UCLA Luskin School of Public Affairs Applied Policy Report

Transitioning to Alternative Fuel Vehicles

A Feasibility Study for the City of Arcadia

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*Image Source: http://www.freegreatpicture.com/files/141/20194-green-cars.jpg

Acknowledgements

We would like to thank our advisor, Professor Mark Kleiman, for his guidance and support throughout the year. We would also like to thank Professor Martin Wachs and Professor Mark Peterson at the Luskin School of Public Affairs for their advice and feedback.

We would like to extend a special thank you to the Luskin Center of Innovation for their generous grant and expertise. We would like to acknowledge Professor JR DeShazo, Professor Brett Williams, Susan Woodward, and Colleen Callahan.

We are grateful for our client, the City of Arcadia, for making this project possible and providing us with valuable information. Specifically, thank you to Carmen Masud (Management Analyst), Dave McVey (General Services Superintendent), Dominic Lazzaretto (City Manager), Ken Herman (Deputy Public Works Services Director), and Linda Garcia (Communications, Marketing and Special Projects Manager).

Finally, we are appreciative of the field experts we interviewed including Josh Boone (Senior Manager of Business Development and Programs at the PEV Collaborative) and Cris Liban (DEO Environmental Compliance and Services Department at LA Metro).

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Disclaimer

This report was prepared in partial fulfillment of the requirements for the Master in Public Policy degree in the Department of Public Policy at the University of California, Los Angeles. It was prepared at the direction of the Department and of the City of Arcadia as a policy client. The views expressed herein are those of the authors and not necessarily those of the Department, the UCLA Luskin School of Public Affairs, UCLA as a whole, or the client.

Abbreviations

AFDC – Alternative Fuels Data Center
AFV – Alternative Fuel Vehicle
AQI – Air Quality Index
AQIP – Air Quality Improvement Program
ARFVTP – Alternative and Renewable Fuel and Vehicle Technology Program
BEV – Battery Electric Vehicle
CARB – California Air Resources Board
CCSE – California Center for Sustainable Energy
CEC – California Energy Commission
CNG – Compressed Natural Gas
CVRP – Clean Vehicle Rebate Project
DOE – Department of Energy
DOT – Department of Transportation
EFMP – Enhanced Fleet Modernization Program
EIA – Energy Information Administration
EPA – Environmental Protection Agency
EV – Electric Vehicle
GGE – Gasoline Gallon Equivalent
GHG –Greenhouse gas
GIS – Geographic Information Systems
GMC – General Motors Corporation
HEV – Hybrid Electric Vehicle
HP – Horsepower
HVIP – Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project
ICE – Internal Combustion Engine
ICEV – Internal Combustion Engine Vehicle
KBB – Kelley Blue Book
LCA – Life-cycle Cost Analysis
LNG – Liquefied Natural Gas
MPG – Miles per gallon
MSRP – Manufacturer Suggested Retail Price
NHTSA – National Highway Traffic Safety Administration
PEV – Plug-in Electric Vehicle
PHEV – Plug-in Hybrid Electric Vehicle
PWSD – Public Works Services Department
SCAQMD – South Coast Air Quality Management District
ZEV – Zero-emission Electric Vehicle

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Executive Summary

The City of Arcadia requested a report analyzing the feasibility of transitioning its non-safety vehicle fleet from conventional vehicles to alternative fuel vehicles (AFVs). In light of emerging alternative fuel technologies and policies, we make recommendations regarding the approach Arcadia should take in incorporating these technologies and policies into its general plan. We recommend particular AFVs, which are most appropriate to replace the City's vehicles due for replacement in the next ten years. We specifically analyzed the three types of AFVs: compressed natural gas (CNG), hybrid, and plug-in electric against the conventional gasoline or diesel vehicles. The main consideration was cost, but other vehicle specifications, such as the City's vehicle performance requirements, reliability, and emissions, were also evaluated to guarantee comparable performance.

The table below lists our top recommendations for the sedan, SUV, light-duty pickup truck, and medium-duty pickup truck categories. The life-cycle cost for each existing and recommended AFV is noted in parentheses. Special equipment (e.g. aerial trucks and cranes) or any vehicle measured in hours, and not miles, (e.g. loaders, backhoes, crane buckets) were excluded from our analysis. In order to account for uncertainty in fuel prices, we performed a sensitivity analysis. It is cost advantageous for the City to transition existing sedans, SUVs and medium-duty pickup trucks to AFVs. However, the City should not switch current light-duty pickup trucks to the CNG bi-fuel option.

Final Vehicle Recommendations

Existing Vehicles: Descriptions	Existing Vehicles: Make and Model	Recommended Alternative Fuel Vehicles: Make and Model
SEDANS	Chevy Malibu ($50,175) Ford Fusion Hybrid ($47,704)	Nissan Leaf ($38,379)
SUVs	Ford Escape Hybrid*	Toyota Prius v ($43,903)
LIGHT-DUTY PICKUP TRUCKS	Ford F-150 ($59,063), Chevy 2500 ($68,665), Ford Ranger*, Chevy Colorado ($61,375), GMC Sonoma*	None
	Ford F-250 ($76,821), Ford F-250 SD**, Chevy 2500 ($68,665), Chevy 2500 HD**	None
MEDIUM-DUTY PICKUP TRUCKS	Ford F-450 ($79,901)	Ford F-450 Chassis Cab XL CNG Bi-Fuel ($73,037)
	Ford F-700*, Chevy Kodiak*, Chevy 60 Series*	Ford F-750 Chassis Cab CNG Bi-Fuel ($107,802)

Note: These numbers were computed using the Life Cycle Analysis tool. The references for the values inputted in the tool are found in Appendix G.
Vehicles not considered: CNG Sweeper, Sewer Cleaner, Chipper, Loader, and Vacuum Truck

*Price not available because vehicle is out of production

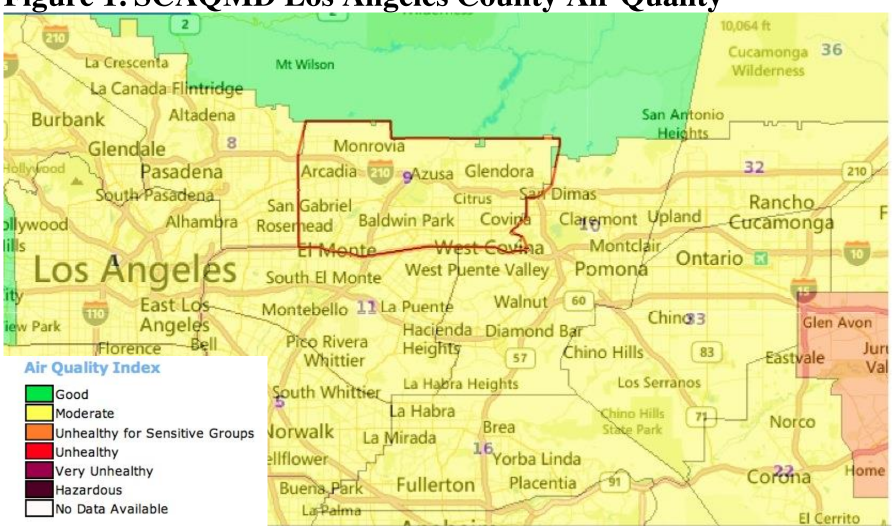
**Only base MSRP available

Introduction

Alternative fuel technology is at the forefront of environmental and transportation policy. Alternative fuel vehicles reduce people's dependence on gasoline and diesel, and play an important role in improving the nation's environmental impact. According to the Environmental Protection Agency (EPA), alternative fuels are defined as substitutes to traditional gasoline and diesel fuels.[1] The term is often used interchangeably with renewable fuel, but EPA deems 'renewable fuels' as fuels made from renewable, non-petroleum sources.[2] A brief overview on the U.S.'s declining air quality and increasing dependence on petroleum provides significant insight for the importance of AFVs.

Air pollution is of high priority for public policymakers. Los Angeles County is ranked the worst county in California, emitting about 223,261 tons of volatile organic compounds per year.[3] In addition, the EPA gives Los Angeles County an Air Quality Index (AQI) of 212. The index considers 0-50 good quality, 100-200 unhealthful, 200-300 very unhealthful, and 300 and above hazardous (Figure 1).[4] Furthermore, transportation needs account for approximately a third of America's carbon dioxide emissions – 80% of these emissions come from vehicles.[5] So in order to lessen CO_2 emissions originating from the transportation sector, there is a large push from policymakers to increase the use of efficient vehicles and alternative fuels.[6]

Figure 1. SCAQMD Los Angeles County Air Quality[7]



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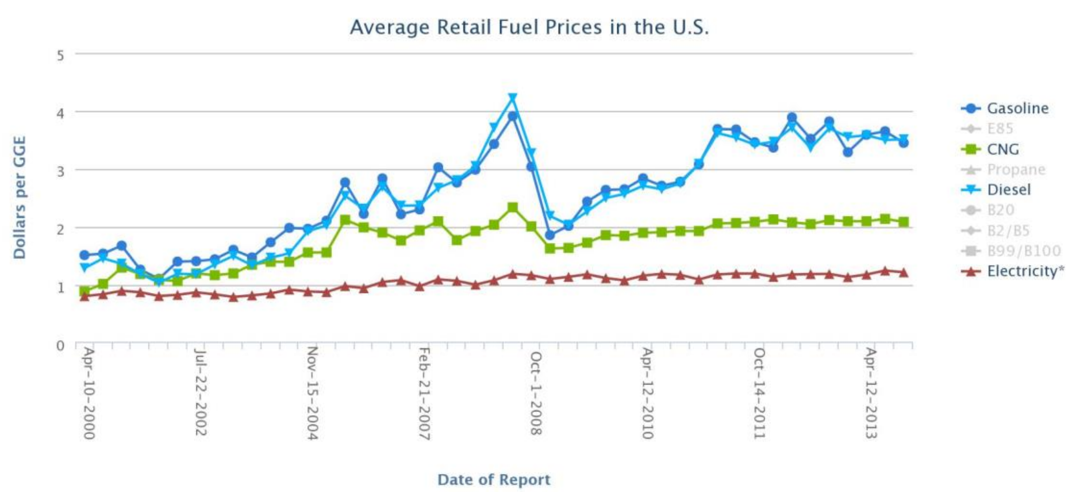
[1] "Renewable and Alternative Fuels | Fuels and Fuel Additives," U.S. Environmental Protectional Agency (EPA), August 1, 2013, http://www.epa.gov/otaq/fuels/alternative-renewablefuels/index.htm.
[2] Ibid.
[3] "Pollution Locator: Smog and Particulates: Rank Counties by Emissions," Scorecard, 2011, http://scorecard.goodguide.com/env-releases/cap/rank-counties-emissions.tcl?fips_state_code=06.
[4] Ibid.
[5] Matthew Barth and Kanok Boriboonsomsin, "Traffic Congestion and Greenhouse Gases," University of California Transportation Center, 2009, http://www.uctc.net/access/35/access35_Traffic_Congestion_and_Grenhouse_Gases.shtml.
[6] Ibid.
[7] "AQMD GIS Maps," South Coast Air Quality Management District, accessed March 2, 2014, http://www3.aqmd.gov/webappl/gisaqi2/VEMap3D.aspx.

The U.S. is currently the top consumer of petroleum in the world, using 18,490.21 thousand barrels per day.[8] California alone consumes about 9% of this share, using about 642.9 million barrels a year.[9] Approximately 40% of this oil is imported from foreign sources.[10] These statistics are unsettling, considering diplomatic relationships can quickly change and impact the U.S.'s supply of oil. The nonrenewable characteristic of oil only adds to its volatile nature, as proven by constantly fluctuating gas prices. Over the past 10 years, yearly average prices have dramatically increased from $1.51 in 2002 to $4.03 in 2012.[11] Some recent estimates from the Energy Information Administration (EIA) predict that oil supplies may peak as soon as 2019.[12] Thus, many experts emphasize the significance of using alternative fuels to mitigate the U.S.'s dependence on oil and reduce the risks associated with solely utilizing nonrenewable fuel sources.[13]

The Alternative Fuel Price Report, provided by the U.S. Department of Energy's (DOE) Alternative Fuels Data Center (AFDC), contains a database of publications on natural fuel prices in each specific region. Please note the graph below for a quick and general illustration of the varying fuel prices among diesel, gasoline, CNG, and electricity (Figure 2).[14]

Figure 2. Average Retail Fuel Prices[15]



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[8] "Overview Data for United States," U.S. Energy Information Administration (EIA), May 30, 2013, http://www.eia.gov/countries/country-data.cfm?fips=US.
[9] "Independent Statistics and Analysis," U.S. Energy Information Administration (EIA), February 20, 2014, http://www.eia.gov/state/data.cfm?sid=CA#ConsumptionExpenditures.
[10] "EIA's Energy in Brief: How Dependent Are We on Foreign Oil?," U.S. Energy Information Administration (EIA), May 10, 2013, http://www.eia.gov/energy_in_brief/article/foreign_oil_dependence.cfm.
[11] "California Gasoline Prices Adjusted for Inflation," California Energy Commission, accessed March 2, 2014, http://energyalmanac.ca.gov/gasoline/gasoline_cpi_adjusted.html.
[12] "Annual Energy Outlook 2013: Market Trends - Oil/Liquids," U.S. Energy Information Administration (EIA), April 15, 2013, http://www.eia.gov/forecasts/aeo/MT_liquidfuels.cfm.
[13] "Renewable and Alternative Fuels | Fuels and Fuel Additives."
[14] "Alternative Fuels Data Center: Maps and Data," U.S. Department of Energy | Energy Efficiency & Renewable Energy, accessed March 2, 2014, http://www.afdc.energy.gov/data/?q=fuel+prices.
[15] Ibid.

Existing Policies

Fears of greenhouse gas (GHG) emissions and fossil fuel dependency have pushed alternative fuel technologies to the forefront of federal and state policy initiatives. The Global Warming Solutions Act of 2006 (AB 32) and the Sustainable Communities and Climate Protection Act of 2008 (SB 375) both seek to improve air quality standards in California. Both acts are pertinent to this study. AB 32 mandates for California to return its GHG emissions back to 1990 levels by 2020.[16] SB 375, on the other hand, has the objective of changing land use patterns and improving transportation systems to reduce GHG emissions.[17]

In addition to these two legislative mandates, the South Coast Air Quality Management District (SCAQMD) contains two related regulations for fleet operators. Rule 1196 "requires public fleet operators to acquire alternative fuel heavy-duty vehicles when procuring or leasing these vehicles to reduce air toxic and criteria pollutant emissions."[18] Rule 1191 "requires passenger car, light-duty truck, or medium-duty vehicle public fleet operators to acquire low-emitting gasoline or alternative-fueled vehicles."[19]

The Client

The City of Arcadia is located about 20 miles east of Los Angeles and encompasses 11.2 square miles. It is a full-service city, possessing its own Police Department, Fire Department and Library. Arcadia also has a City Council-City Manager form of government. The City Council serves as the legislative and policymaking body of the City. The councilmembers enact all laws and establish policy. Under the direction of the City Council, the City Manager is the Chief Executive officer and directs all operations of the City.

The City's general plan outlines its objectives for growth and development, including a list of sustainability goals. In order to address these goals, the City has identified several policy areas that require attention: "air quality, water quality and water resource conservation, energy conservation, waste management and recycling, sustainable building practices, management of hillside resources, and management of mineral resources."[20] Within these policy areas, Arcadia aims to comply with state and federal legislation and safeguard environmental quality for future generations.

The City's policy goals for air quality are particularly significant to this study. These goals incorporate the field of transportation and aim to:

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[16] "Assembly Bill 32 - California Global Warming Solutions Act," California Enivronmental Protection Agency Air Resources Board, accessed March 2, 2014, http://www.arb.ca.gov/cc/ab32/ab32.htm.
[17] "Senate Bill 375 Regional Targets," California Environmental Protection Agency Air Resources Board, January 7, 2014, http://www.arb.ca.gov/cc/sb375/sb375.htm.
[18] "Rule 1196. Clean On-Road Heavy-Duty Public Fleet Vehicles," South Coast Air Quality Management District, November 15, 2006, http://www.aqmd.gov/tao/FleetRules/1196HDV/.
[19] "Rule 1191. Clean On-Road Light- and Medium-Duty Public Fleet Vehicles," South Coast Air Quality Management District, January 4, 2012, http://www.aqmd.gov/TAO/FleetRules/1191/index.htm.
[20] "Arcadia General Plan Draft- Ch. 6 Resource Sustainability Element," accessed March 2, 2014, http://www.ci.arcadia.ca.us/docs/6_draft_resource_sustainability_element__04-28-10.pdf.

1) Continue improvement in local and regional air quality
2) Reduce Arcadia's carbon footprint
3) Promote and utilize clean forms of transportation[21]

In order to achieve its third policy goal, the City proposes to "develop a City fleet that, to the extent feasible, uses clean, alternative fuel and consists of energy-efficient vehicles" and "incorporate energy-efficient vehicles into the City's transit system."[22]

The Current Fleet

Arcadia has a current fleet of about 70 non-safety vehicles. Thus, fire and police department vehicles are not included. The City's vehicle types include light- and medium-duty pickup trucks, sedans, and SUVs. The fleet also contains special equipment vehicles, including aerial trucks, dump trucks, chippers, backhoes, vacuum trucks, sewer cleaners, sweepers, crane buckets, and water tankers. We have chosen to exclude certain special equipment vehicles because there are no market-ready alternatives. Additionally, the City already owns a few AFVs; these vehicles have been incorporated into our study. Due to the variance in vehicle types, this study has categorized vehicles according to size and function to best match conventional ones with their alternative fuel counterparts.

