Sacramento plans on using its awarded $600,000 grant plus a match of $600,000 to upgrade and expand the existing LNG infrastructure.

Through PONs 10-603 and 10-604, AB 118 offers grants to buy down the incremental cost of natural gas and propane vehicles. Grant amounts range from $3,000 to $32,000 per natural gas vehicle and from $3,000 to $20,000 for propane vehicles. Grant amounts are based on vehicle weight. These grant opportunities are available until April 1, 2014, or until the funds are exhausted.

**California Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project.** The HVIP Program is intended to speed the early market introduction of clean, low-carbon hybrid and electric trucks and buses. The HVIP Program is designed to offset approximately one-half of the incremental additional cost of eligible hybrid and battery-electric medium- and heavy-duty vehicles and reduces this cost at the time of purchase. The HVIP base vouchers range from $8,000 to $45,000 on a first-come, first-served basis for the purchase of each eligible new hybrid or electric truck or bus. With the program's additional funding for qualified vehicles (the first three vehicles purchased), voucher levels can reach $65,000 per vehicle. As of March 29, 2013, over $12 million in vouchers are still available in the program.

**Light-Duty Clean Vehicle Rebate Program.** The Light-Duty Clean Vehicle Rebate Project is funded by the ARB and administered statewide by the California Center for Sustainable Energy. A total of $26.1 million has been appropriated for FY 2009–2012 to promote the production and use of zero-emission vehicles, including EVs, PHEVs, and FCVs. Rebates of up to $2,500 per light-duty vehicle are available for individuals and business owners who purchase or lease new eligible zero-emission EVs or PHEVs.

## Regional Funding

Regional funding sources include Bay Area Air Quality Management District (BAAQMD) grants and incentives, Yolo-Solano Clean Air Funds, and Western Propane Gas Association's New Propane Vehicle Rebate Program.

**Bay Area Air Quality Management District Funds.** Part of Solano County is covered by the BAAQMD and can apply for BAAQMD grants and incentives. These grants and incentives include Climate Protection Grants, Lower-Emission School Bus funds, and the Transportation Fund for Clean Air. For example, the Transportation Fund for Clean Air can provide for a wide range of funding opportunities, including the purchase or lease of clean air vehicles.

**Yolo-Solano Air Quality Management District Clean Air Funds**. Yolo-Solano Air Quality Management District Clean Air Funds allow private businesses, non-profit organizations, and public agencies to apply for grants for projects designed to reduce emissions from motor vehicles. The funds can be used for vehicles or infrastructure. Projects awarded Clean Air Funds include replacing or retrofitting diesel trucks and off-road equipment that do not qualify for other regional programs, new electric vehicles, construction of pedestrian and bicycle facilities, transit projects, and public information and education programs. Proposals can be made in one of three categories: clean technologies and low-emission vehicles; alternative transportation; transit; and public education.

**Sacramento Metropolitan Air Quality Management District Regional Funding Program**. Private business and public agencies that operate heavy-duty vehicles or mobile off-road equipment in the Sacramento Federal Non-Attainment Area (SFNA) which includes the eastern portion of Solano County, including Vacaville, Dixon, and Rio Vista, can receive funds to defray the costs of new lower emission technologies that meet cost effectiveness criteria. The program can help fleets pay for new lower emission engines, lower emission retrofits, and new equipment replacements under the district's Heavy-Duty Low-Emission Vehicle Program.

**Western Propane Gas Association New Propane Vehicle Rebate Program**. The Western Propane Gas Association funds a New Propane Vehicle Rebate Program. Up to $1,000 is available to California propane customers who purchase a new propane vehicle or convert an existing vehicle to a propane system. The program runs until August 31, 2013.

## Regulatory Funding

**Low Carbon Fuel Standard.** In some cases, LCFS directly may apply to transit or municipal fleets, due to the definition of a "regulated party." Entities that produce (CNG) and consume (CNG, electricity) alternative fuels can voluntary opt-in to the LCFS and become a regulated party to generate credits. Requirements of a regulated party include quarterly and annual fuel consumption reports, which are done on-line through the state's LCFS tool and are used to calculate the credits generated. Opt-in parties are different than refiners and importers of gasoline and diesel, who are required to be regulated parties in the LCFS. For conventional natural gas fuel (as opposed to biogas), LCFS defines the regulated party as the entity that owns the natural gas fueling equipment. Also, if the transit or municipal fleets uses electricity in BEV or PHEVs in a fleet of three or more vehicles, the agency is eligible to opt-in to the LCFS and generate credits. These credits then can be sold to regulated parties for increased revenue and help offset incremental vehicle costs and infrastructure costs. Credits are currently being sold between $40-$65 per credit, which equates to approximately $0.09-$0.15 per GGE of CNG and $0.31-$0.50 per GGE of electricity.

# 5. Implementation Steps

Based on the assessment of the technologies, benefits, and costs of alternative fuel vehicles and infrastructure presented in the previous chapters, it appears that the three most promising areas of focus for Solano County public agencies interested in promoting alternative transportation fuels are:

- Biofuels
- Natural gas
- Electric vehicles

The most effective implementation steps for public agencies differ among these three fuel categories. This chapter discusses implementation steps, with an emphasis on near-term actions that can be led by Solano County public agencies interested in use of alternative fuels.

## 5.1. Biofuels

As discussed in Chapters 2 and 4, biofuels differ from most other alternative fuels in that they do not require large investments in new vehicle technologies. Many FFVs in municipal fleets are already capable of running on E85, and biodiesel blends up to B20 can be used in most HDVs without modification. Rather, the major barriers to increased use of biofuels are limited fueling infrastructure and limited understanding of biofuel options among the vehicle operators.

For agencies that are interested in increasing use of biofuels, the following implementation steps should be considered. These recommendations are based on a high-level assessment; a more detailed assessment that considers specific sites and operating environments would be needed to fully understand the benefits and drawbacks that any one alternative fuel type offers.

### E85

E85 vehicles using corn-based ethanol produce modest reductions in GHG and air pollution emissions. In the future, by using E85 made from cellulosic ethanol (currently limited in supply), fleets can obtain much larger GHG emissions benefits.

One simple step to increase E85 use is simply to educate drivers or other staff about FFVs that may already be in their fleets. The fleet survey reported in Chapter 3 of this plan identified 133 FFVs currently in municipal fleets, but it is believed that this number is an undercount. Some city staff may not realize that they have FFVs, because the vehicles look identical to conventional gasoline vehicles and can operate solely on gasoline. For example, all Ford Crown Victorias model year 2006 and newer (a common police patrol vehicle) come flex-fuel capable from the factory. To reminder operators about their fueling options, fleets should apply a designator for E85 capability to all FFVs, new and existing, if the fleet does not already do so.

The limited E85 fueling infrastructure is clearly another barrier to increasing the use of biofuels. As discussed in Chapter 3, the County currently has only three E85 fueling facilities—two that are publicly available (in Fairfield and Vacaville) plus the fueling station at Solano County's corporate yard.

Both municipal fleets and private fleets can potentially modify fueling infrastructure at their operations and maintenance facilities to install E85 refueling infrastructure. This is a straightforward step to increase the amount of E85 consumed in fleets. There are two main pathways to install E85 infrastructure: (1) retrofit the existing storage tanks and dispenser to be E85 compatible; or (2) install new storage tanks and dispensers for E85. Generally, retrofits are cheaper; however, it is likely that a fleet may not have sufficient storage tank capacity to convert an existing tank to E85 storage and maintain sufficient on-site storage to continue dispensing gasoline and diesel to other vehicles in the fleet. If new storage tanks and dispensers are to be installed, fleets should consider an aboveground storage tank (AST) to reduce the installation costs associated with an underground storage tank (UST). For instance, the Solano County Corporation Yard installed an AST for E85 in 2009. Generally, due to space constraints and consumer convenience, retail fueling stations install USTs for E85.

ICF estimates the following costs to retrofit or install a new E85 fueling station–these estimates include the costs of tanks, dispensers, hanging hardware, and additional equipment:[62]

- In a retrofit scenario, costs range from $11,000 to $30,000.
- In a new installation, typical costs range from $50,000 to $125,000.