Vehicle Maintenance and Repair

The City of Arcadia presently has a maintenance and repair center for its existing fleet. In the case that repairs are too extensive and beyond the capabilities of its shop, vehicles are taken to the dealership. If the service light in a fleet vehicle turns on or some other repairs are needed, a diagnostic software called Mitchell is used. The City should take into consideration that it owns an older version of the software that only diagnoses American cars (e.g. Ford, Chevrolet, GMC). Since our recommendations include other vehicle brands, it is the City's advantage to purchase an updated version of Mitchell or equivalent software.

The City should also consider its specified vehicle maintenance budget, which is organized by department (Table 1). If the repairs required are beyond its allotted budget, the City will wait until a sufficient amount is available.

Table 1. Vehicle Maintenance Accounts

DEPARTMENT	BUDGET	VEHICLES	BUDGET PER VEHICLE
Admin. Services.	$1,500.00	1	$1,500.00
City Manager	$2,500.00	1	$2,500.00
Development Services.	$20,400.00	8	$2,550.00
Library	$1,700.00	1	$1,700.00
Recreation	$9,000.00	4	$2,250.00
Public Works: Street	$251,200.00	41	$6,126.83
Public Works: Water	$264,400.00	22	$12,018.18

[21] "Sustainable Arcadia - Air Quality," City of Arcadia, CA, accessed March 2, 2014, http://www.ci.arcadia.ca.us/home/index.asp?page=1738.
[22] Ibid.

The City's Drivers

There are no issues anticipated for the City's drivers concerning the use of AFVs. Alternative fuel vehicles do not require special training for driving and re-fueling practices. Driving AFVs is comparable to driving conventional vehicles. Although EVs are quieter, their performance is similar to gas-powered vehicles and the accelerator, brake, and steering wheel will be familiar to anyone who has driven a car before. [23] Likewise, CNG vehicles have similar performance to their gasoline counterparts.[24] In addition, fueling AFVs is similar to fueling conventional fuel vehicles. CNG dispensers perform in a way similar to public gasoline stations.[25] For electric vehicles, re-fueling practices are slightly different, but simple to learn. Drivers only need an outlet and a heavy-duty extension cord. Drivers can leave vehicles to charge overnight by simply plugging them into the wall to start the charging process.[26] Given the recharging requirements of EVs, it will be important for the City's drivers to add this activity to their work routines.

Leasing and Conversion Options

Our report excludes conversion and leasing options. Converting the City's current vehicles would not only be costly, but also cumbersome. The City would have to hire a licensed technician, comply with numerous national regulations and standards, and completely change its current system of fleet acquirement. Detailed vehicle conversion difficulties for BEVs, HEVs, PHEVs and CNG vehicles are provided within the relevant sections.

Although leasing vehicles may be cheaper than purchasing them, we did not include the leasing option because the City would have to change its entire payment structure as Arcadia currently pays for their vehicles upfront. Other issues of leasing include: higher insurance premiums, continuous car payments, penalties of exceeding predicted mileage, and wear and tear fees.[27] More importantly, the City cannot use in-house mechanics who currently work on the Public Works Services Department (PWSD) site for leased vehicle maintenance and repairs. The City can only use mechanics who are pre-approved by the dealership. Furthermore, conditions regarding early lease termination may result in payment of higher fines. Although leasing is a way for the City to unlock the $7,500 federal tax credit, it can also unlock this deal by negotiating with the dealer.

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[23] "Driving Electric NYC - What Is an 'Electric Car?,'" NYC Resources: Office of the Mayor, accessed March 16, 2014, http://www.nyc.gov/html/ev/html/you/electric-car.shtml.

[24] "Drive Clean - Compressed Natural Gas (CNG)," California Environmental Protection Agency Air Resources Board, accessed March 16, 2014, http://www.driveclean.ca.gov/Search_and_Explore/Technologies_and_Fuel_Types/Compressed_Natural_Gas.php.

[25] "Alternative Fuel Driver Training Companion Manual," U.S. Department of Energy | Energy Efficiency & Renewable Energy, September 2005, http://www.afdc.energy.gov/pdfs/37275.pdf.

[26] Marshall Brain, "HowStuffWorks 'Charging an Electric Car,'" accessed March 16, 2014, http://auto.howstuffworks.com/electric-car5.htm.

[27] "Pros and Cons of Car Leasing and Buying a New or Used Car," DMV, 2014, http://www.dmv.org/buy-sell/new-cars/leasing-vs-buying.php#Cons-of-Car-Leasing.

Overview

Our report begins by listing the assumptions used in our analysis. Then, some observations about the local fueling infrastructure are discussed in order to access the City's capacity to fuel AFVs. A general overview about the various types of alternative fuels considered in our study is then provided. Our report focuses on BEVs, hybrids, PHEVs, and CNG vehicles. Each portion outlines the fuel type's basic information, sources, conversion practices, vehicle maintenance and safety concerns, and applicable laws. Next, we review current AFV incentives from the local to federal level. The report also presents a breakdown of our quantitative analysis and findings, which comprises of four sections: methodology, results, recommendations, and sensitivity analysis. Lastly, a conclusion summarizing our overall proposal is provided thereby solidifying our recommendation that the City of Arcadia should convert some of their current conventional vehicles to alternative fuel types.

Assumptions

There are specific factors that are hard to account for due to risk and uncertainty in our project. Because our analysis covers a long time horizon with multiple unpredictable variables, certain assumptions are expected. Most of our recommendations are based upon current technology. Below is a list of general assumptions made:

- In regards to medium-duty trucks, our project only considers the vehicle cost without special equipment outfitting (e.g. stake, dump, aerial) because special equipment costs remain the same regardless of engine type.
- Light-duty pickup truck fuel costs are based on Kelley Blue Book (KBB) values. Medium-duty pickup truck fuel costs are based on www.cars.com. BEV, PHEV, Hybrid fuel costs are based on www.fueleconomy.gov.
- Ford, KBB, and www.cars.com do not provide MPG or maintenance and repair costs for medium-duty trucks. The only available information is on the Ford F-450. Since the other medium-duty trucks are comparable (i.e. similar performance and capacity), we used the Ford F-450's MPG and maintenance and repair costs for all the medium-duty vehicles.
- Because of the variability in driving patterns, it is difficult to predict the City's exact bi-fuel engine split time. Our report assumes a 50/50 CNG and gas engine split driving time for CNG bi-fuel vehicles and a 50/50 electric and gas split driving time for PHEVs. Although a vehicle's alternative fuel range is potentially higher than 50%, the general assumption for bi-fuel vehicles is an even 50/50 split.[28]
- The Life-cycle analysis assumes a 15,000-mile per year average and a $0.12/kWh electricity price. This is the same assumption made on the U.S. DOE's Fuel Economy website.
- We omitted insurance costs in our analysis because we assume that the slightly higher premiums associated with AFVs are balanced out by the AFV discount rates offered by insurance companies.[29]
- The LCA only includes vehicles up to the 2015 models because that is the latest year of AFVs with available data (though extremely limited) at this time.
- The AFV database does not inflate MSRP values to the existing vehicle's replacement year, only reflecting the purchase cost for the year of the model. As such, our recommendations assume the City will change out its vehicles this current year.
- Our LCA on AFVs omits auction and salvage values because these vehicles are new and have no historical data from which we can base resale values. Therefore, our AFV life-cycle costs are slightly higher than the actual ones because auction and salvage values are not included.
- The batteries in BEVs have a limited number of charging cycles, so it is important to consider battery life, warranties, and the manufacturer's battery recycling policy. Currently, many manufacturers offer eight-year or 100,000 mile warranties for BEV

[28] "Light-Duty Vehicle Regulations Provide New Incentives for Automaker Production of NGVs," -, accessed May 1, 2014, http://www.ngvc.org/pdfs/LDV_Rules_Analysis_VNG_Summary.pdf.
[29] "Alternative Fuels Data Center: Alternative Fuel Vehicle (AFV) and Hybrid Electric Vehicle (HEV) Insurance Discount," U.S. Department of Energy | Energy Efficiency & Renewable Energy, November 12, 2013, http://www.afdc.energy.gov/laws/law/CA/6015.

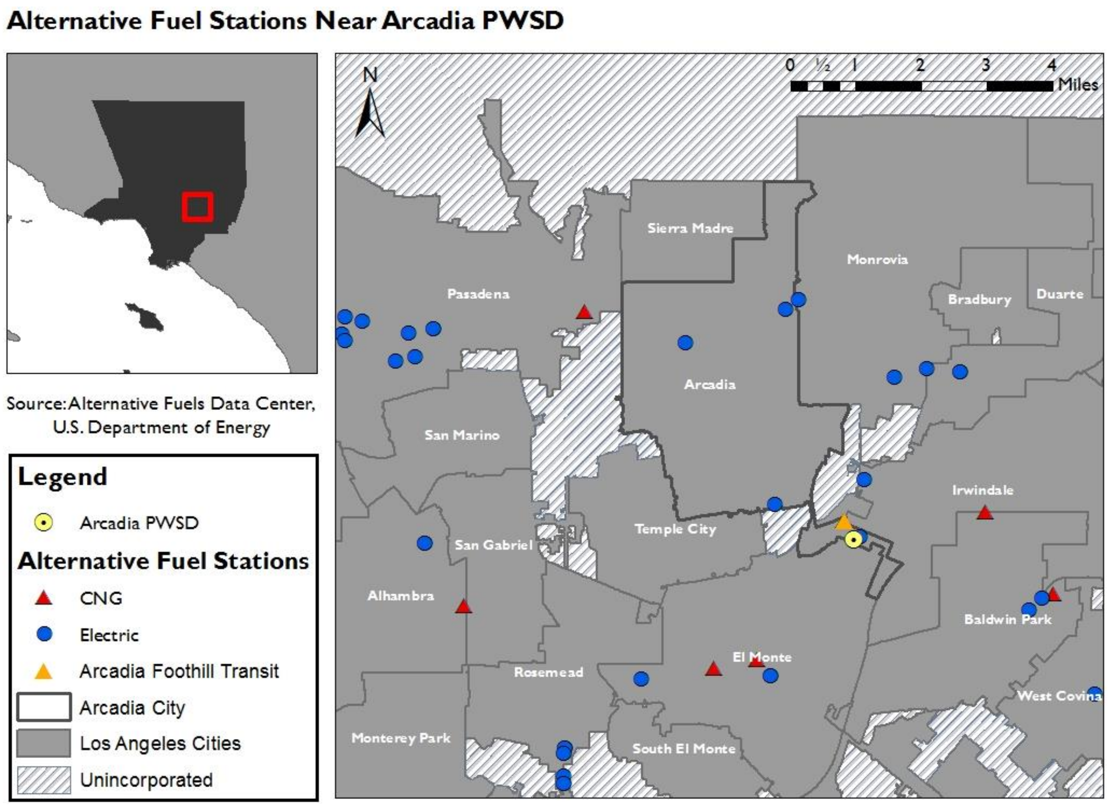
batteries.[30] Given the City's similar replacement criteria of 100,000 miles, we assume the City will not need to replace the battery. If the City needs to replace a battery outside the warranty, the cost is expected to be high. Manufacturers have yet to publish exact prices. With advancing technologies, some estimates suggest that battery costs may drop at a rate of 7% per year.[31]

[30] "Nissan LEAF® Electric Car Range," accessed March 15, 2014, http://www.nissanusa.com/electric-cars/leaf/charging-range/range/.
[31] John Voelcker, "How Much And How Fast Will Electric-Car Battery Costs Fall?," Green Car Reports, March 16, 2012, http://www.greencarreports.com/news/1074183_how-much-and-how-fast-will-electric-car-battery-costs-fall.

Local Fueling Infrastructure

The Geographic Information Systems (GIS) map in Figure 3 visually shows the geographic locations of Level 2 charging stations for all PEV's and CNG stations for fueling CNG vehicles. The map area is limited to the City of Arcadia and the following surrounding cities: Pasadena, San Marino, Alhambra, San Gabriel, Rosemead, Temple City, El Monte, Baldwin Park, Irwindale, Duarte, Bradbury, Monrovia, and Sierra Madre.

Figure 3. CNG and Electric Fueling Stations



The City currently fuels its internal combustion engine vehicles (ICEVs) at the Arcadia PWSD. There is no Level 2 charging station (i.e. 240-volt charging) for EV's on the PWSD lot. For their existing CNG vehicles, the City goes to the Arcadia Foothill Transit Center to refuel.

From the map, we can see that the Foothill Transit Center is conveniently close to Arcadia PWSD. If the City chooses not to build its own fueling station, it can continue fueling here, or at the stations in El Monte, Baldwin Park, and Pasadena. Figure 3 above also indicates that Arcadia has at least four Level 2 fueling stations available within City limits.

Because our recommendations include both plug-in electric and bi-fuel CNG vehicles, we recommend that the City makes the following considerations:

1. Use Level 1 charging stations (i.e. conventional 120-volt outlets) at Arcadia PWSD to charge its PEV's. For faster charging, the City can visit nearby electric Level 2 fueling stations.
2. For CNG charging, the City should continue charging at Foothill Transit Center, but it can also begin to consider establishing its own CNG fueling station.

Building a CNG fueling station would cost Arcadia $200,000.[32] This estimate is based on the price of a Galileo CNG Nanobox, which is a CNG compressor. It is a product offered by Clean Fuel Connection, Inc. – an Arcadia-based distributor of CNG compressors. A compressor that is the size of the CNG Nanobox is ideal for small fleets and requires no special installation requirements.[33] By owning a CNG fueling station, the City of Arcadia would avoid waiting in line for fueling at public stations. However, the City must contact its gas provider, Southern California Gas Company, to learn where it is viable to construct a CNG fueling station. For CNG station construction funding, the City can consider programs like Alternative and Renewable Fuel and Vehicle Technology Program (ARFVTP) and the Motor Vehicle Registration Fee Program, which are further discussed in the Incentives section of this report.

[32] Joseph Shinn, CNG Station Costs Discussion with the Manager of Sales and Marketing Strategy at Clean Fuel Connection, March 14, 2014.
[33] "Clean Fuel Connection - Compressed Natural Gas - CNG - Nanobox," accessed March 15, 2014, http://www.cleanfuelconnection.com/cng-nanobox-compression-system.html.

Battery Electric Vehicles

Basic Information (Including Benefits & Considerations)

BEVs are plug-in vehicles (PEVs) that use electrical energy stored in batteries to power the motor.[34] In order to charge the batteries, the vehicles must be plugged into an electric power source. These vehicles run entirely on electricity, and are also known as all-electric vehicles, or simply as electric vehicles (EVs). BEVs can have a driving range of 100 to 200 miles per single charge.[35] However, the vehicles mentioned in this report have a smaller range of around 100 miles. This fact is important to consider because it makes BEVs range-limited. Nevertheless, the City mainly uses these vehicles to drive within the City limits, which encompasses only 11.2 square miles. Given the City's driving patterns, a range of approximately 100 miles per day is sufficient for its purposes.

Electricity– the energy used to fuel BEVs– is not as vulnerable to dramatic changes in prices over time compared to conventional fuels. The City of Arcadia's electric power supply comes from Southern California Edison. Vehicle recharge prices are therefore dependent on local electric rates. According to studies done by groups like the Electric Power Research Institute, California's electrical grid has the potential to power a large number of PEVs.[36] This high capacity is important given the existing state and federal policies encouraging greater use of AFVs, like PEVs.

There are several benefits to choosing BEVs over internal combustion engine vehicles (ICEV). These benefits include efficiency, lower emissions, infrastructure and vehicle availability, fuel economy, and lower maintenance costs.

1. Efficiency

BEV's are energy efficient. They can convert 59% to 62% of electrical energy to power at the wheels, while gasoline-powered vehicles only convert 17% to 21% of the energy in gasoline to power at the wheels.[37] While the driving range is shorter, BEVs do not require gasoline for fuel.

2. Lower Emissions

The U.S. EPA identifies BEVs as zero-emission vehicles (ZEVs) because they do not produce tailpipe emissions or direct exhaust.[38] However, it cannot be assumed that the electricity used to power BEVs is completely clean. Electricity used to power BEVs is produced at power plants. These power plants may emit air pollutants depending on how they are powered. For example, if power plants are coal-powered, then they emit air pollutants.

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[34] "Alternative Fuels Data Center: All-Electric Vehicles," U.S. Department of Energy | Energy Efficiency & Renewable Energy, February 7, 2013, http://www.afdc.energy.gov/vehicles/electric_basics_ev.html.

[35] Ibid.

[36] "Impact of Plug-in Electric Vehicle Technology Diffusion on Electricity Infrastructure," *Electric Power Research Institute*, December 22, 2008, http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000000001016853.

[37] "All-Electric Vehicles," U.S. Department of Energy | Energy Efficiency & Renewable Energy, February 28, 2014, https://www.fueleconomy.gov/feg/evtech.shtml.

[38] "Alternative Fuels Data Center: All-Electric Vehicles."

3. Infrastructure and Vehicle Availability

BEVs can charge overnight at the fleet facility or at public charging stations.[39] The Alternative Fuels Data Center (AFDC) provides a resource for locating a nearby station by entering a zip code of interest. When researching charging stations, it is important to consider whether they are public or private because this may determine accessibility.

A variety of BEV models are available on the market. Even more are expected to enter the market given the fast-changing technology. Options for BEVs are extensive and include both domestic and foreign automakers. A list of existing vehicles is available at the U.S. DOE's AFDC.[40]

4. Vehicle Performance

Compared to conventional vehicles, BEVs have smoother and quieter electric engines with more powerful acceleration.[41] Even with these performance benefits, a few considerations related to the batteries still need to be made. Unlike fast gasoline refueling, BEVs require time-consuming recharges. A full charge can take anywhere from four to eight hours using Level 2 charging, which is faster than Level 1 charging. Finally, the large and heavy battery packs take up a lot of space inside the vehicle.[42]

Sources

BEVs are powered by the energy stored in their batteries. Like any plug-in electric vehicle (PEV), BEVs can be charged using a 120-volt outlet (i.e. Level 1). For even faster charging, BEVs can be charged using a 240-volt outlet (i.e. Level 2). Since BEVs run solely on electricity, they rely on the electric grid as a source for energy. Southern California Edison is the City of Arcadia's electric service provider. Sources for electricity in Arcadia are broken down into: 53.04% Gas, 14.93% Nuclear, 12.72% Hydro, 7.33% Coal, 4.37% Geothermal, 2.76% Wind, 2.72% Biomass, and 1.36% Oil.[43]

Vehicle Conversions

A typical car– an ICEV– can be converted to a BEV. This can be done by "removing the engine and adding a battery pack, one or more electric motors, high-voltage cables, and instrumentation."[44] Conversions to BEVs are usually done on smaller, lighter-weight vehicles in order to maximize the driving range.[45] Any vehicle owner or fleet manager who wishes to

[39] "Alternative Fuels Data Center: Developing Infrastructure to Charge Plug-In Electric Vehicles," U.S. Department of Energy | Energy Efficiency & Renewable Energy, September 25, 2013, http://www.afdc.energy.gov/fuels/electricity_infrastructure.html.

[40] "Alternative Fuels Data Center: Light-Duty Vehicle Search," U.S. Department of Energy | Energy Efficiency & Renewable Energy, December 30, 2013, http://www.afdc.energy.gov/vehicles/search/light/autos?fuel_type_code=ELEC.

[41] "All-Electric Vehicles."

[42] Ibid.

[43] "Alternative Fuels Data Center: Emissions from Hybrid and Plug-In Electric Vehicles," U.S. Energy Information Administration (EIA), July 30, 2012, http://www.afdc.energy.gov/vehicles/electric_emissions.php.

[44] "Alternative Fuels Data Center: Hybrid and Plug-In Electric Vehicle Conversions," U.S. Department of Energy | Energy Efficiency & Renewable Energy, September 24, 2013, http://www.afdc.energy.gov/vehicles/electric_conversions.html.

[45] Ibid.

convert a vehicle is required to work with the manufacturer or an authorized representative.[46] While conversions are possible, they require a lot of steps and can cost up to $24,000.[47]

Vehicle Maintenance & Safety Concerns

BEVs require less maintenance than conventional vehicles, hybrids, and plug-in hybrids. The battery, motor, and other electronics in the car require minimal or no regular maintenance. BEVs have fewer fluids to change and fewer moving parts than conventional vehicles. Additionally, BEVs have reduced break wear as a result of regenerative braking.[48]

Like standard vehicles, BEVs must pass safety testing and meet safety standards. There are also some PEV-specific requirements. For example, PEVs have been designed to deactivate the high-voltage electric system in the event of collisions. Further safety measures include requirements to limit spillage and prevent electric shock.[49]

A major safety concern associated with BEVs, and PEVs in general, is their quiet engine. This poses a danger to pedestrians who may not hear these vehicles passing by. There are already PEV options that make audible noise for pedestrians to hear, like the Volt and the Leaf.[50]

Laws

There are several laws and regulations related to BEVs. Governor Brown issued the Zero-Emission Vehicle Executive Order B-16-2012 in March 2012 in order to increase the number of zero-emission vehicles on the road to over 1.5 million by 2025. In addition, the Executive Order also requires that Californians have access to ZEV infrastructure. Assembly Bill 118 was passed in 2007 to give $1.4 billion through the Alternative and Renewable Fuel and Vehicle Technology Program (ARFVTP) for clean vehicles and infrastructure. Senate Bill 454, also known as the Electric Vehicle Charging Stations Open Access Act, facilitates EV charging by making stations easier to locate and useable for all vehicle drivers, even if the drivers do not have a network subscription.[51]

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[46] "Alternative Fuels Data Center: Conversion Regulations," U.S. Department of Energy | Energy Efficiency & Renewable Energy, January 18, 2013, http://www.afdc.energy.gov/vehicles/conversions_regulations.html.
[47] Jim Motavalli, "New Electric Car Conversion Kit Will Charge Your Car (and Wallet)," *Forbes*, May 24, 2012, http://www.forbes.com/sites/eco-nomics/2012/05/24/new-electric-car-conversion-kit-will-charge-your-car-and-wallet/.
[48] "Alternative Fuels Data Center: Maintenance and Safety of Hybrid and Plug-In Electric Vehicles," U.S. Department of Energy | Energy Efficiency & Renewable Energy, September 24, 2013, http://www.afdc.energy.gov/vehicles/electric_maintenance.html.
[49] "Plug-In Electric Vehicle Handbook for Fleet Managers (Brochure), Clean Cities, Energy Efficiency & Renewable Energy (EERE)," accessed March 2, 2014, http://www.afdc.energy.gov/pdfs/pev_handbook.pdf.
[50] Ibid.
[51] "Zero-Emission Vehicles in California: Community Readiness Guidebook," accessed March 2, 2014, http://opr.ca.gov/docs/ZEV_Guidebook.pdf.

Hybrids and Plug-In Hybrids

Basic Information (Including Benefits and Considerations)

Hybrid electric vehicles (HEVs) have both an electric motor and internal combustion engine (ICE). An electric motor allows for a smaller ICE, powers auxiliary loads, and reduces engine idling, all of which offer better fuel economy. HEV batteries do not have the option to charge by plugging into the wall. The batteries charge through regenerative braking and through the ICE.[52]

Plug-in hybrid electric vehicles (PHEVs) also have an electric motor and an ICE, which means that they can use electricity from the grid or gasoline to power the vehicle. PHEVs have bigger battery packs, which allow them to run longer distances on just electricity. PHEVs can be plugged into an outside power source to charge, unlike HEVs. When PHEVs run on only electricity, they are considered to have zero tailpipe emissions, although they do produce evaporative emissions.[53]

Like other AFVs, there are benefits to choosing hybrids and plug-in hybrids over internal combustion vehicles. Below is a list of benefits:

1. Energy Efficiency

Since hybrids combine electric and gasoline power, hybrids have a driving range greater than or equal to the range of ICEVs.[54] As previously mentioned, PHEVs have a larger battery that can be recharged using energy from the electric grid. The distance PHEVs can travel on battery power alone ranges from 15 to 35 miles.[55] After this, they can run on energy from gasoline.

2. Lower Emissions

HEVs and PHEVs have lower direct emissions than conventional ICEVs. PHEVs have zero tailpipe emissions when running fully on electric mode, but when using the ICE, they will produce emissions. Also, they have evaporative emissions from the fuel system and fueling process in a PHEV. Since HEVs and PHEVs also use gasoline, these vehicles have "well-to-wheel emissions," such as extracting petroleum, refining petroleum, distributing fuel, and burning fuel in vehicles.[56]

3. Infrastructure and Vehicle Availability

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[52] "Alternative Fuels Data Center: Hybrid Electric Vehicles," U.S. Department of Energy | Energy Efficiency & Renewable Energy, February 7, 2013, http://www.afdc.energy.gov/vehicles/electric_basics_hev.html.

[53] "Alternative Fuels Data Center: Plug-In Hybrid Electric Vehicles," U.S. Department of Energy | Energy Efficiency & Renewable Energy, February 7, 2013, http://www.afdc.energy.gov/vehicles/electric_basics_phev.html.

[54] "Drive Clean - Hybrid Electric," California Environmental Protection Agency Air Resources Board, accessed March 2, 2014, http://www.driveclean.ca.gov/Search_and_Explore/Technologies_and_Fuel_Types/Hybrid_Electric.php.

[55] "Drive Clean - Plug-in Electric Vehicle Resource Center," California Environmental Protection Agency Air Resources Board, accessed March 2, 2014, http://www.driveclean.ca.gov/pev/Plug-in_Electric_Vehicles/Find_the_Right_PEV.php#pevcompare.

[56] "Alternative Fuels Data Center: Emissions from Hybrid and Plug-In Electric Vehicles."

Hybrids refuel through widely available gas stations, though refueling visits are less frequent than conventional ICEVs. Likewise, PHEVs can also be refueled at gasoline stations. PHEVs have the added advantage of being refueled at electric stations. Furthermore, HEVs offer the greatest number of vehicle models. In 2014, for example, the AFDC lists 39 new HEV models. Both domestic and foreign automakers offer HEVs. Although not as common as HEVs, there are also many PHEV options.

4. Vehicle Performance

The benefits of PHEVs include lower charging time. They take only 1 hour to fully charge on a 240-volt charger (Level 2) and 3 hours on a 120-volt charger (Level 1). They also have very low direct emissions that depend on the electric/gas ratio the PHEVs use.[57] Also, since they can also run on gasoline, they are not limited to the driving range of the battery.

Sources

HEVs and PHEVs use gasoline as a fueling source. Even with recent declines in oil imports, the United States has a heavy dependence on foreign petroleum imports with 40% coming from abroad.[58] California prices for gasoline tend to be more variable than other states because of factors like few supply sources, stringent California programs, and additional taxes.[59]

As mentioned, HEVs and PHEVs can both use gasoline to power their ICEs. Since HEVs cannot run on electricity entirely, their gasoline usage is higher than PHEVs. PHEVs, unlike HEVs, can also be powered with electricity from the grid through 120- or 240-volt charging.[60]

Vehicle Conversions

HEV conversions can be done on conventional vehicles. However, it is important to consider the vehicle's payload capacity, or cargo, to ensure that it can support the weight and space of hybrid equipment. Existing HEVs can also be converted to PHEVs through the addition of more battery capacity and equipment to charge the vehicles. Converting PHEVs requires EPA and/or CARB certification.[61] Like BEVs, HEV and PHEV conversions are a complex process and can be costly.

Vehicle Maintenance & Safety Concerns

Both HEVs and PHEVs have ICEs, so they require maintenance similar to conventional cars. The electric components of these vehicles require very little maintenance. For instance, the regenerative brake system makes the vehicle's brakes last longer.[62] Furthermore, HEVs and

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[57] "Drive Clean - Plug-in Electric Vehicle Resource Center."
[58] "EIA's Energy in Brief: How Dependent Are We on Foreign Oil?".
[59] "Regional Gasoline Price Differences - Energy Explained, Your Guide To Understanding Energy," U.S. Energy Information Administration (EIA), August 14, 2012, http://www.eia.gov/energyexplained/index.cfm?page=gasoline_regional.
[60] "Drive Clean - Plug-in Electric Vehicle Resource Center."
[61] "Alternative Fuels Data Center: Hybrid and Plug-In Electric Vehicle Conversions."
[62] "Alternative Fuels Data Center: Maintenance and Safety of Hybrid and Plug-In Electric Vehicles."

PHEVs share similar conditions in cases of battery replacement. Finally, the safety concerns regarding the high-voltage electrical systems in HEVs and PHEVs are similar to BEVs.

Laws

The same laws, regulations, and incentives that affect HEVS and PHEVs affect BEVs. For more information on these laws, please look at the section on laws and regulations for BEVs.

Compressed Natural Gas

Basic Information (Including Benefits & Considerations)

Vehicles can operate on either CNG or LNG, but CNG is used more often. CNG is a mixture of methane and other hydrocarbon gases that has been compressed and stored into a pressurized storage vessel.[63] Natural gas is naturally voluminous and must be stored in large high-pressure fuel tanks, making passenger and cargo space more limited in CNG vehicles. The amount of CNG that can be stored in these tanks varies depending on four factors: ambient temperature, fueling rate, pressure rating and cylinder type.

CNG is not only colorless odorless, but also non-corrosive and non-toxic.[64] It can be used as a substitute for either gasoline or diesel in vehicles. CNG-powered vehicles receive roughly the same fuel economy to their gasoline-powered counterparts. A gasoline gallon equivalent (gge) equals around 5.66 pounds of CNG.[65] An added benefit is that CNG produces fewer undesirable gases and is considered to be one of the cleanest alternative burning fuels available.

Other benefits include energy security, infrastructure and vehicle availability, vehicle performance and lower emissions.

1. Energy Security

In 2013, approximately 40% of the petroleum consumed in the United States was imported with the transportation sector accounting for over 70% of that total consumption.[66] Because much oil is produced in the Middle East, the U.S. must maintain good political relations with those countries. Comparatively, the EIA approximates that 95% of our country's natural gas consumption is produced domestically.[67] With natural gas reserves abundant in the U.S., CNG is a preferable alternative fuel option in offsetting America's high dependency on petroleum.

2. Infrastructure and Vehicle Availability

Most recently, car manufacturers are introducing new types of commercial CNG vehicles into the market. These vehicles range in size, availability, and application. To reduce costs, fleet managers can convert their existing diesel or gasoline vehicles to CNG vehicles by using qualified system retrofitters.[68]

Although light-duty CNG vehicles are increasing in number, there is still a limited supply. Check the AFDC (http://www.afdc.energy.gov/vehicles/search/light/) or the Clean Cities 2013

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[63] *North Carolina Alternative Fuels Feasibility Study under Session Law 2012-186* (North Carolina Department of Commerce, December 1, 2012), http://digital.ncdcr.gov/cdm/singleitem/collection/p249901coll22/id/657359/rec/20.
[64] "Compressed Natural Gas (CNG) as a Transportation Fuel," California Energy Commission, 2014, http://www.consumerenergycenter.org/transportation/afvs/cng.html.
[65] "Alternative Fuels Data Center: Natural Gas Fuel Basics," U.S. Department of Energy | Energy Efficiency & Renewable Energy, November 4, 2013, http://www.afdc.energy.gov/fuels/natural_gas_basics.html.
[66] "Alternative Fuels Data Center: Natural Gas Benefits and Considerations," U.S. Department of Energy | Energy Efficiency & Renewable Energy, November 4, 2013, http://www.afdc.energy.gov/fuels/natural_gas_benefits.html.
[67] "Table 1. Summary of Natural Gas Supply and Disposition in the United States, 2008-2013.," *Natural Gas Monthly - U.S. Energy Information Administration*, February 2014.
[68] "Compressed Natural Gas (CNG) as a Transportation Fuel."

Vehicle Buyer's Guide (http://www.afdc.energy.gov/uploads/publication/55873.pdf) for availability.[69]

The United States, especially California, has recognized the need to mitigate the amount of anthropogenic GHG emissions. Despite this environmental stance, alternative fueling infrastructure has remained limited and inadequate; however, this is less true in California. While it may be convenient for public fleet managers to install their own natural gas station, doing so can be costly. As such, cities that plan to convert their diesel and gasoline fleets to alternative fuel should find comparable partners willing to join in on this expenditure. Having extra shareholders will improve the payback period for all parties involved.[70]

3. Vehicle Performance

CNG vehicles are comparable to gasoline and diesel vehicles in terms of acceleration, cruising speed, and power.[71] But similar to other alternative fuel types, the driving range of CNG vehicles is typically less than the driving range of similar conventional vehicles. This is primarily due to the fact that natural gas needs to be stored in larger and heavier high-pressure tanks. With natural gas, "less overall energy content can be stored in the same size tank as the more energy-dense gasoline or diesel fuels."[72] Adding larger or additional CNG tanks increases driving range, but at the cost of a heavier weight load onboard.

4. Lower Emissions

In general, natural gas vehicles produce fewer emissions compared to conventional gasoline or diesel vehicles. CNG produces about 20% to 45% less smog-producing pollutants and roughly 5% to 9% less GHG emissions.[73] A 2007 California Energy Commission (CEC) study found that light-duty CNG vehicles have fewer GHG emissions compared to their gasoline and diesel counterparts; this is primarily due to "low petroleum usage in the production phase and the low-carbon intensity of the fuel during use."[74]

In sum, adopting more CNG vehicles will not only increase our nation's energy security but also lower the level of toxic upstream emissions in the environment. Financially speaking, natural gas is less expensive than gasoline. The two biggest concerns are that the current natural gas fueling infrastructure is limited and that CNG vehicles provide fewer miles per gallon (MPG). Over the past six years, consumption of CNG has increased by 145%, and CNG fueling infrastructure continues to grow.[75] Increased public interest in CNG vehicles and the rapid technological advancement will continue to fuel CNG's growth in the coming years.