It is a significant challenge to provide more public E85 refueling opportunities because of the economics that retail fueling infrastructure providers face. First, most retail fueling infrastructure providers are small business owners. A common misconception is that fueling stations are owned by large energy companies, but the larger companies started divesting from retail fueling stations due to lower profit margins in the 1990s. Consequently, most of the fueling station owners today have limited access to the capital that is required to invest in E85 infrastructure. Second, the return on the investment in E85 is often difficult to justify given weak demand for E85. Generally, the most cost-effective choice for E85 infrastructure is a retrofit or conversion of an existing tank and dispensers. In other words, the retail station owner needs to ensure that the demand for E85 will be sufficient to generate revenue to pay back the initial investment and offset the lost sales of the converted dispenser. This need often puts additional strain on the return-on-investment calculations performed by retail station owners.

Despite these barriers, there is an increasing interest in E85 refueling infrastructure, due in large part to regulatory drivers such as California's LCFS and EPA's RFS2. For instance, Propel is expanding the network of E85 infrastructure in nearby Sacramento significantly with the support of a grant from the CEC. Propel also has secured significant private investment, which is likely a positive indication of increased private interest in expanding E85 infrastructure. Moving forward, Solano County agencies should seek to engage local retail fueling station owners and E85 infrastructure providers such as Propel to determine the feasibility of expanding the availability of E85 to the general public and identifying grant opportunities to support this expansion.

## Biodiesel

Like ethanol, use of biodiesel also results in lower GHG and most air pollution emissions; benefits increase with the percent of biodiesel blend (e.g., B20 has larger benefits than B5). All diesel vehicles can use low-level biodiesel blends (such as B5), and most can use blends up to B20 without vehicle modification or voiding of the vehicle warranty. Moreover, B5 and B20 cost only a few cents more per gallon than conventional diesel.

Use of biodiesel in California is increasing. As noted in Chapter 3, the Solano County fleet uses B5 for its HDVs. Aside from more frequent checking and cleaning of fuel filters during the transition period, Solano County reports no problems with the fuel and is now considering use of higher level blends. Caltrans uses B5 in most of its HDVs, and several transit agencies in California are already using B20.

Among fuel providers, there is significant movement in California toward B5. For instance, Kinder Morgan is providing B5 at its Colton terminal (Southern California) and in Fresno, while Chevron is moving to B5 at its Montebello terminal. These shifts toward B5 are part of a response to the EPA's RFS2 and California's LCFS. Several terminals in Southern California and Central California provide B5; the availability of B5 in Northern California is expected to increase significantly in the near-term future.

In the near term, the fleets with central fueling should consider including a requirement in their bidding process that specifies the use of B5. As an example, SolTrans contracted in late 2011 with Pinnacle Petroleum to provide petroleum products—gasoline and diesel—to SolTrans facilities, including bus facilities and ferry facilities. This contract has a 2-year base with three 1-year options. In other words, it appears that, at the end of 2013, SolTrans could seek to modify the supply and delivery contract to include B5 as part of the specification. Pinnacle Petroleum's webpage indicates that they provide biodiesel products ranging from B5 to B100. The transition to B5 should not require any infrastructure modifications for the fuel supplier, nor should it require any refueling infrastructure or vehicle modifications on behalf of SolTrans or other fleets. While fleet managers should check engine warranties, it is highly unlikely that use of B5 will void any warranties.

Fleets that consider diesel as the best option for their bus or heavy-duty truck fleet in the near-term future should consider a transition to B20. It should be recognized, however, that the transition to B20 can be more challenging than a transition to B5, as it may necessitate a new storage tank and potential vehicle limitations. Fleets should consider the following before making a transition to B20:

- Fleet managers should update their procurement process to account for B20 (similar to the recommendations for B5 above). Most fuel providers should be capable of providing a biodiesel product.
- Fleet managers should confirm that engine warranties are covered by B20.
- Fleet managers will need to confirm that existing USTs are compatible with B20, assuming the fuel will be stored as B20 and not blended on site. Although a vast majority of USTs are compatible with B20, in is likely that a new storage tank would need to be installed, since most fleets would need to maintain conventional diesel fueling for equipment that cannot use

biodiesel. Existing USTs should be cleaned thoroughly prior to transition to B20 to remove any residuals in the tank. Fuel filters need to be cleaned more frequently with B20, particularly in the transition period, because biodiesel acts as a solvent and tends to dislodge contaminants in the fuel system. Fueling hoses likely also will need replacement.

- In the event that the diesel UST is not compatible with B20 (or higher blends), the agency should seek to update their tank as needed. This will require an investment on the order of $175,000, depending on the costs of digging up the tank.
- Fleet managers should confirm that any shelf-life issues with B20 or higher blends will not cause problems, particularly with equipment that is used only seasonally (e.g., chippers).

## 5.2. Natural Gas

As shown in Section 4.1, natural gas fueled vehicles have the potential for lower costs than conventional fueled vehicles. This is especially true with transit and fleet vehicles that refuel at private stations and enjoy lower fuel prices compared to public stations. This discount is usually due to long-term purchasing agreements between the fleet and the fuel provider. Natural gas vehicles also have lower air pollution and GHG emissions.

The most appropriate applications for natural gas as a transportation fuel tend to be those with high fuel use, which enables the higher purchase price of the vehicle to be offset through lower annual fuel costs. The higher the fuel consumption, the quicker the payback period and the more potential for fuel cost savings. Natural gas is not available or suitable for all vehicle types and uses, and should be analyzed on a fleet- and vehicle-specific basis. For example, the lower power of natural gas engines may preclude its use for some off-road applications.

Based on the large current fuel price differential, it appears that many Solano County fleets could reduce their costs by switching to natural gas. But several barriers prevent this from happening. The three main barriers are lack of fueling infrastructure; higher incremental vehicle costs; and lack of familiarity with the fuel, including new maintenance and operational practices. If a fleet is to perform its own fueling and maintenance, then a transition to natural gas requires a significant “all-in” commitment to guarantee the fleet can recoup any necessary infrastructure and vehicles costs. In other words, natural gas differs from most other alternative fuels in that fleets cannot simply “try out” the fuel with a few vehicles. A noted in Section 4.2, the cost of a new CNG fueling station can range from $600,000 to $5 million, and the fleet would also likely need to retrofit its maintenance facility.

For agencies that are interested in increasing use of natural gas as a transportation fuel, the following implementation steps should be considered. These recommendations are based on a high-level assessment; a more detailed assessment that considers specific sites and operating environments would be needed to fully understand the benefits and drawbacks that any one alternative fuel type offers.

## Fueling Infrastructure

Solano County currently has three natural gas fueling stations, two located in Vacaville and one in Fairfield. These stations service the Vacaville City Coach and City of Vacaville transit bus and light-duty fleet vehicles and the Solano Garbage Company medium- and heavy-duty vehicle fleet. The limited refueling infrastructure in Solano County is likely a barrier to implementation, with some fleets possibly resisting conversion to natural gas due to limited fueling capacity. At the same time, there may be insufficient demand for private companies to invest in constructing publicly available natural gas refueling stations. This is a common barrier with many alternative fuels.

Fleets can be the fastest way to break through this "chicken-and-egg" problem as they can quickly, with large vehicle purchases, provide increased demand and justify the construction of new natural gas refueling infrastructure. These new stations can potentially serve a greater purpose of increasing demand outside of the fleet by providing both private and public access to the station. Increased public access will allow small fleets and individual vehicle purchasers an opportunity to take advantage of the fuel price differential between natural gas and gasoline or diesel.

Several potential locations in Solano County have been preliminarily identified for new natural gas refueling stations, as shown in Table 5-1. A feasibility study is currently underway to assess the Vallejo and Benicia locations.