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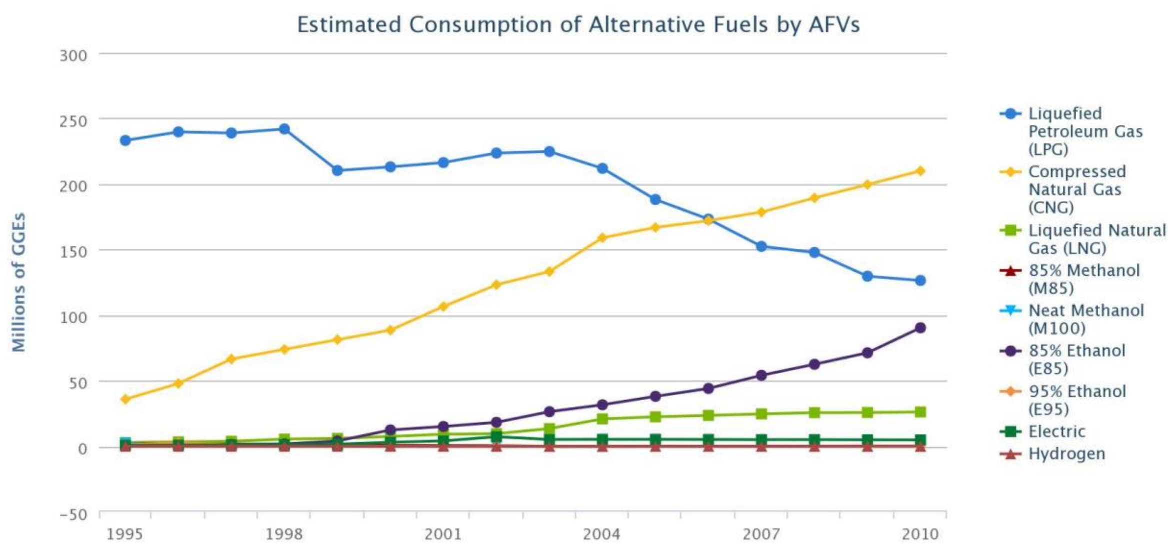
[69] "Alternative Fuels Data Center: Natural Gas Benefits and Considerations."
[71] "Alternative Fuels Data Center: Natural Gas Benefits and Considerations."
[71] "Alternative Fuels Data Center: Natural Gas Benefits and Considerations."
[72] Ibid.
[73] "Argonne GREET Model," U.S. Department of Energy | Argonne National Laboratory, 2012, http://greet.es.anl.gov/.
[74] "Alternative Fuels Data Center: Natural Gas Vehicle Emissions," U.S. Department of Energy | Energy Efficiency & Renewable Energy, November 4, 2013, http://www.afdc.energy.gov/vehicles/natural_gas_emissions.html.
[75] "Compressed Natural Gas (CNG) as a Transportation Fuel."

Sources

More than 99% of our natural gas consumption originates from either domestic or other North American reserves.[76] The graph below illustrates that this growth has been drastically increasing over time, and at a far great rate than any other alternative fuel type (Figure 4). As the U.S. energy consumption grows, the EIA lists Canada and Mexico as other potential natural gas sources.[77]

Figure 4. Alternative Fuel Consumption by AFVs[78]



Natural gas is typically found in areas abundant with crude oil and is typically extracted simultaneously with crude oil. These oil and gas wells are controversial because the extraction process may involve hydraulic fracturing, which is commonly known as 'fracking.' The EIA lists three main environmental concerns regarding fracking. First, fracking requires large amounts of water, which can damage aquatic habitats, and be problematic for regions tackling water scarcity. Second, it produces large quantities of polluted wastewater, which if improperly treated before disposal, can pollute surrounding areas. Third, it contains hazardous chemicals, which can contaminate groundwater and the atmosphere in case of spills or leakage.[79] Additionally, the EPA recognizes that fracking increases methane emissions and releases volatile organic compounds into the air.[80] In light of these environmental concerns, it is important that precautionary techniques are used in the natural gas extraction process to avoid contamination. When considering the purchase of a CNG vehicle, these challenges should also be taken into account.

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[76] Ibid.
[77] Ibid.
[78] "Alternative Fuels Data Center: Natural Gas Fuel Basics."
[79] "What Is Shale Gas and Why Is It Important?," U.S. Energy Information Administration (EIA), December 5, 2012, http://www.eia.gov/energy_in_brief/article/about_shale_gas.cfm.
[80] "Natural Gas Extraction - Hydraulic Fracturing," U.S. Environmental Protection Agency (EPA), March 14, 2014, http://www2.epa.gov/hydraulicfracturing#air.

Vehicle Conversion

CNG vehicle conversions are possible, but the EPA mandates many costly and cumbersome requirements for these conversions. Manufacturers need to ensure that their converted vehicles or engines emit the equivalent or fewer emissions than the original. [81] Conversions must also meet the regulations set by the National Highway Traffic Safety Administration (NHTSA), California Air Resources Board (CARB), and SCAQMD.

Vehicle Maintenance & Safety Concerns

CNG fuel vehicles typically require maintenance less often than conventional ones. However, filters should still be regularly inspected and replaced yearly if necessary.[82] This maintenance should be conducted at qualified service facilities because those facilities have the expertise to handle CNG vehicles. Filters that are used more often should be drained more frequently.

Similar to conventional vehicles, any physical impact or severe collision may damage the CNG vehicles internally. But because natural gas vehicles are not as nationally widespread yet, there is a higher likelihood of drivers and first responders being unfamiliar with the fuel system in the event of an accident. The NHTSA report advises inspection after an accident.[83]

Inspection records should be kept up-to-date so fleet managers know when their vehicles are due for inspection. Certified inspectors can be found by using the search engine on the CSA Group website for "Certified CNG Fuel System Inspector." The CSA Group is an independent, "internationally-accredited standards development and testing & certification organization" dedicated to advancing safety, social good and sustainability.[84] The association writes standards for U.S. natural gas appliances.

Laws

Currently, there are no applicable federal laws or incentives for natural gas. At a more local level, Rule 1186.1 Less-Polluting Sweepers is the only stringent CNG law in place. The law is applicable to Arcadia because the City's fleet contains sweepers having a gross weight of either 14,000 lbs. or more. It mandates that fleet managers must "acquire alternative-fuel or otherwise less-polluting sweepers when purchasing or leasing these vehicles for sweeping

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[81] "Alternative Fuels Data Center: Natural Gas Vehicle Conversions," U.S. Department of Energy | Energy Efficiency & Renewable Energy, October 23, 2013, http://www.afdc.energy.gov/vehicles/natural_gas_conversions.html.

[82] "Alternative Fuels Data Center: CNG Fuel System and Cylinder Maintenance," U.S. Department of Energy | Energy Efficiency & Renewable Energy, September 13, 2013, http://www.afdc.energy.gov/vehicles/natural_gas_cylinder.html.

[83] *Laboratory Test Procedure for FMVSS 304: CNG Fuel Container Integrity* (Washington, DC: U.S. Department of Transportation - National Highway Traffic Safety Administration, December 8, 2003), http://www.nhtsa.gov/DOT/NHTSA/Vehicle%20Safety/Test%20Procedures/Associated%20Files/TP304-03.pdf.

[84] "Home | CSA Group," 2014, http://www.csagroup.org/us/en/home.

operations undertaken by or for government entities in the jurisdiction of the AQMD."[85] The City has already taken the necessary steps (i.e. converting to CNG sweepers) in compliance with this law.

[85] "Rule 1186.1 Less-Polluting Sweepers," September 22, 2009, http://www.aqmd.gov/TAO/FleetRules/1186.1Sweepers/index.htm.

Incentives to Use Alternative Fuel Vehicles

There are currently many programs available that encourage the purchase and use of AFVs. These programs offer purchasers financial assistance in the form of grants or vouchers to cover part of the upfront cost when purchasing these vehicles. Incentives for AFV purchases are available at the local, state, and federal level.

Local Level

Southern California Edison offers reduced prices for electricity used to charge plug-in electric vehicles.[86] It is cheaper for the City to charge during off-peak hours, such as overnight between the hours of 9 p.m. and noon.[87]

State Level

The passage of AB 118 in 2007 gives $200 million every year until 2015 for three programs: the Air Quality Improvement Program (AQIP), the Alternative and Renewable Fuel and Vehicle Technology Program (ARFVTP), and the Enhanced Fleet Modernization Program (EFMP). More specifically, AQIP funds the Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP), which is designed to speed up the use of hybrid and electric vehicles in fleets. The program works by giving dealers a voucher that ranges from $8,000 to $45,000.[88] Purchasers (e.g. fleet managers) pay a reduced price for a vehicle in accordance to the voucher received.[89] The AQIP funding plan for the 2013-2014 Fiscal Year has been approved and includes the continued funding for HVIP.[90] ARFVTP, the second program, offers incentive funding to be overseen by the CEC for 11 types of projects, including the construction of alternative and renewable fuel infrastructure.[91] Since its implementation, ARFVTP has provided funding for many CNG infrastructure projects. As the program is nearing its end, it will give greater focus to fund school districts and public transit, but does not discourage solicitation for other CNG infrastructure projects.[92] Finally, the EFMP – the third program funded by AB 118 – encourages the voluntary retirement of passenger or cargo trucks in a fleet.[93]

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[86] "Alternative Fuels Data Center: California Laws and Incentives for EVs," U.S. Department of Energy | Energy Efficiency & Renewable Energy, November 12, 2013, http://www.afdc.energy.gov/laws/laws/CA/tech/3270.

[87] "PEV Cities | Partnerships | Partners & Vendors | Your City's Fueling Future," Southern California Edison, accessed March 17, 2014, https://www.sce.com/wps/portal/home/partners/partnerships/pev-cities/.

[88] "About the Project - California HVIP - Hybrid Truck & Bus Voucher Incentive Project," California Environmental Protection Agency Air Resources Board, accessed March 2, 2014, http://www.californiahvip.org/about-the-project.

[89] *Implementation Manual for the FY 2011-12 California Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project* (California Environmental Protection Agency Air Resources Board, November 14, 2012), http://www.californiahvip.org/docs/HVIP_Year%203_Implementation%20Manual_2012-11-14.pdf.

[90] "AQIP Funding Plans," California Environmental Protection Agency Air Resources Board, December 31, 2013, http://www.arb.ca.gov/msprog/aqip/fundplan/fundplan.htm.

[91] "Background Information Regarding the Air Quality Improvement Program," California Environmental Protection Agency Air Resources Board, October 9, 2013, http://www.arb.ca.gov/msprog/aqip/bkgrnd.htm#AB118.

[92] Charles Smith, *2013-2014 Investment Plan Update for the Alternative and Renewable Fuel and Vehicle Technology Program* (California Energy Commission, May 2013), http://www.energy.ca.gov/2012publications/CEC-600-2012-008/CEC-600-2012-008-CMF.pdf.

[93] "Zero-Emission Vehicles in California: Community Readiness Guidebook."

Smaller vehicles (e.g. sedans) are covered by the Clean Vehicle Rebate Project (CVRP), which provides rebates for purchasing or leasing certain vehicles. Rebates of up to $2,500 are available for light-duty zero emission and plug-in hybrid light-duty vehicles.[94] Applicants must apply for these rebates after the date of purchase or lease and must keep the vehicle in the state for three years.[95]

There is also the Motor Vehicle Registration Fee Program, which offers funding for projects that increase AFV purchases and develops relevant infrastructure.[96] The funds for the program are to be used for projects that reduce emissions and projects that are part of air district clean air plans.[97] For city fleet managers, eligible projects may involve purchasing AFVs and installing alternative fueling infrastructure.

At the time this report was written, no state grants specific to natural gas usage were found. Please review the SCAQMD website (https://www.aqmd.gov/aqmd/funding.html) for the most up-to-date list.[98]

Federal Level

At the federal level, purchasers of PEV's can consider the Plug-In Electric Drive Motor Vehicle Tax Credit. With the purchase of a new, qualifying PEV, a buyer can get a tax credit that ranges from $2,500 to $7,500.[99] The amount of the tax credit depends on the battery capacity and the gross vehicle weight rating. The vehicle must have a minimum battery capacity of five-kilowatt hours and a maximum vehicle weight rating of 14,000 pounds.[100] It is important for future buyers to note that the tax credit phases out for each manufacturer who sells 200,000 vehicles for use in the United States.[101] While cities cannot claim a tax credit, the car dealers can pass on the savings to the buyer. Oklahoma City has set a precedent for this by obtaining $7,500 tax credit for two new Nissan Leafs in the City's public vehicle fleet.[102] Within the same year, the City of Indianapolis received the same $7,500 tax credit.[103] This value has not been included in our calculations because it is highly dependent on the dealer.

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[94] "Clean Vehicle Rebate Project," California Center for Sustainable Energy, 2014, http://energycenter.org/clean-vehicle-rebate-project.
[95] Ibid.
[96] "Planning: 1998 Criteria & Guidelines Addendum," California Air Resources Board, accessed March 15, 2014, http://www.arb.ca.gov/planning/tsaq/mvrfp/criteria/addend.pdf.
[97] Ibid.
[98] "Funding Incentives / Opportunities," South Coast Air Quality Management District, January 9, 2014, https://www.aqmd.gov/aqmd/funding.html.
[99] "Alternative Fuels Data Center: Qualified Plug-In Electric Drive Motor Vehicle Tax Credit," U.S. Department of Energy | Energy Efficiency & Renewable Energy, November 12, 2013, http://www.afdc.energy.gov/laws/law/US/409.
[100] Ibid.
[101] "Plug-In Electric Drive Vehicle Credit (IRC 30D)," IRS, February 13, 2014, http://www.irs.gov/Businesses/Plug-In-Electric-Vehicle-Credit-(IRC-30-and-IRC-30D).
[102] Cindy Brauer, "How Public Sector Fleets Can Take Advantage of EV Tax Credits," *Green Fleet Magazine*, October 19, 2012, http://www.greenfleetmagazine.com/article/51258/how-public-sector-fleets-can-take-advantage-of-ev-tax-credits.
[103] Rick Callahan, "Indianapolis to Replace Entire Fleet with Electric, Hybrid Cars," *NBC News*, December 13, 2012, http://www.nbcnews.com/id/50188097/ns/us_news-environment/t/indianapolis-replace-entire-fleet-electric-hybrid-cars/#.UyHjwPldV0x.

Evaluative Criteria

The City of Arcadia provided a full list of currently owned vehicles, divided by sector: Fire, Police, Public Works: Water, Public Works: Sewer, and Public Works: Streets. The focus of the project is on non-safety vehicles, so we eliminated Fire and Police vehicles and aggregated all remaining vehicles (with specifications) into one master spreadsheet.

In line with the City's established replacement plan, we utilized the City's set criteria of 100,000 miles to compile a table of vehicles due within the next ten years (Table 2). These vehicles were the base vehicles considered in our LCA. However, from our discussions with the City and by evidence of the existing vehicle list, we found that some vehicles were kept beyond their retirement criteria date. This was particularly true for some of the large special equipment vehicles, which are expensive to replace. The City chose to keep these vehicles due to budget constraints and/or because these vehicles were infrequently used. These large special equipment vehicles were taken out of our LCA.

Table 2. Vehicles Due for Replacement

Asset #	Year	Dept.	Vehicle Description	Make and Model
Due Now				
80089	2000	Water	PICKUP-3/4 TON	Ford F-250
80172	2004	Water	PICKUP-3/4 TON	Ford F-250
60087	1991	Streets	TRUCK-DUMP (Refurbished)	Chevrolet Kodiak
60188	1995	Streets	PICKUP-COMPACT	GMC Sonoma
80173	2004	Streets	PICKUP-1/2 TON	Ford F-150
80105	2001	Sewer	SEWER CLEANER (REBUILT)	Sterling Vacon
80022	1998	Sewer	PICKUP-3/4 TON	Chevrolet 2500
80155	2003	Streets	CHIPPER	Vermeer B4100
Due in 1 year				
80270	2010	Water	FUSION HYBRID	Ford Fusion
80088	2000	Streets	PICKUP-3/4 TON	Ford F-250
80060	1999	City Hall	PICKUP-COMPACT	Ford Ranger
Due in 2 years				
80215	2006	Water	PICKUP-3/4 TON	Ford F-250 SD
80106	2001	Streets	PICKUP-COMPACT	Ford Ranger
80156	2003	Streets	PICKUP-3/4 TON	Chevrolet 2500
Due in 3 years				
80090	2000	Streets	TRUCK-ARIEL LIGHT	Ford F-450
80229	2007	Sewer	SEWER CLEANER	Sterling Vacon
Due in 4 years				
80191	2005	Water	VACUUM TRUCK	Sterling Vactor
60135	1992	Streets	TRUCK-DUMP	Ford F-700
80111	2001	Streets	TRUCK-STAKE	Ford F-450
80272	2010	Streets	CNG SWEEPER	Elgin Crosswind

80278	2011	Streets	PICKUP-3/4 TON (PROP A)	Ford F-250
60011	1986	Streets	LOADER	Caterpillar IT18

Due in 5 years

80227	2008	Water	PICKUP-3/4 TON	Ford F-250 SD
80228	2008	Water	PICKUP-3/4 TON	Ford F-250 SD
80289	2009	Water	PICKUP-COMPACT	Chevrolet Colorado
80110	2001	Streets	PICKUP-3/4 TON	Chevrolet 2500 HD
80235	2008	Water	PICKUP-3/4 TON	Ford F-250 SD
80143	2002	Streets	PICKUP-1/2 TON	Chevrolet 2500
80271	2010	Streets	CNG SWEEPER	Elgin Crosswind
80107	2001	City Hall	PICKUP-COMPACT	Ford Ranger

Due in 6 years

80290	2012	Sewer	PICKUP-3/4 TON	Chevrolet 2500 HD

Due in 7 years

80109	2001	Water	PICKUP-1/2 TON	Ford F-150
80269	2009	Water	PICKUP-COMPACT	Ford Ranger
80280	2011	Water	PICKUP-3/4 TON	Ford F-250 SD
60066	1990	Streets	TRUCK-FLAT BED	Chevrolet Kodiak

Due in 8 years

80279	2011	Water	PICKUP-3/4 TON	Ford F-250 SD

Due in 9 years

80127	2002	Water	SEDAN-MID	Chevrolet Malibu
80214	2006	Streets	PICKUP-3/4 TON	Ford F-250
80216	2006	Streets	PICKUP-1/2 TON	Chevrolet 2500

Due in 10 years

70101	1985	Streets	TRUCK-DUMP	Chevrolet 60 Series
80236	2008	City Hall	SUV HYBRID	Ford Escape

Our final vehicle recommendations were determined by using the following evaluative criteria, listed in order of significance:

1) Cost
2) City's vehicle performance requirements
3) Reliability
4) Emissions

Cost

Because the City's most important criterion is cost, we performed a LCA over a ten-year time frame. The costs included are the Manufacturer Suggested Retail Price (MSRP), annual maintenance cost, annual repair cost, the annual fuel cost, and any federal or state incentives. The MSRP and incentives are only included in the initial year's cost. However, the fuel, maintenance and repair costs occur annually over the ten-year time frame. We discount those future dollars back into present value.

Discount Rate

In order to convert all future dollar values into present value, our LCA incorporates a discount rate and fuel price index. The *Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis – 2013* provides our base equations for calculation.[104] The U.S. Department of Commerce's National Institute of Standards and Technology produces this document annually. The document uses the DOE'S real discount rate (*d*) of 3%, which is the same discount rate used in our calculations and by the City of Arcadia. We assumed a constant-dollar annual maintenance and repair cost (*A*) for each vehicle in the LCA. Based off this assumption, we are able to use Equation 1 to calculate the present value (*P*) for the maintenance and repair cost. The variable *N* represents the ten year life-cycle.

Equation 1[105]: $P = \mathrm{A} \times \frac{(1+d)N \ \ -1}{d(1+d)^N}$

Equation 2 is used to calculate fuel costs. The fuel costs are affected by the U.S. DOE 2013 fuel price index (*I)* and the real discount rate (*d*). A different index is used for each fuel type considered: gasoline, electricity (commercial) and natural gas (commercial). Again, we used the 3% real discount rate. The present value fuel cost (*P*) is calculated by multiplying the 2013 fuel cost (A_0) by the combined effect of the fuel price index and real discount rate. The variable *t* is the index for incrementing the years over a time period of *N*.

Equation 2[106]: $P = A_0 \times \sum_{t=1}^{N} \left(\frac{I_{(2013+t)}}{(1+d)^t}\right)$

If the City wants to use a different real discount rate, the 3% rate can be varied in the LCA spreadsheet tool. Due to market fluctuations, Appendix I illustrates the change in vehicle life-cycle cost at potential 5% and 10% discount rates. For instance, the Nissan Leaf has a life-cycle cost of $38,379 at a real discount rate of 3%. However, if that rate increases to 5% or 10%, the life-cycle cost drops to $37,234 and $35,000 respectively. As the discount rate increases, the life-cycle cost decreases. This is because a higher discount rate discounts future costs more than a lower discount rate. The relative difference in savings between the City's existing vehicles and recommended vehicles consequently decrease as the discount rate increases. At 3%, the recommended Nissan Leaf is $11,796 cheaper than the existing Chevy Malibu and $9,325 cheaper than the existing Ford Fusion Hybrid. But at 10%, the recommended Nissan Leaf is only $7,294 cheaper than the existing Chevy Malibu and $7,128 cheaper than the existing Ford Fusion Hybrid. This reduction in savings is consistent across all vehicle types.

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[104] Amy Rushing, Joshua Kneifel, and Barbara Lippiatt, *Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis-2013* (U.S. Department of Commerce National Institute of Standards Technology, June 2013), http://www1.eere.energy.gov/femp/pdfs/ashb13.pdf.

[105] Ibid.

[106] Ibid.

City's Vehicle Performance Requirements

Using the asset numbers from Table 2, we requested from the City the specific engine, transmission, HP, and payload data for our listed replacement vehicles so that we could more closely match the vehicle performance with our recommended AFVs. Because the City owns multiple versions of the same vehicle or vehicle class, our recommendations are separated by vehicle type. The categories are sedans, SUVs, light-duty pickup trucks and medium-duty pickup trucks. For each vehicle class, we compiled a list of new 2013- 2014 AFVs complete with the specifications and costs associated with each vehicle.

Reliability

We compiled a ranking table based on *Consumer Reports'* Best and Worst Cars for 2014 (Table 3). This list contains rankings for the existing and recommended sedans and SUVs. *Consumer Reports* did not possess rankings on our recommended CNG bi-fuel light-duty and medium-duty trucks.

Consumer Reports' overall scores are on a 100-point scale and are based on over 50 tests, including acceleration, fuel economy and safety features.[107] Reliability scores are based on the experience of 1.2 million owners, who reported on problems with their vehicles in the last 12 months based on 16 trouble spots, including engine, transmission, drive system, electrical, body integrity and brakes.[108] All of our recommended vehicles scored a 3 (average), 4 (better than average) or 5 (much better than average) on reliability. Additionally, all our recommended sedans earned the *Consumer Reports'* recommended status, for which they "must perform well in [their] testing, have average or better reliability; and, if crash-tested, provide an adequate overall safety rating."[109]

Table 3. *Consumer Reports* Best and Worst Cars for 2014

Sedan	Year	Reliability Score	Overall Score
Chevrolet Malibu ($50,175)	2014	3	84
Ford Fusion Hybrid ($47,704)	2014	2	85
Nissan Leaf ($38,379)	2014	5	69
Toyota Prius ($39,756)	2014	5	79
Honda Civic Hybrid ($40,785)	2014	4	66
Toyota Prius Plug-in ($43,251)	2014	3	71
SUVs	**Year**	**Reliability Score**	**Overall Score**
Ford Escape Hybrid*	N/A	N/A	N/A
Toyota Prius v ($43,903)	2014	4	80
Subaru XV Crosstrek Hybrid AWD ($48,260)	2014	3	75

*No longer in production

Key City's existing vehicles
Recommended Alternative Fuel Options

[107] "Guide to New-Car Ratings and Reviews," Consumer Reports, October 2013, http://www.consumerreports.org/cro/2012/04/a-guide-to-new-car-ratings-and-reviews/index.htm.
[108] *Best and Worst Cars for 2013* (Consumer Reports, 2013).
[109] "Guide to New-Car Ratings and Reviews."

Finally, we considered the environmental impact of vehicle emissions. We ranked each sedan and SUV with a GHG and Smog Rating, both on a scale from 1 to 10, from the Drive Clean (www.driveclean.ca.gov) website. As expected, the BEVs received the cleanest ratings. The Drive Clean website did not include GHG and Smog Ratings for the alternative fuel light-duty and medium-duty pickup trucks. Intuitively, our recommended CNG bi-fuel truck options should have lower ratings compared to their conventional counterparts. These emission ratings were considered last in our evaluative criteria.

A GHG score of 10 represents the cleanest score for each vehicle. The GHG rating includes both upstream and tailpipe emissions. A rating of 1 pertains to an emission level of above 520 CO_2 grams per mile, while a rating of 10 pertains to an emission level of less than 200 CO_2 grams per mile. A detailed breakdown is provided in Table 4 below; this standard is set by the Pavely (AB 1493) regulations.

Table 4. GHG Rating[110]

Greenhouse Gas Rating	CO_2 – equivalent Grams per mile
10	Less than 200
9	200-239
8	240-279
7	280-319
6	320-359
5	360-399
4	400-439
3	440-479
2	480-519
1	520 and up

The Smog standards are set from the Air Resources Board Low Emission Vehicle Program. It focuses on the amount of non-methane organic gas (NMOG) and nitrogen oxides (NO_x) emitted from the tailpipe. The smog rating ranges from a score of 1 (with 0.130 NMOG and NO_x g/mile) to 10 (with 0.000 NMOG and NO_x g/mile). Similar to the GHG Rating table above, a score of 10 represents the cleanest emission level. A complete breakdown is provided in Table 5 below.

[110] "Drive Clean - Know the Greenhouse Gas Rating," California Environmental Protection Agency Air Resources Board, accessed March 2, 2014, http://www.driveclean.ca.gov/Know_the_Rating/Know_the_Greenhouse_Gas_Rating.php.

Table 5. Smog Standards[111]

Smog Rating	NMOG + NO_x (g/mile)
10	0.000
9	0.030
8	0.030
7	0.085
6	0.110
5	0.125
4	0.160
3	0.190 - 0.200
2	0.240
1	0.325 - 0.356

The GHG rating, smog rating, annual fuel cost, and city/highway/combined MPG appear on the new Fuel Economy and Environment Label. This label is mandated by the U.S. EPA and U.S. DOT for all vehicles model year 2013 or later and replaces the California Environmental Performance Label.

[111] "Drive Clean - Understand the Smog Rating," California Environmental Protection Agency Air Resources Board, accessed March 2, 2014, http://www.driveclean.ca.gov/Know_the_Rating/Understand_the_Smog_Rating.php.

Results

Life-cycle cost calculations were first made for all the AFVs on the market. The vehicles were then ranked from lowest to highest life-cycle cost within each vehicle category. After a cursory review of the top vehicles within each category, a few vehicles with low life-cycle costs were eliminated due to obvious vehicle performance problems. For instance, the Mitsubishi i-MiEV has the lowest life-cycle cost at $31,268, but it is too small for carpooling. Likewise, the Chevrolet Spark has a low life-cycle cost of $35,254, but is also too small for carpooling. Because the City needs vehicles with a larger capacity, both of these vehicles were eliminated.

City vehicles are separated into four categories– sedans, SUVs, light-duty pickup trucks and medium-duty pickup trucks. The sedan category considers AFVs that are BEVs, PHEVs, CNG vehicles, and hybrid vehicles. The SUV category includes the hybrids and BEVs on the market. The light-duty and medium-duty pickup trucks focus on CNG bi-fuel options. This CNG bi-fuel conversion cost is approximately $10,000. For the medium-duty pickup truck category, there is a PHEV available at a $60,000 conversion cost. Due to the high cost, the PHEV medium-duty pickup truck was eliminated from our recommendations.

Table 6 displays the match-ups for the City's up-for-replacement vehicles against our top vehicle choices for each alternative fuel type. The life-cycle costs for the existing and top potential AFVs are listed side-by-side to illustrate the cost savings by switching to an AFV.

Table 6. Top Potential AFVs Replacements by Vehicle Type

Existing Vehicles: Descriptions	Existing Vehicles: Make and Model	Potential AFVs: Make and Model
SEDAN- MID	Chevy Malibu ($50,175)	Nissan Leaf ($38,379), Toyota Prius ($39,756), Honda Civic Hybrid ($40,785), Toyota Prius Plug-in ($43,251)
FUSION HYBRID	Ford Fusion Hybrid ($47,704)	
SUV HYBRID	Ford Escape Hybrid*	Toyota Prius v ($43,903), Subaru XV Crosstrek Hybrid AWD ($48,260)
PICKUP- 1/2 TON	Ford F-150 ($59,063), Chevy 2500 ($68,665)	Ford F-150 CNG Bi-Fuel ($56,209), Chevy Silverado 2500HD 2WD CNG Bi-Fuel ($64,158)
PICKUP- COMPACT	Ford Ranger*, Chevy Colorado ($61,375), GMC Sonoma*	
PICKUP- 3/4 TON	Ford F-250 ($76,821), Ford F-250 SD**, Chevy 2500 ($68,665), Chevy 2500 HD**	Ford F-350 CNG Bi-Fuel ($67,037), Chevy Silverado 2500HD 2WD CNG Bi-Fuel ($64,158)
TRUCK-STAKE	Ford F-450 ($79,901)	Ford F-450 Chassis Cab XL CNG Bi-Fuel ($73,037), Ford F-550 Chassis Cab XL CNG Bi-Fuel ($74,137)
TRUCK- ARIEL LIGHT	Ford F-450 ($79,901)	
TRUCK- DUMP	Ford F-700*, Chevy Kodiak*, Chevy 60 Series*	Ford F-750 Chassis Cab CNG Bi-Fuel ($107,802)
TRUCK- FLAT BED	Chevy Kodiak*	

Vehicles not considered: CNG Sweeper, Sewer Cleaner, Chipper, Loader, and Vacuum Truck
*Price not available because vehicle is out of production
**Only base MSRP available

Table 6 and our LCA model use 2014 MSRPs to calculate the life-cycle costs for existing vehicles. These are the prices the City would pay to replace its vehicles today. Vehicles that are out of production do not include a life-cycle cost in Table 6.

Recommendations

The results in Table 6 mainly used cost as the evaluative criterion. Table 7 takes the analysis a step further and lists the final recommendations after an inclusive review of all four evaluative criteria: cost, City's vehicle performance requirements, reliability, and emissions.

Table 7. Final Vehicle Recommendations

Existing Vehicles: Descriptions	Existing Vehicles: Make and Model	Recommended Alternative Fuel Vehicles: Make and Model
SEDANS	Chevy Malibu ($50,175) Ford Fusion Hybrid ($47,704)	Nissan Leaf ($38,379)
SUVs	Ford Escape Hybrid*	Toyota Prius v ($43,903)
LIGHT-DUTY PICKUP TRUCKS	Ford F-150 ($59,063), Chevy 2500 ($68,665), Ford Ranger*, Chevy Colorado ($61,375), GMC Sonoma*	None
	Ford F-250 ($76,821), Ford F-250 SD**, Chevy 2500 ($68,665), Chevy 2500 HD**	None
MEDIUM-DUTY PICKUP TRUCKS	Ford F-450 ($79,901)	Ford F-450 Chassis Cab XL CNG Bi-Fuel ($73,037)
	Ford F-700*, Chevy Kodiak*, Chevy 60 Series*	Ford F-750 Chassis Cab CNG Bi-Fuel ($107,802)

Vehicles not considered: CNG Sweeper, Sewer Cleaner, Chipper, Loader, and Vacuum Truck
*Price not available because vehicle is out of production
**Only base MSRP available

A thorough analysis for each vehicle category is provided below.

Sedans

The AFV results from Table 6 for sedans have lower life-cycle costs than those of the City's existing vehicles. Currently, the City owns a Ford Fusion Hybrid and a Chevrolet Malibu that fit into the sedan category. The Ford Fusion Hybrid has a life-cycle cost of $47,704; the Chevy Malibu has a life-cycle cost of $50,175. From our analysis, the alternative fuel recommendations we provided are at least $4,500 cheaper than the Ford Fusion Hybrid and $7,000 cheaper than the Chevrolet Malibu. Furthermore, all of our AFV results meet the needs of the City, which include having four doors and the capacity to comfortably seat multiple passengers. As such, we recommend that the City does not repurchase the Ford Fusion Hybrid or Chevrolet Malibu. Instead, the City should consider sedans from the following AFV types: BEVs, PHEVs, and HEVs.

Our top BEV result is the Nissan Leaf with a life-cycle cost of $38,379. Aside from being the cheapest BEV vehicle, the Nissan Leaf is also our final sedan recommendation. Compared to the City's Ford Fusion Hybrid and Chevrolet Malibu, the Nissan Leaf is cheaper by $9,000 and $11,800, respectively. Since BEVs are fully powered through electricity, they require long charging periods. Since the City charges at Level 1, BEVs will need to be charged overnight. Although this vehicle is limited to a driving range of 84 miles per single charge, this does not pose a problem since the City mainly uses these vehicles for carpooling within City limits.[112] According to 2014 *Consumer Reports*, the Nissan Leaf has a reliability score of 5 (out of 5), which indicates a much better than average rating. As a BEV, the Nissan Leaf has the highest possible (10 out of 10) GHG and smog ratings compared to our other recommended AFVs.

The Toyota Prius Plug-in is the top PHEV result for the sedan category with a life-cycle of $43,251. When comparing to the life-cycle costs of the Ford Fusion Hybrid and the Chevrolet Malibu, the savings are $4,500 to $7,000, respectively. While the PHEV is more expensive than the recommended BEV, this PHEV offers benefits like a higher driving range and greater horsepower. It also has a higher overall score than the Nissan Leaf on the 2014 *Consumer Reports*.

The top HEV result for the sedan category is the Toyota Prius, which has a life-cycle cost of $39,756. This is lower than the Ford Fusion life-cycle cost by $8,000 and the Chevy Malibu by $10,400. Out of the three top sedan results, the Toyota Prius has the highest reliability and overall score. Furthermore, it has worse GHG and smog ratings than both the BEVs and PHEVs. The Prius is also more expensive than the Nissan Leaf. Due to the extensive HEV market, the Honda Civic Hybrid was considered as another top AFV result. The Civic Hybrid has a life-cycle cost of $40,785 and savings of approximately $7,000 compared to the Ford Fusion Hybrid and $9,400 compared to the Chevrolet Malibu.

Our final recommendation for the sedan vehicle category is the Nissan Leaf.

SUVs

For SUVs, the City owns one Ford Escape Hybrid, which is due for replacement in ten years. Because this vehicle is out of production, we analyzed other equivalent vehicles. Our two recommended alternative fuel SUVs are the Toyota Prius v and the Subaru XV Crosstrek AWD, both of which are hybrids. These were selected based on low life-cycle costs and high overall *Consumer Reports* scores. Of our two SUV recommendations, the Toyota Prius v has the lower life-cycle cost of $43,903 and the higher *Consumer Reports'* overall score.

Our top recommendation for the SUV vehicle category is the Toyota Prius v.