**Table 5-1. Possible Locations for New Natural Gas Fueling Facilities in Solano County**

| City | Location | Potential Users |
|---|---|---|
| Vallejo | SolTrans Bus Maintenance Facility<br>1850 Broadway | SolTrans buses, Vallejo public works, public |
| Vallejo | Vallejo Transit Center Park & Ride<br>Curtola Parkway & Lemon Street | SolTrans buses, Vallejo public works, public |
| Benicia | Benicia Industrial Park | SolTrans buses, Benicia public works, public |
| Dixon | Dixon Public Works Maintenance Yard<br>285 East Chestnut Street | Dixon public works, public, trucks using I-80 |
| Rio Vista | To be determined | Rio Vista public works, public, trucks using Highway 12 |

Ideally, these stations would have both public and private fleet access, but this type of access can increase station costs. The main variables affecting station cost are pipeline access (estimated cost of $1 million per mile for pipeline access), existing infrastructure, and the type of station (time-fill versus fast-fill). Existing infrastructure and site suitability affect the costs for site preparation.

The type of station depends on the main fuel users of the station, as described below.

- **Time-fill stations** are built for fleet vehicles that operate during the day and refuel overnight. These stations do not require compressed storage, because the large compressors refuel vehicles directly and multiple vehicles at a time. The main cost component for this type of station is the compressors.
- **Fast-fill stations** are built for public access where the refueling can happen within 5 minutes. These stations have high-pressure storage tanks that refuel the vehicle and compressors that refill the tanks between fueling events. The two main cost components for this type of station are compressors and storage tanks (either high pressure of liquefied).

Stations built to fulfill both private fleet and public access will need equipment to satisfy both types of refueling events.

An organization wishing to develop a new natural gas station typically has the option of financing the station on its own or securing a private developer to build and operate the station. To build the station on its own, the local agency would need to obtain the private capital necessary to build and operate the station. State and federal funding may be available for natural gas infrastructure. This approach was used by Solano Garbage, the local subsidiary of Republic Services, in Fairfield. The company built an LNG/CNG station, where the natural gas is stored as LNG and can be dispensed as either LNG or CNG. The main benefit of building your own station is lower fuel prices, because the station owner is paying only for the commodity price of the gas, amortized capital, and operations and maintenance costs. For comparison, privately developed stations incur all of these costs in addition to the mark-up and fee of the private developer and operator. The second benefit is the potential source of income from contracting with outside fleets and individual vehicle operators who would like to use the station. The DOE's Alternative Fuels Data Center has a link to the Clean Cities Vehicle and Infrastructure Cash-Flow Evaluation (VICE) Model, which can help in evaluating the return on investment and payback period for natural gas infrastructure.[63]

**Building It Yourself – Solano Garbage**

Solano Garbage Company built and operates an LNG/CNG fueling facility in Fairfield. Solano Garbage is a subsidiary of Republic Services, a national waste management services company. The company uses liquefied natural gas (LNG) in Class 8 refuse trucks as well as compressed natural gas (CNG) in several Ford E-450 vans. The original motivation behind natural gas vehicle (NGV) adoption in 2001 was the company's waste collection contract with the City of Fairfield, which specified vehicle emissions requirements. Republic Services chose to pursue LNG as a means to satisfy this mandate.

Solano Garbage used federal grants to help offset the costs of the natural gas station. By owning and operating the station, Solano Garbage can contract with other outside fleets, including Suisun City, who want to use the station for refueling.

When the station was constructed, the company planned ahead for future capacity expansion. Because all vehicles are dedicated NGVs, driver education was essential early on to ensure that the vehicles were sufficiently and properly fueled. The company has encountered no significant barriers related to vehicles or infrastructure.


The other approach is to contract with a private developer to build, own, and operate the natural gas station. Examples of private developers are Trillium CNG and Clean Energy. This option does not require capital expenditure for the station, but usually requires a long-term fueling agreement that guarantees a minimum fuel throughput for the operator. The fuel costs for this station option are usually higher than the build-it-yourself option to include cost recovery, mark-up, and fee.  This option also allows for the potential of public refueling dispensers. Transit agencies in Elk Grove and Montebello, California have recently chosen this option with Clean Energy. The station built for the City of Elk Grove also has a public dispenser.

**Private Developer – City of Elk Grove**

The City of Elk Grove's transit bus system, *e-tran*, maintains a fleet of more than 50 vehicles, all of which are powered by compressed natural gas (CNG). Prior to 2011, *e-tran* buses were using a nearby Pacific Gas and Electric Company fueling station, but the time-fill capabilities were not ideal, and there was a possibility that the station would be unavailable during upgrades or relocated in the future. The City began to explore other options, including building a fueling facility of their own.

The City faced several challenges, primarily a lack of space to install a station at their corporate yard and no capital resources that could be diverted from vehicle investments to infrastructure. Working with Clean Energy, the City was able to overcome both hurdles. Clean Energy negotiated with the owner of an existing card lock fueling station and leased available property for the CNG infrastructure. Clean Energy also provided up-front capital in exchange for a 10-year fueling agreement with the City. The City was able to ensure a reduced CNG fuel rate for the long term as long as a minimum fuel consumption commitment was met. Federal grants also reduced the overall infrastructure costs.

Operated and maintained by Clean Energy, the station opened for business in March 2011 and is available to area fleets as well as the public. Additional dispensers were included at the station to ensure that *e-tran* vehicles are always able to fuel as needed.


When an agency is considering installation of a new station and weighing the options, it is important to contact cities and fleets to better understand the pros and cons of both approaches. Cities and transit operators can learn from and build off the experiences of others. Cities and transit operators may also be able to make use of another agency's resources, such as maintenance facility specifications and scopes of work for procurements and solicitations.

## Incremental Vehicle Cost

As discussed in Section 4.1, NGVs carry a higher purchase price than their gasoline and diesel counterparts, mainly because of the cost of the fuel tanks. This higher up-front cost usually will be offset by lower fueling costs over the lifetime of the vehicle. The payback period depends primarily on the amount of fuel used per year and the price differential between natural gas and conventional fuel. Transit buses often have the shortest payback period, while light-duty trucks and sedans have a longer payback.

The incremental costs for NGVs can be reduced by state and federal funding, including AB 118, CMAQ, FTA, and DERA 2 programs. For more information on these funding sources, see Section 4.5. Reducing the incremental vehicle costs from state and federal funding will reduce the price differential necessary for a positive payback and increase the cost savings. It is recommended that fleets investigate these avenues of funding during the planning stages for NGV purchases to take advantage of all available funding sources.

### Unfamiliar Maintenance and Operational Practices

Natural gas stations, infrastructure, and vehicle maintenance facilities require meeting more stringent safety guidelines than conventional fueling stations and vehicle maintenance facilities. The local fire marshal and utility can help with identifying these requirements. Additional investment may be needed to address these guidelines and needs. The City of Montebello, for example, required $50,000 in improvements to its maintenance facility when it switched to natural gas buses. It is recommended that agencies and fleets considering natural gas refueling contact their local fire marshal and other local agencies and fleets that have installed natural stations and maintain their own vehicles. This first-hand experience has immense value in identifying what upgrades and improvements could be required and what changes to maintenance practices could be required.

Another resource to assist transit agencies with the transition to natural gas is the Natural Gas Transit Users Group, operated through the Clean Vehicle Education Foundation and funded by the DOE.[64] This group helps stakeholders by sharing lessons learned and problem-solving techniques; providing a technical forum for fleet maintenance staff; and communicating safety issues, codes, and standards. It is recommended that agencies not only contact and visit local fleets (including Vacaville and Elk Grove) and transit agencies that have made the switch to natural gas, but also connect with Transit Users Group to address any potential questions and concerns.

## 5.3. Electric Vehicles

Electric vehicles have the potential to reduce GHG emissions, criteria air pollutant emissions, and displace petroleum. Although electric vehicles currently have only a small market share, the long-term success of electrification depends on steps that are taken today. This is why local and regional agencies have prioritized EV readiness and planning. These near-term efforts are intended to pave the way for the long-term transition to electric vehicles consistent with California's regulatory initiatives such as AB 32, the Low Carbon Fuel Standard, and the ZEV Program. For instance, the ZEV Program requires that by 2025 about 15% of new light-duty vehicles be ZEVs, with ARB's most likely compliance scenario weighted towards EVs (rather than FCVs).

Electrification of transportation is part of California's long-term strategy to achieve significant GHG and criteria pollutant reductions, and near-term actions – such as EV deployment in municipal fleets –can help facilitate and accelerate that transition. The transition to electric vehicles, however, will face a number of barriers that should decrease over time. The sections below highlight the potential for electric vehicle deployment, while recognizing that there are considerable costs for consumers and fleets alike which will limit deployment until cost competitiveness improves.