Light-Duty and Medium-Duty Pickup Trucks

Because all pickup truck recommendations are of similar, if not the same, Ford and Chevrolet make and model, the primary differentiating factor is life-cycle cost. The market for

[112] "Nissan LEAF® Electric Car Range."

alternative fuel pickup trucks includes predominantly CNG bi-fuel options. CNG bi-fuel light-duty and medium-duty pickup trucks are approximately $10,000 to $11,000 more than conventional pickup trucks. For the medium-duty pickup trucks, there is a PHEV, but this vehicle was eliminated based on its high conversion cost. Therefore, our recommendations only include CNG bi-fuel options for the pickup trucks.

For light-duty pickup trucks, we considered the CNG bi-fuel options for the Ford-150, Ford F-350 and Chevrolet Silverado 2500HD. These vehicles are the same types of trucks that the City already owns, but with the added CNG bi-fuel option. The LCA reveals that these AFVs are cheaper than the City's conventional counterparts. However, through the sensitivity analysis, we computed that the City's conventional light-duty pickup trucks were in fact cheaper than the CNG bi-fuel options, given the current gas price of $4.47/gal and CNG price of $2.74/gge. To reconcile this discrepancy, we presume that the KBB annual fuel cost used in the LCA most likely utilized a higher gas price than the sensitivity analysis' highest preset gas price of $4.75/gal. Because Arcadia's actual gas and CNG prices are closer to the preset prices in the sensitivity analysis, the sensitivity analysis results are favored over the LCA results.

Our top recommendation for the light-duty pickup truck category is for the City to repurchase the conventional vehicles.

For medium-duty pickup trucks, our preferred AFVs are the CNG bi-fuel options for the Ford F-450, F-550 and F-750. The Ford F-450 CNG bi-fuel option is approximately $6,900 cheaper than the regular gasoline version. The Ford F-550 CNG bi-fuel option is around $5,800 cheaper than the regular gasoline version.

Our top recommendation for the medium-duty pickup truck category is the Ford F-450 CNG bi-fuel option to replace the Ford F-450, as long as the City does not need the extra payload capacity of the Ford F-550. *To replace the City's Ford F-700, which is out of production, the Ford F-750 CNG bi-fuel option is our top recommendation*.

Diagnostic Software Recommendation

Given the variety of car make and model recommendations, it would be to the City's benefit to update the vehicle diagnostic software. As previously mentioned, the City currently owns an older version of Mitchell software that is limited to diagnosing American vehicles. Considering the City's familiarity with the software, we recommend the City upgrade to a newer version of Mitchell to diagnose a greater variety of makes and models, including non-American brands. Mitchell no longer offers software that can be purchased; instead, it leases its software on a yearly basis. The price for subscription of the modern software version that meets the needs of the City's vehicles is $2,100 per year.[113] This price is a reduced amount that is only available to government-affiliated clients.

[113] Kevin Fishbeck, Mitchell Software Interview with a Mitchell Representative, Phone, February 20, 2014.

Sensitivity Analysis

Fuel Prices

Given the uncertainty and assumptions of many of the costs in the life-cycle cost calculations, we performed a sensitivity analysis to show flexibility in our fuel calculations. The sensitivity analysis held constant the regular gasoline price and noted the break-even point for the other alternative fuel (CNG or electricity) price at which point it would be worth switching to the AFV. The sensitivity analysis was completed using the existing and recommended vehicle match ups determined in the Results section. Hybrids were not included in the sensitivity analysis because their only fuel intake is regular gasoline.

This calculation was performed using the Excel Add-in tool, Solver, which sets an objective function subject to changing one value in the calculation. In general, an objective function is an equation that optimizes a solution given certain constraints in the variables. In this case, the objective function set the recommended vehicle's life-cycle cost equal to the existing vehicle's life-cycle cost by varying the alternative fuel price and holding constant the regular gasoline price. The result was the break-even alternative fuel price given a set gasoline price. This calculation was completed for every vehicle match-up in our top recommendations in terms of three pre-chosen regular gasoline prices: \$3.75, \$4.25, and \$4.75. These gasoline prices were chosen based on current average prices around Southern California. While these prices are representative in the short-term, fuel prices are likely to experience greater fluctuations over the next ten years. This report omits an analysis of a wider range in fuel prices, but the excel tool provided can be used to conduct such an analysis.

All the vehicle match-up scenarios analyzed and the resulting break-even CNG and electric prices are presented below (Table 8).

Table 8. Fuel Price Sensitivity Analysis

Sedans

Existing Vehicle		*vs.*	*Recommended Vehicle*	
Chevrolet Malibu		**vs.**	**Toyota Prius Plug-in (PHEV)**	
Gas Prices			*Electric Prices*	
$3.75	$/gal		$5.70	$/kWh
$4.25	$/gal		$6.78	$/kWh
$4.75	$/gal		$7.86	$/kWh
Chevrolet Malibu		**vs.**	**Nissan Leaf (BEV)**	
Gas Prices			*Electric Prices*	
$3.75	$/gal		$0.50	$/kWh
$4.25	$/gal		$0.58	$/kWh
$4.75	$/gal		$0.66	$/kWh

Light-Duty Pickup Trucks

Existing Vehicle		*vs.*	*Recommended Vehicle*	
Ford F-150		**vs.**	**Ford F-350 Super Duty XL (CNG bi-fuel)**	
Gas Prices			*CNG Prices*	
$3.75	$/gal		$1.52	$/gal
$4.25	$/gal		$1.95	$/gal
$4.75	$/gal		$2.37	$/gal
Ford F-250		**vs.**	**Ford F-350 Super Duty XL (CNG bi-fuel)**	
Gas Prices			*CNG Prices*	
$3.75	$/gal		$1.73	$/gal
$4.25	$/gal		$2.15	$/gal
$4.75	$/gal		$2.58	$/gal
Chevrolet 2500		**vs.**	**Chevrolet Silverado 2500HD 2WD (CNG bi-fuel)**	
Gas Prices			*CNG Prices*	
$3.75	$/gal		$1.13	$/gal
$4.25	$/gal		$1.56	$/gal
$4.75	$/gal		$1.98	$/gal

Medium-Duty Pickup Trucks

Existing Vehicle		*vs.*	*Recommended Vehicle*	
Ford F-450 Chassis Cab XL		**vs.**	**Ford F-450 Chassis Cab XL (CNG bi-fuel)**	
Diesel Prices			*CNG Prices*	
$3.75	$/gal		$2.52	$/gal
$4.25	$/gal		$2.95	$/gal
$4.75	$/gal		$3.37	$/gal
Ford F-450 Chassis Cab XL		**vs.**	**Ford F-550 Chassis Cab XL (CNG bi-fuel)**	
Diesel Prices			*CNG Prices*	
$3.75	$/gal		$2.36	$/gal
$4.25	$/gal		$2.79	$/gal
$4.75	$/gal		$3.21	$/gal
Ford F-750 Chassis Cab (Diesel)		**vs.**	**Ford F-750 Chassis Cab (CNG bi-fuel)**	
Diesel Prices			*CNG Prices*	
$3.75	$/gal		$2.52	$/gal
$4.25	$/gal		$2.95	$/gal
$4.75	$/gal		$3.37	$/gal

In the first row of Table 8, given a set gasoline price of $3.75/gal, electricity prices would need to be below $5.70/kWh for it to be cheaper to purchase a Toyota Prius Plug-in instead of a Chevrolet Malibu in lieu of our LCA. As the current price of electricity is only $0.12/kWh, the Toyota Prius Plug-in, a PHEV, is likely to be a good choice since the Prius Plug-in is relatively insensitive to upcoming fuel price changes.[114]

The subsequent comparison demonstrates how a BEV could also replace the Chevrolet Malibu. As expected, the BEV is more sensitive to fuel price than the Toyota Prius Plug-in. This outcome was anticipated because BEVs rely entirely upon electricity whereas PHEVs can use both gas and electricity. As evidenced, it is worth switching from the Chevrolet Malibu to the Nissan Leaf only when electricity prices are below $0.50/kWh given a set gasoline price of $3.75/gal. As such, the BEVs are considered good choices for replacement as well since the expected electricity price is still well below $0.50/kWh.

The sensitivity analysis also shows that light-duty and medium-duty pickup trucks are sensitive to fuel price fluctuations for CNG and regular gasoline. The price of CNG in Arcadia (i.e. 5640 Peck Road) is currently $2.74/gge.[115] Given this CNG fuel price, the conventional light-duty pickup trucks are cheaper than the CNG bi-fuel options at $3.75/gal, $4.25/gal, and $4.75/gal gas prices. However, based on our LCA spreadsheet tool, we arrived at the reverse conclusion from using KBB's annual fuel cost. Because the CNG fuel price of $2.74/gge is higher than our calculated break-even CNG values, we deduce that KBB most likely used a fuel price higher than $4.75/gal. (In an interview with a KBB representative, the representative was unable to provide the fuel price used in their 5-year cost to own calculation.) Since Arcadia's current gas price is $4.47/gal (provided by the City), we recommend that the City continue purchasing conventional light-duty pickup trucks (i.e. Ford F-150, Ford F-250 and Chevy 2500).

For medium-duty pickup trucks, the CNG bi-fuel option is cheaper than the conventional vehicle for the $4.25/gal and $4.75/gal diesel prices, but not the $3.75/gal diesel price. Because the CNG fuel price of $2.74/gge lies in between our preset gasoline prices, the medium-duty pickup trucks are more sensitive to CNG price fluctuations. By comparison, the medium-duty pickup trucks are more sensitive to their alternative fuel price than the BEV and PHEV matchups. At the current Arcadia diesel price of $3.79/gal, the City should continue purchasing conventional medium-duty pickup trucks. However, at $4.25/gal and $4.75/gal diesel prices, the City should switch to the CNG bi-fuel options. We recommend the City use the provided life-cycle cost spreadsheet tool to help decide whether or not to purchase a CNG bi-fuel pickup truck as future fuel prices become known.

This sensitivity analysis strengthens our recommendations for the sedan category, but demonstrates the risk in transitioning to CNG for the City's light-duty and medium-duty pickup trucks.

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[114] "All-Electric Vehicles: Compare Side-by-Side," accessed January 21, 2014, http://www.fueleconomy.gov/feg/evsbs.shtml.
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Conclusion

Based on the findings of this report, it would be cost-effective for the City of Arcadia to switch the existing sedan and SUV vehicle types non-safety vehicles to AFVs. Benefits include improved air quality, less dependence on foreign oil, and better environmental consciousness. For light-duty pickup trucks, we **do not** recommend the City transition to CNG bi-fuel options given the current gas price of $4.47/gal. For medium-duty pickup trucks, we **do** recommend the City transition to CNG bi-fuel options.

As this report has also shown, AFVs can present some challenges. The market for AFVs is constantly growing, allowing for new and improved models to be added every year. Prices will likely decrease as alternative fuel technology improves. By following our recommendations, the City of Arcadia can reach its sustainability goals: improving local and regional air quality, reducing its carbon footprint, and promoting clean transportation.

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Appendix A: Vehicle Equipment List

Vehicle Label	License Plate	Year/Make/Model	Gas or Diesel	Department
60188	E1003891	1995/Chevrolet/Compact Pickup	unleaded	PWSD
80106	1041951	2001/Ford/Compact Pickup	unleaded	PWSD
80108	1041953	2001/Ford/1/2 Ton Pickup	unleaded	PWSD
80173	1175414	2004/Ford/1/2 Ton Pickup	unleaded	PWSD
80214	1180240	2006/Ford/3/4 Ton Pickup	unleaded	PWSD
80225	1180321	2008/Ford/3/4Ton Pickup	unleaded	PWSD
80278	1342951	2011/Ford/3/4 Ton Pickup	unleaded	PWSD
80290	1368601	2012/Chevrolet/3/4 Ton Pickup	unleaded	PWSD
80307	141304	2013/Chevrolet/3/4 Ton Pickup	unleaded	PWSD
80291	1369240	2012/Ford/F-550	CNG	PWSD
60066	E278397	1990/Chevrolet/Flat Bed Stake Truck	unleaded	PWSD
80111	1129267	2001/Ford/Flat Bed Stake Truck	diesel	PWSD
70101	E471154	1985/Chevrolet/Dump Truck	unleaded	PWSD
60087	E337739	1991/Chevrolet/Dump Truck	unleaded	PWSD
60134	E337810	1992/Ford/Dump Truck	unleaded	PWSD
60135	E337822	1992/Ford/Dump Truck	unleaded	PWSD
80146	1126172	2002/International/Dump Truck	diesel	PWSD
60021	E370077	1994/Atheyl/Sweeper	diesel	PWSD
80129	1105027	2001/Elgin/Sweeper	diesel	PWSD
80271	1265466	2010/Elgin/Sweeper	CNG	PWSD
80272	1265467	2010/Elgin/Sweeper	CNG	PWSD
80105	1108654	2001/Sterling/Sewer Cleaner	diesel	PWSD
80229	1180332	2007/Sterling/Sewer Cleaner	diesel	PWSD
80191	1181617	2005/Sterling/Vacuum Truck	diesel	PWSD
80001	E050461	1997/Ford/Water Tanker	diesel	PWSD
80096	E1072772	2000/Freightliner/Aerial Truck	diesel	PWSD
80103	1094437	2001/Chevrolet/Malibu	unleaded	PWSD
80119	1108659	2002/Chevrolet/Malibu	unleaded	PWSD
80127	1094597	2002/Chevrolet/Malibu	unleaded	PWSD
80269	1255032	2010/Ford/Compact Pickup	unleaded	PWSD
80289	136860	2012/Chevrolet/Compact Pickup	unleaded	PWSD
80300	1413308	2012/Chevrolet/Compact Pickup	unleaded	PWSD
80279	1342951	2011/Ford/1/2 Ton Pickup	unleaded	PWSD
80280	1354509	2011/Ford/1/2 Ton Pickup	unleaded	PWSD
80104	1041952	2001/Ford/1/2 Ton Pickup	unleaded	PWSD
80109	1041954	2001/Ford/1/2 Ton Pickup	unleaded	PWSD
80022	E1003105	1998/Chevrolet/3/4 Ton Pickup	unleaded	PWSD
80089	E1077175	2000/Ford/3/4 Ton Pickup	unleaded	PWSD
80172	1175415	2004/Ford/3/4 Ton Pick Up	unleaded	PWSD

80215	1180242	2006/Ford/3/4 Ton Pickup	unleaded	PWSD
80227	1180320	2008/Ford/3/4Ton Pickup	unleaded	PWSD
80228	1180327	2008/Ford/3/4Ton Pickup	unleaded	PWSD
80235	1180348	2008/Ford/3/4Ton Pickup	unleaded	PWSD
80305	1413309	2013/Chevrolet/1/2 Ton Pickup	unleaded	PWSD
80308	1413305	2013/Chevrolet/3/4 Ton Pickup	unleaded	PWSD
60144	E337823	1992/Ford/Crane	diesel	PWSD
60154	E352192	1993/Ford/Dump Truck	unleaded	PWSD
60193	E047327	1996/GMC/Dump Truck	unleaded	PWSD
80088	E1077176	2000/Ford/3/4 Ton Pickup	unleaded	PWSD
80090	E1040646	2000/Ford/Aerial Light Truck	diesel	PWSD
80110	1108652	2001/Chevrolet/3/4 Ton Pickup	unleaded	PWSD
80143	1126172	2002/Chevrolet/1/2 Ton Pickup	unleaded	PWSD
80156	1156826	2003/Chevrolet/3/4 Ton Pickup	unleaded	PWSD
80157	1156986	2003/Chevrolet/1 Ton Pickup	unleaded	PWSD
80216	1180242	2006/Chevrolet/1/2 Ton Pickup	unleaded	PWSD
80249	1320705	2008/Chevrolet/3/4 Ton Pickup	unleaded	PWSD
80114		Mini-van	unleaded	ADMIN
80236		Hybrid Ford Escape	unleaded	BUILDING
80120		Mid-size Sedan	unleaded	CM
80052		Mid-size Sedan	unleaded	DSD
80060		Compact Pickup	unleaded	DSD
80107		Compact Pickup	unleaded	DSD
80116		Mid-size Sedan	unleaded	DSD
80122		Mid-size Sedan	unleaded	DSD
80131		Mid-size Sedan	unleaded	DSD
80138		Compact Pickup	unleaded	DSD
80177		Mid/size Hybrid	unleaded	DSD
80178		Mid/size Hybrid	unleaded	DSD
60098		Tractor 50-EX	unleaded	PWSD
70011		Chipper	unleaded	PWSD
71402		Passenger Van	unleaded	PWSD
80076		Mid-size Sedan	unleaded	Library
80067		3/4 Ton Pickup	unleaded	PWSD
80154		3/4 Ton Pickup	unleaded	PWSD
80155		Chipper	unleaded	PWSD
80162		CAT Loader	diesel	PWSD
80075		Mid-size Sedan	unleaded	RECREATION
60024		CAT Loader	diesel	WATER
60124		Backhoe	diesel	WATER
80066		3/4 Ton Pickup	unleaded	WATER
80263		Backhoe	diesel	WATER
80270		Admin Sedan	unleaded	WATER
80130		Elgin Sweeper	CNG	PWSD
60011		CAT LOADER	unleaded	PWSD

Appendix B: Vehicle Replacement Plan and Miles Per Year

Public Works Services - Water (By Mileage/Year)