The greatest barrier to increased use of EVs among Solano County residents in the near term is the high vehicle price. Because local governments are typically not in a position to provide incentives for consumer purchasing of vehicles, the ability for Solano County agencies to overcome this barrier is limited. Federal and state agencies have taken the lead in overcoming price barriers by offering incentives such as the federal tax credit (valued at up to $7,500 per vehicle) and the California Vehicle Rebate Project, administered by ARB (with rebates valued up to an additional $2,500 per vehicle). Despite the limited ability to influence car purchasing decisions, local agencies can help facilitate the deployment of EVs in several key areas, including: (1) targeted infrastructure deployment; (2) EV readiness through actions such as expedited permitting processes; and (3) deploying EVs in municipal fleets.

For agencies that are interested in increasing use of electric vehicles, the following implementation steps should be considered. These recommendations are based on a high-level assessment; a more detailed assessment that considers specific sites and operating environments would be needed to fully understand the benefits and drawbacks that any one alternative fuel type offers.

## Infrastructure Deployment

### Overview

Most EVs are likely to be charged at the owner's residence. However, the availability of public charging for personal vehicles and fleet vehicles likely will significantly benefit the transition to electric vehicles. Regional agencies such as BAAQMD and the Metropolitan Transportation Commission (MTC) have played a central role in coordinating the initial deployment of and planning for EVSE in the Bay Area. STA has played a key role in developing Solano County's charging station infrastructure to date using funding from the CMAQ program, BAAQMD Transportation Fund for Clean Air funds, and Yolo-Solano Clean Air Funds. The City of Vacaville has also been a leader in EVSE deployment. In 2011, Vacaville was voted runner-up for the "Most EV-Ready Community" award given by the Bay Area Climate Collaborative. In the next several years, it will be incumbent on local agencies to continue to play a central role in facilitating publicly available EVSE.

Several levels of EV charging are relevant to this discussion. EVSE is based on current standards established by the Society of Automotive Engineers (SAE) and differentiated by the maximum amount of power provided to an EV battery:

- **Level 1 AC** – These use standard 120-volt (V), single-phase service with a three-prong electrical outlet at 15–20 amperage (A).
- **Level 2 AC** – These are used specifically for EV charging and are rated at less than or equal to 240 V AC, and less than or equal to 80 A.
- **DC fast-charging units** – These provide power much faster than the AC counterparts, with a 480-V input. However, DC fast-charging equipment is more expensive to build and operate.

The times needed to replenish a battery halfway and fully for some common EVs—including the Toyota Prius Plug-in, Chevrolet Volt, Nissan LEAF, and Tesla Roadster—are shown in Table 5-2. Charging times on Level 1 EVSE are primarily suitable for small battery vehicles, such as the Volt, which require more than 7 hours to fully charge. Estimated charge times using DC fast charging for the Volt, LEAF, and Roadster are included, despite not being equipped with the appropriate hardware, and are meant only for illustrative purposes. For DC fast charging, calculations assume that the battery is charged only to 80%, and the remaining 20% is completed by charging at a slower rate. If left connected at high power, the time to fully charge the battery will increase to over 1 hour because of the nature of DC fast charging.

**Table 5-2. Estimated Charging Times Using Electric Vehicle Supply Equipment (hours: minutes)**

| Charger Type / Usable Power | Charge Level | Vehicle | | | |
|---|---|---|---|---|---|
| | | Prius | Volt | LEAF | Roadster |
| Level 1 / 1.4 kW | Half | 1:34 | 3:42 | 7:42 | 15:08 |
| | Full | 3:08 | 7:25 | 15:25 | 30:17 |
| Level 2 / 7.5 kW | Half | 0:40 | 1:34 | 3:16 | 2:49 |
| | Full | 1:20 | 3:09 | 6:32 | 5:39 |
| DC fast / 50 kW | Half | 0:02 | 0:06 | 0:12 | 0:25 |
| | Full | 0:05 | 0:47 | 1:39 | 1:08 |
| DC fast / 150 kW | Half | 0:01 | 0:02 | 0:04 | 0:08 |
| | Full | 0:02 | 0:41 | 1:25 | 0:41 |

The costs of EVSE depend on factors such as hardware, permitting, and installation. The following ranges of costs are typical:

- Single-family homes with dedicated parking: $900–$2,350
- Multiple-dwelling units (e.g., multi-family) and workplace installations
  - Level 1 EVSE: $3,800–$5,000
  - Level 2 EVSE: $5,600–$14,000
- Public installations (e.g., parking lots or on-street parking)
  - Level 1 and Level 2 EVSE: same as above for workplace installations
  - DC fast-charging EVSE: $100,000–$150,000

These ranges are based on each EVSE location installed and generally include two ports. It is also worth noting that the marginal cost of the next EVSE installation is a fraction of the total installed cost reported. The EVSE hardware is the only cost element that does not yield some benefit with increased number of installations. This is particularly relevant because the hardware represents a small fraction of the overall cost for both Level 1 and Level 2 EVSE. Even for DC fast-charging EVSE, multiple installations result in potentially significant savings, with approximately 25–60% of the installed cost represented by the hardware. There is already some downward pressure on the hardware costs of DC fast-charging EVSE, as evidenced by Nissan's recent partnership with Sumitomo to market a charger for $9,900.[65]

Level 2 and DC fast-charging EVSE costs for multiple-dwelling units and workplaces will vary considerably depending on the siting characteristics. For instance, PG&E has estimated a range of $500–$30,000 for Level 2 charging EVSE. A number of factors could significantly increase the cost of DC fast charging, such as distribution upgrades and increased construction costs (e.g., increased trenching and repair or concrete work).

### Siting Analysis: Residential Charging, Workplace Charging, and Opportunity Charging

With respect to EV fueling or charging, vehicle architecture plays a significant role in determining both the frequency and amount of charging needed during any fueling session; this is because different types of EVs use electricity somewhat differently. For example, PHEVs use electricity to extend the range of the vehicle and to provide a dual-fuel option, while BEVs use electricity as their sole source of propulsion energy. With this in mind, siting of charging infrastructure is a key component of successful EV deployment and requires consideration of the following questions:

- **Location:** What are potential venues and areas to locate EVSE? Options are generally characterized as at home, at workplaces, and on public or private property.
- **Quantity:** How many EVSE are needed to support electric vehicle drivers?
- **Level of charging:** What voltage and power levels are necessary for useful EV charging at the various locations—Level 1, Level 2, or DC fast charging?
- **Investment:** Who pays for and maintains public and private infrastructure?
- **Payment:** How much should individuals pay for a "charge"?

BAAQMD recently commissioned a siting analysis as part of the *Bay Area Plug-In Electric Vehicle Readiness Plan* to start answering some of these questions.[66] The analysis focused on (1) residential charging; (2) workplace charging; and (3) publicly accessible charging (also referred to as *opportunity charging*). The results specific to Solano County have been extracted for the purposes of this report, as discussed below.

Overall, Solano County residents appear to be somewhat less likely to purchase EVs compared to other residents in the San Francisco Bay Area, based on data from the Clean Vehicle Rebate Project shown in Table 5-3. Solano County residents to date have received rebates for the purchase of 70 PHEVs and 51 BEVs, accounting for 2% of all Bay Area rebates. The ratio of EV rebates per 1,000 residents (0.29) is lower than ratios for the other eight Bay Area Counties.

**Table 5-3. Rebates Issued in the Bay Area from the Clean Vehicle Rebate Project**

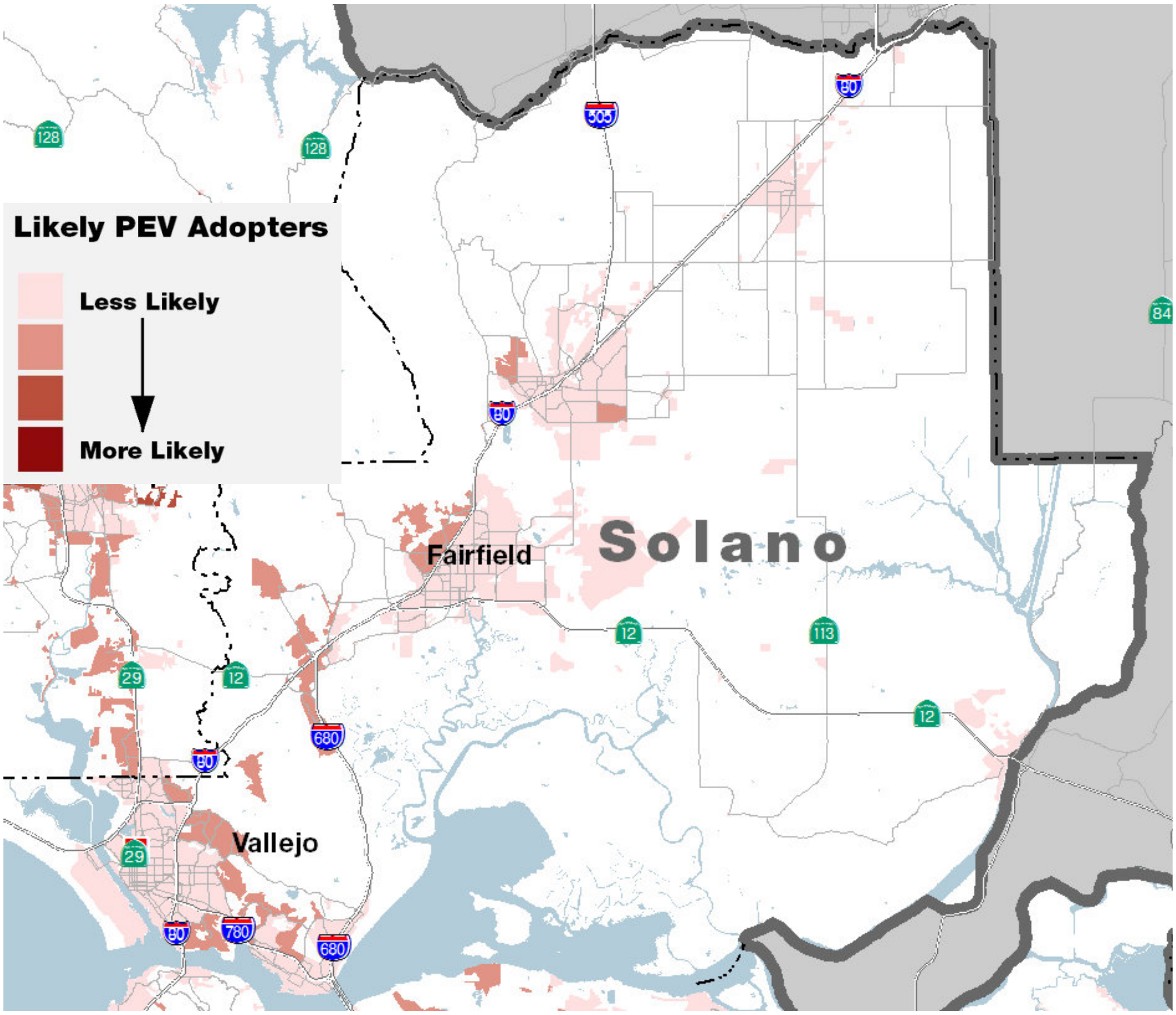
| County | EV Rebates Issued through April 2013 | | | | Population (2011) | Rebates per 1,000 Residents |
|---|---|---|---|---|---|---|
| | PHEVs | BEVs | Total | Percent | | |
| Alameda County | 680 | 919 | 1,599 | 20% | 1,530,000 | 1.05 |
| Contra Costa County | 369 | 420 | 789 | 10% | 1,066,000 | 0.74 |
| Marin County | 151 | 222 | 373 | 5% | 255,000 | 1.46 |
| Napa County | 28 | 31 | 59 | 1% | 138,000 | 0.43 |
| San Francisco County | 151 | 318 | 469 | 6% | 813,000 | 0.58 |
| San Mateo County | 300 | 660 | 960 | 12% | 727,000 | 1.32 |
| Santa Clara County | 1,239 | 2,030 | 3,269 | 41% | 1,809,000 | 1.81 |
| Solano County | 70 | 51 | 121 | 2% | 416,000 | 0.29 |
| Sonoma County | 110 | 193 | 303 | 4% | 488,000 | 0.62 |
| **Bay Area Total** | **3,098** | **4,844** | **7,942** | **100%** | **7,242,000** | **1.10** |

Source: http://energycenter.org/index.php/incentive-programs/clean-vehicle-rebate-project/cvrp-project-statistics ; accessed April 8, 2013

### *Residential Charging*

As part of the *Bay Area Plug-In Electric Vehicle Readiness Plan* development, ICF identified the most likely adopters of EVs in the Bay Area based on household factors such as income, hybrid ownership, household type (e.g., single family vs. multi-family units), home ownership, and education. Figure 5-1 shows the home location of the most likely EV adopters.