Asset	Yr	Description	Criteria	Curr Reading 2012	2013	Mi/Yr	Total Mi	Years to 100,000 miles	Current Cost
60024	1988	LOADER	7,500HR/20YR	3182HRS	3300HRS	118HRS	3300HRS	36	$ 152,900
60124	1991	BACKHOE	7,500HR/20YR	3766HRS	3800HRS	34HRS	3800HRS	110	$ 81,900
60144	1992	CRANE BUCKET	7,500HR/20YR	1953HRS	1963HRS	10HRS	1963HRS	554	$ 117,600
60154	1993	TRUCK-DUMP	100,000/20YR	53,500	55,000	1,500	55,000	30	$ 175,100
60193	1996	TRUCK-DUMP	100,000/20YR	41,688	42,000	312	42,000	186	$ 175,100
80089	2000	PICKUP-3/4 TON	100,000/12YR	103,218	115,000	11,782	115,000	-1	$ 40,000
80103	2000	SEDAN-MID	100,000/10YR	41,197	45,000	3,803	45,000	14	$ 23,500
80109	2001	PICKUP-1/2 TON	100,000/12YR	54,487	60,000	5,513	60,000	7	$ 30,900
80119	2001	SEDAN-MID	100,000/10YR	40,209	42,000	1,791	42,000	32	$ 23,500
80127	2002	SEDAN-MID	100,000/10YR	73,375	76,000	2,625	76,000	9	$ 23,500
80172	2004	PICKUP-3/4 TON	100,000/12YR	95,361	105,000	9,639	105,000	-1	$ 40,000
80191	2005	VACUUM TRUCK	7,500HR/8YR.	3,000	4,000	1,000	4,000	4	$ 262,000
80215	2006	PICKUP-3/4 TON	100,000/12YR	62,819	75,000	12,181	75,000	2	$ 40,000
80227	2008	PICKUP-3/4 TON	100,000/12YR	46,413	55,000	8,587	55,000	5	$ 40,000
80228	2008	PICKUP-3/4 TON	100,000/12YR	34,899	45,000	10,101	45,000	5	$ 40,000
80235	2008	PICKUP-3/4 TON	100,000/12YR	28,823	40,000	5,101	40,000	12	$ 40,000
80263	2009	BACKHOE	7,500 HRS/25YR	586HRS	600HRS	14HRS	600HRS	493	$ 89,500
80269	2009	PICKUP-COMPACT	100,000/12YR	19,450	30,000	10,550	30,000	7	$ 19,600
80270	2010	FUSION HYBRID	100,000/10YR	50,040	72,000	21,960	72,000	1	$ 30,900
80279	2011	PICKUP-3/4 TON	100,000/12YR	8,214	18,000	9,786	18,000	8	$ 21,000
80280	2011	PICKUP-3/4 TON	100,000/12YR	4,374	17,000	12,626	17,000	7	$ 20,000
80289	2009	PICKUP-COMPACT	100,000/12YR	50,000	58,000	8,000	58,000	5	$ 18,000
80300	2012	PICKUP-COMPACT	100,000/12YR	0	10	10	10	9,999	$ 23,000
80305	2013	PICKUP-1/2 TON	100,000/12YR	0	10	10	10	9,999	$ 30,800

Public Works Services - Streets (By Mileage/Year)

Asset	Yr	Description	Criteria	Curr Reading 2012	2013	Mi/Yr	Years to 100,000 miles	Total Mi	Current Cost
60011	1986	LOADER	10,000HR/25YR	7,444	8,000	556	4	8,000	$ 152,900
60066	1990	TRUCK-FLAT BED	100,000/15YR	71,210	75,000	3,790	7	75,000	$ 65,500
60087	1991	TRUCK-DUMP (Refurbished)	100,000/20YR	109,361	115,000	5,639	-3	115,000	$ 275,600
60134	1992	TRUCK-DUMP	100,000/20YR	61,561	62,000	439	87	62,000	$ 175,100
60135	1992	TRUCK-DUMP	100,000/20YR	81,105	85,000	3,895	4	85,000	$ 275,600
60188	1995	PICKUP-COMPACT	100,000/12YR	95,744	112,000	16,256	-1	112,000	$ 38,000
70101	1985	TRUCK-DUMP	100,000/20YR	62,562	66,000	3,438	10	66,000	$ 175,100
80001	1997	WATER TANKER	10,000HR/25YR	6,252	6,500	248	14	6,500	$ 103,700
80088	2000	PICKUP-3/4 TON	100,000/12YR	70,087	89,000	18,913	1	89,000	$ 40,000
80090	2000	TRUCK-ARIEL LIGHT	100,000/15YR	73,209	80,000	6,791	3	80,000	$ 350,000
80106	2001	PICKUP-COMPACT	100,000/12YR	71,080	80,000	8,920	2	80,000	$ 34,000
80108	2001	PICKUP-1/2 TON (SOLID WASTE)	100,000/12YR	59,957	63,000	3,043	12	63,000	$ 30,900
80110	2001	PICKUP-3/4 TON	100,000/12YR	55,871	63,000	7,129	5	63,000	$ 40,000
80111	2001	TRUCK-STAKE	100,000/15YR	75,579	81,000	5,421	4	81,000	$ 54,600
80143	2002	PICKUP-1/2 TON	100,000/12YR	70,355	75,000	4,645	5	75,000	$ 31,000
80146	2002	TRUCK-DUMP	100,000/20YR	15,401	16,000	599	140	16,000	$ 175,100
80155	2003	CHIPPER	7,000HR/15YR	4,000	7,000	3,000	0	7,000	$ 29,600
80156	2003	PICKUP-3/4 TON	100,000/12YR	55,000	71,000	16,000	2	71,000	$ 40,000
80157	2003	PICKUP-1 TON	100,000/12YR	15,963	18,000	2,037	40	18,000	$ 41,200
80162	2003	LOADER	10,000HR/25YR	2,304	2,500	196	38	2,500	$ 152,900
80173	2004	PICKUP-1/2 TON	100,000/12YR	85,301	97,000	11,699	0	97,000	$ 40,000
80214	2006	PICKUP-3/4 TON	100,000/12YR	36,955	43,000	6,045	9	43,000	$ 40,000
80216	2006	PICKUP-1/2 TON HYBRID	100,000/12YR	35,696	42,000	6,304	9	42,000	$ 30,900
80225	2008	PICKUP-3/4 TON	100,000/12YR	20,000	23,000	3,000	26	23,000	$ 40,000
80249	2008	PICKUP-3/4 TON	100,000/12YR	19,592	25,000	5,408	14	25,000	$ 40,000
80271	2010	CNG SWEEPER	100,000/8YR	24,689	38,000	13,311	5	38,000	$ 250,000
80272	2010	CNG SWEEPER	100,000/8YR	24,406	39,000	14,594	4	39,000	$ 250,000
80278	2011	PICKUP-3/4 TON (PROP A)	100,000/12YR	15,347	33,000	17,653	4	33,000	$ 40,000
80291	2012	ASPHALT PATCH TRUCK	100,000/12YR	0	100	100	999	100	$ 120,000

Public Works Services - Sewer Mileage									
Asset	Yr	Description	Criteria	Curr Reading 2012	2013	Mi/Yr	Total Mi	Years to 100,000 miles	Current Cost
80105	2001	SEWER CLEANER (REBUILT)	7,500HR/8YR.	9,000	10,000	1,000	10,000	-3	$ 247,200
80229	2007	SEWER CLEANER	7,500HR/8YR.	3,346	4,346	1,000	4,346	3	$ 247,200
80022	1998	PICKUP-3/4 TON	100,000/12YR	89,000	100,000	11,000	100,000	0	$ 40,000
80290	2012	PICKUP-3/4 TON	100,000/12YR	158	15,000	14,842	15,000	6	$ 30,000

All Other City Hall Departments (By Mileage/Year)										
Asset	Yr	Description	Dept	Criteria	Curr Reading 2012	2013	Mi/Yr	Years to 100,000 miles	Total Mi	10-11 Current Cost
80060	1999	PICKUP-COMPACT	DEVELOPMENT	100,000/12YR	86,190	95,000	8,810	1	95,000	$ 34,000
80107	2001	PICKUP-COMPACT	DEVELOPMENT	100,000/12YR	65,592	71,000	5,408	5	71,000	$ 34,000
80122	2001	SEDAN-MID	DEVELOPMENT	100,000/10YR	65,282	67,000	1,718	19	67,000	$ 23,500
80138	2002	PICKUP-COMPACT	DEVELOPMENT	100,000/12YR	48,647	53,000	4,353	11	53,000	$ 34,000
80177	2004	HYBRID-MID	DEVELOPMENT	100,000/10YR	21,000	24,000	3,000	25	24,000	$ 32,800
80178	2004	HYBRID-MID	DEVELOPMENT	100,000/10YR	13,525	16,000	2,475	34	16,000	$ 32,800
80236	2008	SUV HYBRID	DEVELOPMENT	100,000/10YR	22,068	29,000	6,932	10	29,000	$ 24,000
80076	2000	SEDAN-MID	LIBRARY	100,000/10YR	29,446	32,000	2,554	27	32,000	$ 23,500
80120	2001	SEDAN-MID	CITY MANAGER	100,000/10YR	24,135	25,000	865	87	25,000	$ 23,500
80075	2000	SEDAN-MID	RECREATION	100,000/10YR	48,780	52,000	3,220	15	52,000	$ 23,500
80304	2013	EXPLORER	RECREATION	100,000/12YR	0	100	100	70	100	$ 30,000
80114	2001	VAN-MINI**	ADMIN SERVICES	100,000/10YR	21,000	23,334	2,334	33	23,334	$ 26,800

Appendix C: Vehicle Purchase and Outfitting Cost

Vehicle Purchase Cost Only

Department	*Total*	*13-14*	*14-15*	*15-16*	*16-17*	*17-18*
Police	$1,135,866	$65,900	$323,154	$197,557	$89,600	$459,655
PWS- Streets	$2,004,322	$172,200	$84,800	$512,300	$865,872	$369,150
PWS- Water	$566,748	$41,200	$84,800	-	$328,048	$112,700
PWS- Sewer	$310,648	$41,200	-	$269,448	-	-
City Hall	$109,100	$70,000	-	-	-	$39,100
Fire	$2,189,600	$45,000	$254,000	$820,000	$261,600	$809,000
Total	$6,316,284	$435,500	$746,754	$1,799,305	$1,545,120	$1,789,605

Vehicle Purchase & Outfitting Costs

Department	*Total*	*13-14*	*14-15*	*15-16*	*16-17*	*17-18*
Police	$1,347,866	$73,900	$391,154	$235,557	$99,600	$547,655
PWS- Streets	$2,072,322	$184,200	$92,800	$528,300	$885,872	$381,150
PWS- Water	$598,748	$45,200	$92,800	-	$336,048	$124,700
PWS- Sewer	$318,648	$45,200	-	$273,448	-	-
City Hall	$117,100	$74,000	-	-	-	$43,100
Fire	$2,189,600	$45,000	$254,000	$820,000	$261,600	$809,000
Total CIP Expense	$6,644,284	$467,500	$830,754	$1,857,305	$1,583,120	$1,905,605

Appendix D: Vehicle Maintenance Budget

DEPARTMENT	BUDGET	VEHICLES	BUDGET PER VEHICLE
Admin. Svcs.	$ 1,500.00	1	$ 1,500.00
City Manager	$ 2,500.00	1	$ 2,500.00
Development Svcs.	$ 20,400.00	8	$ 2,550.00
Library	$ 1,700.00	1	$ 1,700.00
Recreation	$ 9,000.00	4	$ 2,250.00
Public Works Street	$251,200.00	41	$ 6,126.83
Public Works Water	$264,400.00	22	$ 12,018.18

Appendix E: Auction Prices

Description	Sale Price after transaction fee (~$65)	Car age
BMW R1150 RT-P	$ 1,335.00	9
Honda ST1300 PA7	$ 2,935.00	6
BMW R1200 RT-P	$ 3,435.00	6
Honda ST1300 PA7	$ 3,035.00	5
Chevrolet Lumina	$ 1,435.00	16
Chevrolet Malibu LS	$ 2,635.00	11
Chevrolet Sportvan	$ 1,735.00	20
Kenworth W900	$ 6,375.00	27
Ford F-250 Super Duty	$ 1,035.00	11
Chevrolet 2500	$ 735.00	14
Chevrolet 2500	$ 235.00	17
Chevrolet Malibu LS	$ 2,635.00	11
Ford Crown Victoria	$ 2,535.00	10
Ford Crown Victoria	$ 2,335.00	8
Ford Crown Victoria	$ 1,835.00	8
Chevrolet C2500	$ 1,935.00	14
Ford E-450 SD	$ 5,335.00	8
Ford E-450 SD	$ 5,235.00	8
Ford E-450 SD	$ 5,035.00	8
Ford E-450 SD	$ 4,735.00	8
Ford E-450 SD	$ 4,735.00	8
Ford E-450 SD	$ 4,035.00	8
Ford E-450 SD	$ 4,835.00	8
Ford E-450 SD	$ 3,935.00	8
Ford E-450 SD	$ 4,735.00	8
Ford E-350	$ 935.00	18
Dodge Charger SXT	$ 3,935.00	7
Dodge Charger SXT	$ 3,035.00	7
Dodge Charger SXT	$ 2,635.00	7
Dodge Charger SE	$ 2,735.00	5
Dodge Charger SE	$ 1,735.00	5
Dodge Charger SE	$ 1,535.00	5
Ford Crown Victoria PI	$ 935.00	7
Ford Ranger	$ 1,835.00	13
Ford Ranger	$ 1,635.00	11
GMC Sierra 2500	$ 1,535.00	22
Chevrolet 2500	$ 1,435.00	15
Ford F-250 Super Duty	$ 2,935.00	12
GMC Top Kick	$ 1,135.00	22

Appendix F: Fuel Cost

Summary October 2012 - August 2013							
August Expenses should average at 92%							
PO#80223							
iiFuels							
Account	***Description***	***Total Gallons***	***Average per/gal***	***Budget***	***Cost to Date***	***Balance***	***YTD Used***
001-1637	Police-Unleaded	53,177	$3.68	$196,270.00	$195,643.33	$626.67	99.68%
001-1638	Fire-Diesel	16,457	$3.79	$67,440.00	$62,340.38	$5,099.62	92.44%
001-1639	Fire-Unleaded	2,195	$3.72	$11,080.00	$8,160.25	$2,919.75	73.65%
001-1640	PWS-Diesel	11,766	$3.79	$47,940.00	$44,547.01	$3,392.99	92.92%
001-1642	PWS-Unleaded	25,352	$4.47	$115,940.00	$113,221.77	$2,718.23	97.66%
Subtotal (Fuel)		**108,947**		**$438,670.00**	**$423,912.74**	**$14,757.26**	**96.64%**
001-2102-6760	Police-Extra Ordinary Repair	N/A	N/A	$1,000.00	-	$1,000.00	0.00%
001-2202-6760	Fire-Extra Ordinary Repair	N/A	N/A	$9,750.00	$7,371.45	$2,378.55	75.60%
001-2202-6160	Fire- AST Testing	N/A	N/A	$960.00	$700.00	$260.00	72.92%
001-3309-6760	PWS-Extra Ordinary Repair	N/A	N/A	$1,850.00	$1,136.78	$713.22	61.45%
520-7206-6760	Extra Ordinary Repair Fire 60%	N/A	N/A	$2,000.00	$985.43	$1,014.57	49.27%
001-3309-96160	AST Testing	N/A	N/A	$750.00	$340.00	$410.00	45.33%
Subtotal (ExtraOrd+Testing)				**$16,310.00**	**$10,533.66**	**$5,776.34**	**64.58%**
	TOTAL	**108,947**		**$454,980.00**	**$434,446.40**	**$20,533.60**	**95.49%**

Annual Summary							
October 2011 - September 2012							
Account	**Description**	**Total Gallons**	**Average per/gal**	**Total Cost**	**Budget**	**Difference**	**Change(%)**
001-1637	Police-Unleaded	56,165	$3.79	$213,076.54			
001-1638	Fire-Diesel	8,072	$3.76	$30,323.80			
001-1639	Fire-Unleaded	17,902	$3.83	$68,605.44			
001-1640	PWS-Diesel	10,391	$3.75	$38,974.05			
001-1642	PWS-Unleaded	33,938	$3.66	$124,283.17			
Subtotal (Fuel)		**126,468**		**$475,263.00**			
001-2102-6760	Police-Extra Ordinary Repair	N/A	N/A	$443.71			
001-2202-6760	Fire-Extra Ordinary Repair	N/A	N/A	$5,140.73			
001-2202-6160	Fire- AST Testing	N/A	N/A	$187.50			
001-3309-6760	PWS-Extra Ordinary Repair	N/A	N/A	$851.22			
001-3309-96160	AST Testing	N/A	N/A	$1,440.00			
Subtotal (ExtraOrd+Testing)				**$8,063.16**			
	TOTAL	**126,468**	**N/A**	**$483,326.16**	**$425,000.00**	**($58,326.16)**	**-14%**

Appendix G: AFV Databases

AFV BEVs
Source: https://energycenter.org/clean-vehicle-rebate-project, http://www.fueleconomy.gov/feg/taxphevb.shtml
http://www.fueleconomy.gov/feg/PowerSearch.do?action=alts&path=3&year1=2013&year2=2015&vtype=Hybrid&srchtyp=newAfv
http://corporate.ford.com/news-center/press-releases-detail/ford-f-150-to-offer-ability-to-run-on-compressed-natural-gas
http://www.ford.com/resources/ford/general/promotions/Alt_Fuel_Guide_Final_km.pdf
driveclean.ca.gov
* Values rounded to the nearest $50. Based on 15,000 miles annual driving and an electricity cost of $0.12/kWh.
http://www.afdc.energy.gov/vehicles/electric_maintenance.html
http://www.fueleconomy.gov/feg/label/learn-more-gasoline-label.shtml