**Figure 5-1. Locations of Most Likely Electric Vehicle Adopters in Solano County**

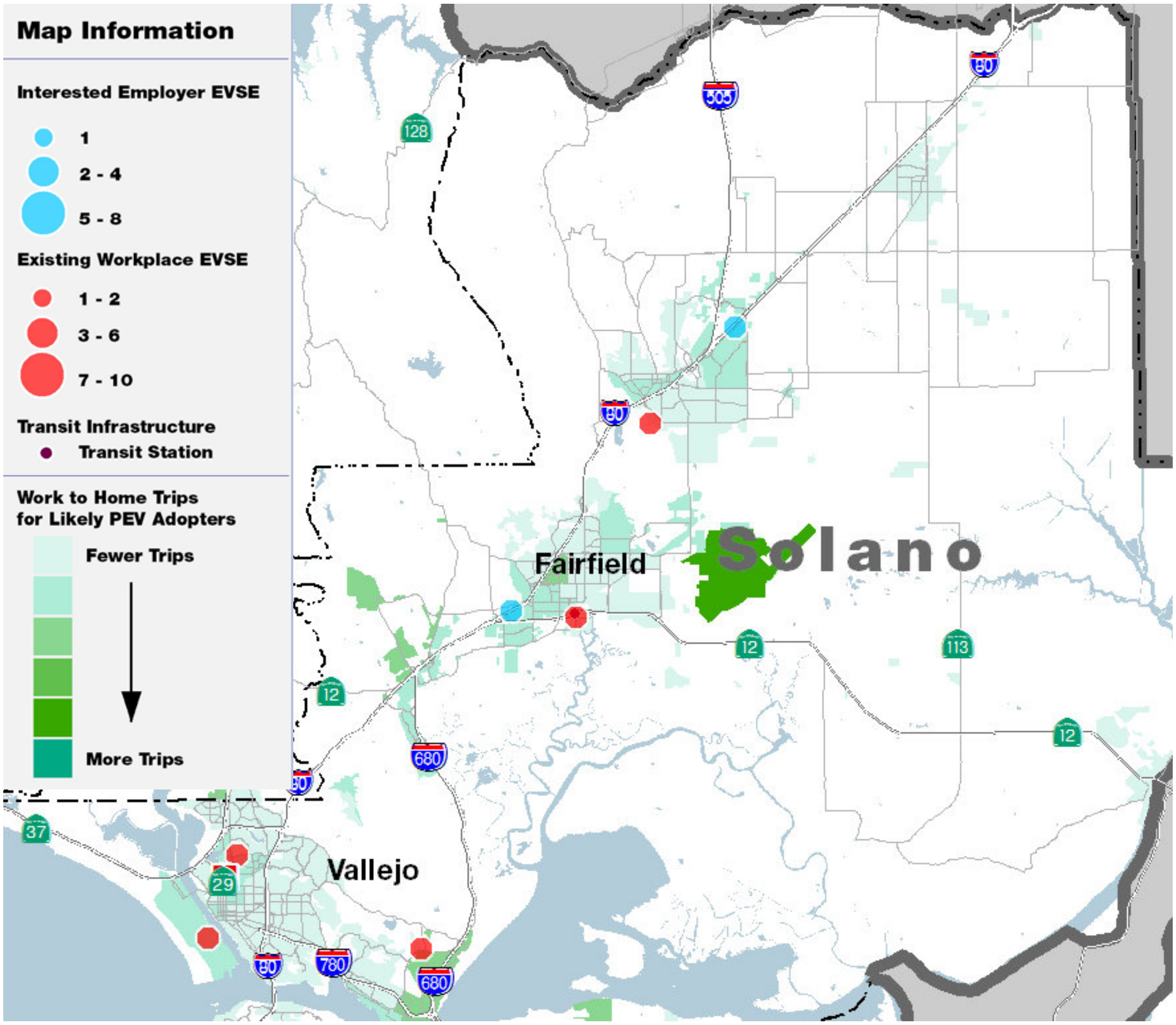



### *Workplace Charging*

Workplace charging is significant because personal vehicles are likely to spend a considerable amount of time parked at work. According to MTC analyses, the average distance traveled to work for Bay Area commuters in 2010 was approximately 13 miles; these miles include only the distance between home and work and do not factor in any side trips, errands, or other trips that may extend the daily distance traveled. In other words, the average round-trip commute distance in the Bay Area is approximately 26 miles. In some cases (e.g., with the Chevrolet Volt) there may be sufficient range to make these trips entirely using electricity. However, with increases in the sales of PHEVs with less than 25 miles of range, and several more PHEV models with similar ranges hitting the market soon, there is significant potential to extend the all-electric miles traveled in places like Solano County.

Figure 5-2 shows an overlay of the following data: the most likely destination zones for workplace trips (different shades of green), areas with existing workplace Level 2 EVSE (red dots), and areas with employers interested in deploying workplace EVSE for employee charging (blue dots). This map was created as part of the *Bay Area Plug-In Electric Vehicle Readiness Plan*.

**Figure 5-2. Workplace Charging Siting Analysis for Solano County**




As shown in Figure 5-2 (as red dots), there is already modest deployment of workplace EVSE today with some interest (light blue dots) in workplace EVSE. Moreover, several areas in Solano County have a significant number of work trips for what have been identified as likely PEV adopters, including at Travis Airforce Base (east of Fairfield), in Green Valley (west of Fairfield), around Vallejo, and around Benicia.

### *Opportunity Charging*

Opportunity charging is distinguished from residential and workplace charging, and covers a wide range of situations in which an EV driver could potentially charge when away from home or work. This category of charging covers a wide variety of venue, such as retail shopping parking lots, on-street parking, airport long- and short-term parking, and cultural and recreational centers. Table 5-4 provides general guidance regarding the type of EVSE for different venue types, mainly based on the duration of time that an EV driver may be parked at a specific location.

**Table 5-4. Example of Charging Type Based on Trip Purpose**

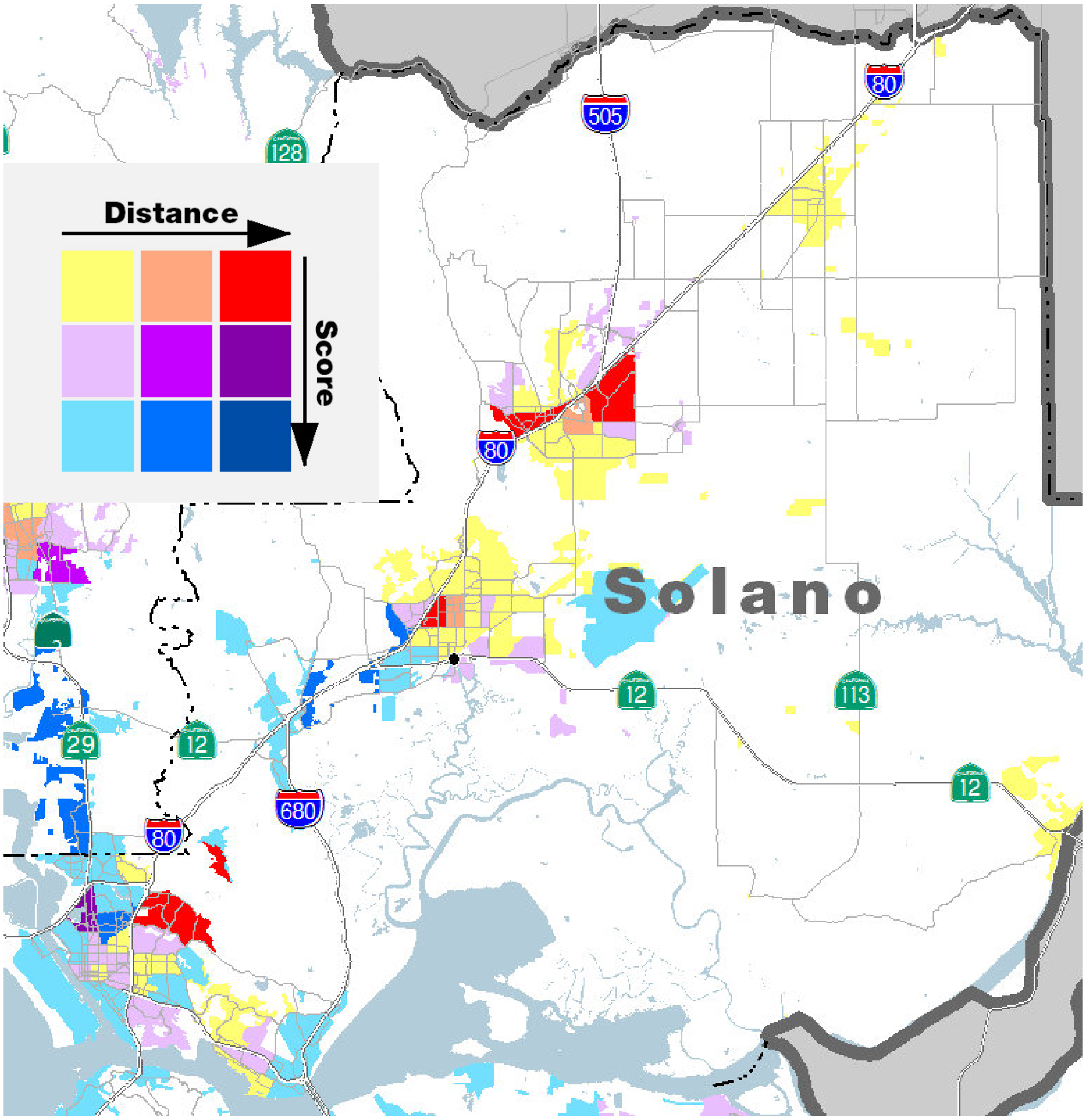
| Category | Typical Venues | Available Charging Time | Charging Method (Primary/Secondary) |
|---|---|---|---|
| Opportunity and Destination | Shopping centers | 0.5 – 2 hours | Level 2/DC fast |
| | Airports (short-term parking) | < 1 hour | Level 2/DC fast |
| | Streets/meters | 1 – 2 hours | Level 1/Level 2 |
| | Other | < 1 hour | Level 2/DC fast |
| | Parking garages | 2 – 10 hours | Level 2/Level 1 |
| | Cultural and sports centers | 2 – 5 hours | Level 2/Level 1 |
| | Airports (long-term parking) | 8 – 72+ hours | Level 1/Level 2 |
| | Hotels/recreation sites | 8 – 72 hours | Level 2/Level 1 |
| Corridor/Pathway | Interstate highways | < 0.5 hours | DC fast/Level 2 |
| | Commuting/recreation roads | < 0.5 hours | DC fast/Level 2 |
| Emergency | Fixed | < 0.1 hours | DC fast |
| | Mobile | < 1 hour | Level 2/DC fast |

Figure 5-3 illustrates the locations with the highest potential for opportunity charging in Solano County. The legend in Figure 5-3 shows nine colors representing a matrix of scoring across three groups of distances and three groups based on the number of EV trips. Each block or color in the horizontal direction (left to right) represents the following trip distances: 0–5 miles, 6–10 miles, and 11+ miles. Each block or color in the vertical direction (top to bottom) represents the highest number of trips by likely PEV adopters to that zone. In other words, the blue shaded zones (light, medium, and dark blue) represent the most trips by likely EV adopters to that particular region. Thus:

- Dark blue zones are expected to have the highest number of long-distance EV trips that would use opportunity charging.
- Light blue zones are expected to have the highest number of short-distance EV trips that would use opportunity charging.
- Red zones are expected to have a moderate number of long-distance EV trips that would use opportunity charging.
- Yellow zones are expected to have a moderate number of short-distance EV trips that would use opportunity charging.

Retail locations (e.g., shopping malls or dining establishments) in the zones with shades of blue (represented in the bottom of the 3x3 matrix in the legend) should be considered the highest priority areas for Level 2 EVSE deployment for opportunity charging.

**Figure 5-3. Opportunity Charging Siting Analysis for Solano County**




The results of the opportunity charging siting analysis are similar to those for workplace EVSE, with some notable differences:

- There is significant potential for Level 1 and Level 2 EVSE around Travis Air Force Base, Green Valley, Vallejo, and Benicia.
- There is a higher concentration of opportunity trips around Fairfield (particularly southwest Fairfield) and a concentration of short-distance trips with a high rating (light blue) around Vallejo, and the opportunity rating for Benicia is noticeably higher than the workplace rating in the previous map.

- Based on the analysis, likely EV adopters would be traveling longer distances to Vacaville (indicated by the red and orange markings along Interstate 80), where Level 2 EVSE would likely be a good candidate.
- There is good potential for Level 2 EVSE in Green Valley and the stretch of Interstate 80 between Green Valley and Fairfield, including around the Fairfield campus of Solano Community College.

### Funding Opportunities

In the near-term future, there will be several funding opportunities for EVSE deployment in Solano County.

- The CEC continues to deploy EVSE through the Alternative and Renewable Fuel and Advanced Vehicle Technology Program (funded via AB 118).
- Last year, NRG Energy Inc. (NRG)—an EVSE infrastructure provider—reached a settlement agreement with the California Public Utilities Commission (CPUC) in the amount of $122.5 million to fund the installation of EVSE throughout California over a period of 4 years. More specifically:
    - 200 Freedom Stations to be deployed statewide, with 55 of these deployed in the Bay Area (including Solano County). Each Freedom Station will consist of at least one 50 kW DC fast charger and one Level 2 EVSE.[67]
    - 10,000 Make-Ready Stubs and 1,000 Make-Ready Arrays,[68] collectively referred to as *Make-Readies*, are to be deployed statewide at a cost of $40 million. An estimated 1,650 Make-Ready Stubs will be deployed in the Bay Area (including Solano County), with an additional 4,000 stubs to be deployed at NRG's discretion. The bulk of the $40 million will go toward wiring homes and preparing workplaces, multi-family dwelling units, hospitals, and schools for EVSE.
- As part of the development of the Bay Area's Sustainable Community Strategy (per Senate Bill 375), MTC and the Association of Bay Area Governments (ABAG) have developed a program referred to as a **Regional EVSE Network Program**. The program is designed to defray the installation costs of EVSE, with a focus on workplace charging. MTC will be coordinating with BAAQMD and other stakeholders as necessary to update the siting analysis that ICF performed and target the regions and employers that will maximize GHG reductions through targeted EVSE deployment.
- Solano County can also work closely with MTC to identify funding opportunities through the Federal Highway Administration (FHWA). Recent changes to some of FHWA's core programs could benefit Solano County. The Moving Ahead for Progress in the 21st Century (MAP-21) Act (Public Law 112-141) added several eligible project types to the Surface Transportation Program (STP)—electric vehicle charging infrastructure that is added to existing or included in new fringe and corridor parking facilities is eligible for STP funding. This is a particularly interesting opportunity for Solano County: Even though the region only has modest EV penetration rates to

date (as discussed briefly), it will likely be an important inter-regional corridor between the San Francisco Bay Area and the Sacramento region. It will be important to deploy DC fast charging along inter-regional corridors in places such as Solano County.

- A tax credit is available for entities installing EVSE, worth up to 30% of the total cost of the installation. This tax credit expires at the end of 2013. This is less of a funding opportunity for Solano County but could be an important factor in any public/private partnerships that Solano County pursues in the near-term future.

## EV Readiness for Local and Regional Governments

The *Bay Area Plug-In Electric Vehicle Readiness Plan* prioritized actions for local governments in the areas of (1) building codes; (2) permitting and inspection practices; and (3) zoning, parking rules, and local ordinances. The objective of EV readiness planning is to outline the actions that local governments and affected stakeholder will need to take in order to be ready to meet the increased and unique demands by EVs and supporting charging infrastructure. The prioritized recommendations from the Readiness Plan are repeated in the Table 5-5, and include both the metrics that regional agencies will be using to track progress and the targets for readiness.

**Table 5-5. Local Government Actions for Electric Vehicle Readiness**

| Recommendations | Metric | Regional Target |
|---|---|---|
| Adopt California Building Code standards for EVSE into local building codes | Percentage of agencies with standards for EVSE in building codes | 100% of local governments by 2014 |
| Create a permitting checklist for residents and contractors | Percentage of agencies that have created a permitting checklist for EVSE | 100% of local governments by 2014 |
| Train permitting and inspection officials in EVSE installation | Percentage of agencies that have trained permitting and inspection officials in EVSE installation | 100% of local governments by 2014 |
| Specify design guidelines for PEV parking spaces | Percentage of agencies that have adopted design guidelines for PEV parking | 100% of local governments by 2014 |
| Adopt requirements for pre-wiring EVSE into the building code and/or minimum requirements for PEV parking spaces | Percentage of agencies that have adopted requirements for pre-wiring EVSE into the building code and/or minimum requirements for EV parking spaces | 100% of local governments by 2021 |
| Work with local utilities to create a notification protocol for new EVSE through the permitting process | Percentage of agencies working with local utilities to create a notification protocol for new EVSE through the permitting process | 100% of local governments in areas where MOUs [memoranda of understanding] provide electricity by 2021 |

| Recommendations | Metric | Regional Target |
|---|---|---|
| Staff the permitting counter with electrical permitting experts | Percentage of agencies staffing the permitting counter with electrical permitting experts | 100% of local governments by 2021 |
| Adopt a climate action plan, general plan element, or stand-alone plan that encourages deployment of PEVs and EVSE | Percentage of agencies that have adopted a climate action plan, general plan element, or stand-alone plan that encourages deployment of PEVs and EVSE | 100% of local governments by 2021 |
| Allow PEV parking spaces to count toward minimum parking requirements | Percentage of agencies that allow PEV parking spaces to count toward minimum parking requirements | 100% of local governments by 2021 |
| Adopt regulations and enforcement policies for PEV parking spaces | Percentage of agencies with regulations and enforcement policies for PEV parking spaces | 100% of local governments by 2021 |

More information is available about each one of these recommendations in the *Bay Area Plug-In Electric Vehicle Readiness Plan*. For the purposes of this plan, however, it is important to note that EV readiness will likely become an important determinant for funding opportunities. EV readiness has been prioritized by regional agencies (including BAAQMD, MTC, and ABAG) and state agencies such as the Office of Planning and Research and the CEC. To the extent that STA can expedite implementation of the recommendations of the *Bay Area Plug-In Electric Vehicle Readiness Plan*, it will likely be easier for regional and state agencies to prioritize funding to Solano County. Furthermore, NRG is working closely with readiness efforts to identify the areas where Freedom Stations and Make-Readies can be deployed; although they have numerical targets, the settlement with the CPUC is tied to expenditures. It is in NRG's best interest to deploy as much EVSE as possible, given the money available to spend; areas with higher levels of readiness are likely to have more cost-effective installations.

## Municipal Fleets

Municipal fleets are often identified as an ideal application for EVs. Municipal fleets tend to have lower mileage than vehicles in the personal light-duty vehicle fleet. Although this increases the payback period for investment, some of this can be offset through innovative fleet financing programs. Municipal fleets have already shown leadership through increased deployment of HEVs. For instance, according to ICF estimates, government fleets have hybrid penetration rates from 25% to 95% greater than the personal light-duty vehicle fleet. One worry of municipal fleet, however, is that staff may not accept BEVs the way they have accepted HEVs, since BEVs introduce new procedures for fueling and drivers may be concerned about range. These concerns can be alleviated through educational and training programs.

The main concern for fleets will be the expenditure associated with acquiring EVs—both the vehicles and the charging infrastructure. Despite the significantly lower costs of electricity as a transportation fuel compared to gasoline (or diesel) and the lower overall maintenance costs of EVs compared to conventional vehicles, the payback period for EVs in a fleet application will likely make it difficult to justify the higher cost of EVs. Furthermore, public fleets are often ineligible for the incentives available today for EV purchasing. For instance, the federal tax credit requires the purchaser to have a tax liability. On the other hand, local government agencies are eligible to receive a rebate through the Clean Vehicle Rebate Project, valued at up to $2,500 per vehicle (note: no entity can receive more than 20 rebates in a calendar year).

Although the costs of EV charging infrastructure are not as significant investment as the vehicles, the additional cost can be a barrier to EV deployment. There are a variety of factors that can increase the cost of EVSE installation. In the case of municipal fleets, older municipal buildings may require electrical upgrades. Most incentives available for EVSE deployment focus on the hardware and/or installation, and costs related to electrical service upgrades are not eligible. Furthermore, government agencies are not in a position to claim the federal tax credit for infrastructure deployment because they do not have a federal tax liability (as noted previously regarding the federal tax credit for vehicles).

Some municipal fleets have been making these upgrades as part of their plan to deploy EVs. For example, staff with Alameda County have noted that many municipalities made upgrades as part of the Local Government EV Fleet project funded by MTC (discussed in more detail below). MTC funding is helping Alameda County and its partners deploy 90 EVs in municipal fleets. Based on feedback from Alameda County staff, many of the municipal facilities did require upgrades; however, most municipalities paid for those upgrades themselves and did not use grant money. Despite being a barrier to EV deployment, there are ancillary benefits beyond EV charging to these upgrades that can help modernize municipal buildings.

Another factor that may affect the deployment of EVs in municipal fleets is the cost of electricity associated with EVs. Charging at off-peak times (e.g., overnight) in a residential application can be very inexpensive for EV drivers – around $0.10/kWh. However, municipal fleets charging during on-peak or partial-peak times may be subject to increased demand charges and increased electricity costs. The impact depends entirely on the rate schedule and can vary considerably. Fleets considering EV deployment should seek to understand the electricity cost impacts of on-peak and partial peak charging on a case-by-case basis to understand the lifecycle cost of EVs. For the sake of reference, the current pump price of gasoline – at about $4.00 per gallon in California – is equivalent to about $0.45/kWh. Even in a scenario in which a fleet exclusively charges during on-peak times (which is unlikely), the electricity costs will be less than that price-equivalent basis.

As part of any evaluation of EVSE deployment, local governments should also consider whether or not the EVSE will be available to the public for EV charging. It is likely that (additional) grant money will be available if the EVSE are made available to the public. If an agency opts to provide publicly available EVSE, they will have to determine how to collect fees for charging. Most smart charging equipment has software (e.g., via ChargePoint or other EV service provider) that allows station owners to set the price of electricity charged at a facility. This type of service is not required for fleet-only charging and will require a recurring cost outlay for the fleet's consideration. Although some municipalities in the Bay Area (and elsewhere in the United States) have provided free charging to the public to help spur the initial market for EVs, this is not a sustainable practice, and most cities are no longer providing the charging freely or have plans to phase out free charging in the near-term future.

There may be opportunities for STA to seek funding through regional initiatives such as MTC's Climate Initiatives Grant Program. The Local Government EV Fleet Project, which is administered by eight local governments (led by Alameda County) that are in the process of procuring 90 PEVs for municipal fleets and 90 Level 2 chargers accessible to both the government fleets and, in some cases, the public. The local government agencies are deploying 78 light-duty PHEVs and BEVs and 12 vans or shuttles. The project received $2.8 million in Climate Initiative funding and additional funding from the BAAQMD and the CEC. The results of this project will help inform MTC's next round of funding.

Another way to offset the transition to EVs for municipal fleets is through credits under California's LCFS. There is potential to earn LCFS credits through the deployment of EVs in fleets. If municipal agencies own and operate more than three EVs and own the EVSE that is used to charge the vehicles, the municipal agency is eligible to receive LCFS credits. These credits can be used toward compliance with the LCFS, which requires a 10% reduction in the carbon intensity of gasoline and diesel by 2020. In principle, these LCFS credits can help fleets defray the higher costs of EV purchasing. The number of credits that can be earned is a function of how much electricity the EVs use, which is linked to vehicle miles traveled.

In addition to BEVs and PHEVs, the use of HEVs in light-duty, medium-duty, heavy-duty, and transit bus applications can reduce gasoline and diesel consumption without the requirement of additional refueling infrastructure. As discussed in Section 4, diesel hybrid transit buses have shown fuel savings on the order 20% - 40% and possibly higher, depending on the type of use. Hybrid-electric technologies can be applied to utility trucks and similar vehicles that require auxiliary power. Funding may be available to help offset the higher purchase price of hybrid buses and trucks, as discussed in Section 4.5.

## 5.4. Summary of Implementation Steps and Action Items

| Fuel Category | Implementation Steps and Action Items |
|---|---|
| **Biofuels** | **E85**<br>• Educate vehicle operators about FFVs already in fleets that can utilize E85<br>• Investigate modifying fueling infrastructure to install E85 by either retrofitting existing or installing new storage tanks and dispensers<br>• Engage local retail fueling station owners and E85 infrastructure providers to determine the feasibility of expanding E85 to the general public<br>• Identify grant opportunities to support public and private expansion of E85<br>**Biodiesel**<br>• Check engine warranties to determine if any buses or heavy trucks are incompatible with low-level biodiesel blends (e.g., B5)<br>• When renegotiating contracts with diesel suppliers, require B5 as part of the specification (assuming no engine warranty concerns)<br>• To prepare for a future move to B20 for diesel fleets: (1) update procurement procedure to account for B20, (2) confirm engine warranties for current vehicles are covered with B20, (3) confirm existing USTs are B20 compatible and, if incompatible, (4) seek to update tanks for compatibility |
| **Natural Gas** | **Expanding Fueling Infrastructure**<br>• Identify potential refueling station locations<br>• Perform feasibility studies of these locations to determine station cost and proximity to current or future natural gas vehicle fleets<br>• Investigate options for new natural gas station development (station built by local agency vs. private developer)<br>**Overcoming Incremental Vehicle Costs**<br>• Pursue federal, state and regional funding sources to reduce NGV incremental costs<br>**Overcoming Unfamiliar Maintenance and Operation Procedures**<br>• Contact the local fire marshal and utility to help identify safety guidelines<br>• Contact other local fleets that have installed natural gas stations and maintain their own fleets to help identify any required upgrades or improvements and changes to maintenance practices<br>• Participate in Natural Gas Transit Users Group, which shares lessons learned and problem-solving techniques; provides a technical forum for fleet maintenance staff; and communicates safety issues, codes, and standards |

| Fuel Category | Implementation Steps and Action Items |
|---|---|
| **Electricity** | **Expanding Infrastructure Deployment**<br>• Utilize the Bay Area Plug-In Electric Vehicle Readiness Plan, including figures in Section 5.3, to identify new locations for potential public charging infrastructure<br>• Pursue potential EVSE deployment funding sources identified in Section 5.3<br>**Ensuring EV Readiness for Local and Regional Governments**<br>• Review the checklist of recommendations from the Bay Area Plug-In Electric Vehicle Readiness Plan that is prioritized in Table 5-5<br>• Identify steps to implement the prioritized items with an emphasis on (1) building codes, (2) permitting and inspection practices, and (3) zoning, parking rules and local ordinances<br>**Deploying EVs in Municipal Fleets**<br>• Identify potential fleets in the County interested in EVs<br>• Perform feasibility studies for fleets, including vehicle and infrastructure costs, infrastructure and vehicle credits and rebates, and potential LCFS revenue from the sale of credits<br>• Contact local fleets that invested in EVs and have taken advantage of federal, state, and regional credits, rebates and funding sources (such as Alameda County), to help in determine accurate costs for feasibility studies<br>• Identify opportunities to deploy hybrid-electric vehicles for municipal fleets or transit. |

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