Category	Year	Make	Model	Fuel Type	Motor (kW)	MPGe City	MPGe Hwy	MPGe Combined	kWh/100mi	EV Range
Light-Duty ZEV	2013	Mitsubishi	i-MiEV	Electric	49	126	99	112	30	62
Light-Duty ZEV	2014	Chevrolet	Spark	Electric	104	128	109	119	28	82
Light-Duty ZEV	2011-2014	Nissan	Leaf	Electric	80	126	101	114	30	84
Light-Duty ZEV	2012-2014	Ford	Focus Electric	Electric	107	110	99	105	32	76
Light-Duty ZEV	2013, 2014	Honda	Fit EV	Electric	92	132	105	118	29	82
Light-Duty ZEV	2012-2014	Toyota	RAV4 EV	Electric	115	78	74	76	44	103

Annual Fuel Cost*	American	MSRP	CVRP Rebate	Federal Tax Credit	Horsepower	Time to Charge Battery @240 volts in hours	GHG Score	Smog Score	Maintenance Cost	Repairs	Life Cycle Cost
$ 550.00	No	$ 22,995.00	$ 2,500	$ -	66	7	10	10	$ 293.00	$ 415.00	$ 31,268.00
$ 500.00	Yes	$ 26,685.00	$ 2,500	$ -	140	7	10	10	$ 384.00	$ 409.20	$ 35,254.00
$ 550.00	No	$ 28,800.00	$ 2,500	$ -	107	8	10	10	$ 375.20	$ 486.00	$ 38,379.00
$ 600.00	Yes	$ 35,170.00	$ 2,500	$ -	143	3.6	10	10	$ 213.00	$ 329.00	$ 42,457.00
$ 500.00	No	$ 37,415.00	$ 2,500	$ -	123	4	10	10	$ 293.00	$ 415.00	$ 45,257.00
$ 800.00	No	$ 49,800.00	$ 2,500	$ -	154	6	10	10	$ 292.00	$ 415.00	$ 60,215.00

AFV HYBRIDS
Source: https://energycenter.org/clean-vehicle-rebate-project, http://www.fueleconomy.gov/feg/taxphevb.shtml
http://www.fueleconomy.gov/feg/PowerSearch.do?action=alts&path=3&year1=2013&year2=2015&vtype=Hybrid&srchtyp=newAfv
http://corporate.ford.com/news-center/press-releases-detail/ford-f-150-to-offer-ability-to-run-on-compressed-natural-gas
http://www.ford.com/resources/ford/general/promotions/Alt_Fuel_Guide_Final_km.pdf
driveclean.ca.gov
* Values rounded to the nearest $50. Based on 15,000 miles annual driving and an electricity cost of $0.12/kWh.
http://www.afdc.energy.gov/vehicles/electric_maintenance.html
http://www.fueleconomy.gov/feg/label/learn-more-gasoline-label.shtml

Category	Year	Make	Model	Engine	City MPG	Highway MPG	Combined MPG	Horsepower	GHG Rating	Smog Rating
Hybrid	2013, 2014	Toyota	Prius c	1.5L, 4 cyl	53	46	50	99	10	8
Hybrid	2013, 2014	Honda	Insight	1.3L, 4 cyl	41	44	42	98	9	9
Hybrid	2013, 2014	Toyota	Prius	1.8L, 4 cyl	51	48	50	134	10	9
Hybrid	2014	Honda	Civic Hybrid	1.5L, 4 cyl	44	47	45	110	10	7
Hybrid	2013, 2014	Ford	C-Max Hybrid FWD	2.0L, 4 cyl	45	40	43	188	10	7
Hybrid	2013, 2014	Volkswagen	Jetta Hybrid	1.4L, 4 cyl	42	48	45	170	10	9
PHEV	2012-2014	Toyota	Prius Plug-in	1.8L, 4 cyl	51	49	50/ 95 MPGe	134	10	9
Hybrid	2013, 2014	Toyota	Camry Hybrid LE	2.5L, 4 cyl	43	39	41	200	9	9
Hybrid	2013, 2014	Ford	Fusion Hybrid FWD	2.0L, 4 cyl	47	47	47	188	10	9
Hybrid	2013, 2014	Hyundai	Sonata Hybrid	2.4L, 4 cyl	36	40	38	199	9	9
Hybrid	2013, 2014	Kia	Optima Hybrid	2.4L, 4 cyl	36	40	38	159	9	9
CNG	2013	Honda	Civic Natural Gas	1.8L, 4 cyl	27	38	31	110	10	9
Hybrid	2014	Honda	Accord Hybrid	2.0L, 4 cyl	50	45	47	195	10	8
Hybrid	2013	Toyota	Camry Hybrid XLE	2.5L, 4 cyl	40	38	40	200	10	9
Hybrid	2014	Toyota	Camry Hybrid XLE/SE	2.5L, 4 cyl	40	38	40	200	9	9
PHEV	2013, 2014	Ford	CMax Energi	2.0L, 4 cyl	44	41	43/100 MPGe	188	10	?
PHEV	2012-2014	Chevrolet	Volt	1.4L, 4 cyl	35	40	37/ 98 MPGe	149	10	9
Hybrid	2013, 2014	Chevrolet	Malibu eAssist	2.4L, 4 cyl	25	37	29	182	7	8
Existing Hybrid	2010	Ford	Fusion Hybrid FWD	2.5L, 4 cyl	41	36	39	156	10	9
Hybrid	2013, 2014	Acura	ILX Hybrid	1.5 L, 4 cyl	39	38	38	111	9	9
Hybrid	2013, 2014	Hyundai	Sonata Hybrid Limited	2.4L, 4 cyl	36	40	37	199	9	9
Existing Gas	2002	Chevrolet	Malibu	3.1L, 6 cyl	18	26	21	150	5	N/A
Hybrid	2013, 2014	Kia	Optima Hybrid EX	2.4L, 4 cyl	35	39	37	159	9	9
Hybrid	2014	Chevrolet	Impala eAssist	2.4L, 4 cyl	25	35	29	182	7	5
Hybrid	2013, 2014	Buick	Regal eAssist	2.4L, 4 cyl	25	36	29	182	7	8
PHEV	2014	Honda	Accord Plug-in	2.0L, 4 cyl	47	46	46/115 MPGe	195		
Hybrid	2013, 2014	Toyota	Avalon Hybrid	2.5L, 4 cyl	40	39	40	200	9	8
PHEV	2013, 2014	Ford	Fusion Energi	2.0L, 4 cyl	44	41	43/ 100 MPGe	188		
Hybrid	2013, 2014	Buick	LaCrosse eAssist	2.4L, 4 cyl	25	36	29	303	7	8
Hybrid	2014	Acura	RLX Sport Hybrid	3.5 L, 6 cyl	28	32	30	310		
Hybrid	2013, 2014	Volkswagen	Touareg Hybrid	3.0L, 6 cyl	20	24	21	380	5	6

Annual Fuel Cost*	MSRP	CVRP Rebate	Federal Tax Credit	Annual Maintenance Cost (KBB)	Annual Repair Cost (KBB)	Lifecycle Cost
$ 1,000.00	$ 19,080.00		$ -	$ 419.60	$ 409.20	$ 34,636
$ 1,200.00	$ 18,600.00			$ 399.80	$ 413.40	$ 35,720
$ 1,000.00	$ 24,200.00		$ -	$ 419.60	$ 409.20	$ 39,756
$ 1,150.00	$ 24,360.00			$ 363.20	$ 418.20	$ 40,785
$ 1,150.00	$ 25,170.00		$ -	$ 366.40	$ 443.40	$ 41,837
$ 1,200.00	$ 24,995.00			$ 406.80	$ 443.40	$ 42,431
$ 900.00	$ 29,990.00	$ 1,500	$ -	$ 419.60	$ 409.20	$ 43,251
$ 1,200.00	$ 26,140.00		$ -	$ 431.40	$ 409.20	$ 43,494
$ 1,050.00	$ 26,270.00		$ -	$ 606.60	$ 465.60	$ 44,327
$ 1,300.00	$ 25,650.00			$ 466.40	$ 433.40	$ 44,358
$ 1,300.00	$ 25,900.00			$ 467.60	$ 433.40	$ 44,618
$ 1,000.00	$ 27,965.00			$ 385.40	$ 414.60	$ 44,666
$ 1,050.00	$ 29,155.00			$ 389.00	$ 409.20	$ 44,874
$ 1,250.00	$ 27,670.00		$ -	$ 431.40	$ 409.20	$ 45,448
$ 1,250.00	$ 27,670.00		$ -	$ 466.80	$ 409.20	$ 45,750
$ 900.00	$ 32,950.00	$ 1,500	$ -	$ 366.40	$ 443.40	$ 46,049
$ 900.00	$ 34,185.00	$ 1,500	$ -	$ 332.60	$ 465.60	$ 47,185
$ 1,700.00	$ 24,985.00			$ 459.60	$ 465.60	$ 47,304
$ 1,250.00	$ 27,950.00	$ -	$ -	$ 606.60	$ 465.60	$ 47,704
$ 1,450.00	$ 28,900.00			$ 417.20	$ 433.60	$ 48,462
$ 1,350.00	$ 30,550.00			$ 466.40	$ 433.40	$ 49,682
$ 2,350.00	$ 22,340.00	$ -	$ -	$ 459.60	$ 465.60	$ 50,175
$ 1,350.00	$ 31,950.00			$ 467.60	$ 433.40	$ 51,092
$ 1,700.00	$ 29,135.00			$ 477.80	$ 465.60	$ 51,609
$ 1,700.00	$ 29,015.00			$ 585.00	$ 483.60	$ 52,557
$ 900.00	$ 39,780.00	$ 1,500	$ -	$ 389.00	$ 409.20	$ 52,780
$ 1,250.00	$ 35,555.00		$ -	$ 474.40	$ 433.20	$ 53,905
$ 900.00	$ 38,700.00	$ 1,500	$ -	$ 606.60	$ 465.60	$ 54,037
$ 1,700.00	$ 31,660.00			$ 528.40	$ 466.00	$ 54,569
$ 1,850.00	$ 65,000.00			$ 417.20	$ 433.60	$ 87,957
$ 2,600.00	$ 62,575.00			$ 566.40	$ 558.60	$ 94,236

Category	Year	Make	Model	Engine	City MPG	Highway MPG	Combined MPG	Horsepower	GHG Rating	Smog Rating
Existing Hybrid SUV	2008	Ford	Escape Hybrid	2.3L, 4 cyl	34	30	32	153	8	9
Hybrid SUV	2013, 2014	Toyota	Prius v	1.8L, 4 cyl	44	40	42	134	9	8
Hybrid SUV	2014	Subaru	XV Crosstrek Hybrid AWD	2.0L, 4 cyl	29	33	31	160	8	9
Hybrid SUV	2014	Nissan	Pathfinder Hybrid 2WD	2.5L, 4 cyl	25	28	26	250	7	6
Hybrid SUV	2014	Nissan	Pathfinder Hybrid 4WD	2.5L, 4 cyl	25	27	26	250	7	6
Hybrid SUV	2013	Toyota	Highlander Hybrid 4WD	3.5L, 6 cyl	28	28	28	280	7	8
Hybrid SUV	2013	Chevrolet	Tahoe Hybrid 2WD	6.0L, 8 cyl	20	23	21	332	5	6
Hybrid SUV	2013	GMC	Yukon 1500 Hybrid 2WD	6.0L, 8 cyl	20	23	21	332	5	6
Hybrid SUV	2013	Chevrolet	Tahoe Hybrid 4WD	6.0L, 8 cyl	20	23	21	332	5	6
Hybrid SUV	2013	GMC	Yukon 1500 Hybrid 4WD	6.0L, 8 cyl	20	23	21	332	5	6
Hybrid SUV	2013	GMC	Yukon Denali 1500 Hybrid 4WD	6.0L, 8 cyl	20	23	21	332		

Annual Fuel Cost*	MSRP	CVRP Rebate	Federal Tax Credit	Annual Maintenance Cost (KBB)	Annual Repair Cost (KBB)	Lifecycle Cost
$ 1,550.00	$ 21,880.00	$ -	$ -	$ 397.60	$ 458.40	$ 42,335
$ 1,200.00	$ 26,650.00		$ -	$ 419.60	$ 409.20	$ 43,903
$ 1,600.00	$ 25,995.00			$ 560.00	$ 458.40	$ 48,260.00
$ 1,900.00	$ 35,110.00			$ 486.00	$ 433.20	$ 59,075
$ 1,900.00	$ 36,710.00			$ 486.00	$ 458.40	$ 60,890
$ 1,750.00	$ 40,170.00		$ -	$ 545.20	$ 468.60	$ 63,669
$ 2,350.00	$ 53,620.00			$ 482.80	$ 519.00	$ 82,108
$ 2,350.00	$ 54,145.00			$ 518.00	$ 549.00	$ 83,189
$ 2,350.00	$ 56,425.00			$ 482.80	$ 543.60	$ 85,123
$ 2,350.00	$ 56,955.00			$ 518.00	$ 573.60	$ 86,209
$ 2,350.00	$ 61,960.00			$ 518.00	$ 573.60	$ 91,214

AFV LIGHT-DUTY TRUCKS
*The Manufacturer's Suggested Retail Price excludes destination freight charge, tax, title, license, dealer fees and optional equipment. Prices shown reflect pre-bifuel conversion.
**Cost is estimated based on the http://www.wingpowersystem.com/faq/ford
***Maintenance, Repairs, and Fuel costs are reflected upon the most recent Kelly Blue Book estimates for a 5yr cost to own (of 2013 or later).
****Maintenance Costs are reduced by as much as 40%. Estimated based on a natural gas feasibility study conducted by the Economic Research & Policy Institute of Oklahoma City University. (http://www.okcu.edu/erpi/naturalgasstudy.ppt)
*****Bi-Fuel Trucks provide up to 40% in fuel cost savings. Estimates is based on http://cngsoutheast.com/why-cng/.

Category	Year	Make	Model	Fuel Type	Motor (kW)	MPG (city)	MPG (hwy)	MPG (combined)	MSRP
Existing Pickup truck	2014	Chevrolet	Chevy 2500	Gas	4.3L, V6	18	24	-	$ 25,575.00
Existing Pickup truck	2012	Chevrolet	Chevy Colorado	Gas	2.9L, V4	18	25	-	$ 18,285.00
Existing Pickup truck	2014	Ford	F-150	Gas	3.7L, V6	17	23	19	$ 24,445.00
Existing Pickup truck	2014	Ford	F-250	Gas	6.2L, V8	17	-	-	$ 30,035.00
Existing Pickup truck	2011	Ford	Ford Ranger	Gas	2.3L, I-4	22	27	-	$ 11,900.00
Existing Pickup truck	2004	GMC	Sonoma	Gas	4.3L, V6	15	19	-	$ 24,960.00

Horsepower (hp)	Torque (lb-ft)	Payload (lb)	Annual Maintenance	Annual Repairs	Annual Fuel	LifeCycle Cost
285	305	2088	$ 484.40	$ 443.40	$ 4,145.00	$ 68,665
185	190	-	$ 484.40	$ 443.40	$ 4,145.00	$ 61,375
302	278	1670	$ 653.80	$ 443.40	$ 2,976.40	$ 59,063
385	405	3640	$ 713.80	$ 647.40	$ 4,145.00	$ 76,821
143	154	1310	-	-	-	-
190	250	1111	-	-	-	-

Category	Year	Make	Model	Fuel Type	Motor (kW)	MPG (city)	MPG (hwy)	MPG (combined)	MSRP*	Conversion Cost**	Total MSRP Cost
Pickup truck	2014	Chevrolet	Silverado 2500 HD 2WD	Bi-Fuel NG	6.0L, V8	15	21	-	$ 29,600.00	$11,000	$40,600
Pickup truck	2014	Chevrolet	Silverado 2500 HD 4WD	Bi-Fuel NG	6.0L, V8	14	20	-	$ 29,600.00	$11,000	$40,600
Pickup truck	2014	Chevrolet	Silverado 2500HD 2WD	Bi-Fuel NG	4.3L, V6	18	24	-	$ 25,575.00	$11,000	$36,575
Pickup truck	2014	Chevrolet	Silverado 2500HD 4WD	Bi-Fuel NG	4.3L, V6	17	22	-	$ 25,575.00	$11,000	$36,575
Pickup truck	2015	Chevrolet	Silverado 3500HD	Bi-Fuel NG	6.0L, V8	-	-	-	-	$11,000	-
Pickup truck	2014	Ford	F-150 Super Duty	Bi-Fuel NG	3.7L, V6	17	23	19	$ 24,445.00	$9,750	$34,195
Pickup truck	2014	Ford	F-250 Super Duty XL	Bi-Fuel NG	6.2L, V8	17	-	-	$ 30,035.00	$9,750	$39,785
Pickup truck	2014	Ford	F-350 Super Duty XL	Bi-Fuel NG	6.2L, V8	-	-	-	$ 30,930.00	$9,750	$40,680
Pickup truck	2014	GMC	Sierra 2500 HD 2WD	Bi-Fuel NG	6.0L, V8	-	-	-	$ 31,310.00	$11,000	$42,310
Pickup truck	2014	GMC	Sierra 2500 HD 4WD	Bi-Fuel NG	6.0L, V8	-	-	-	$ 31,310.00	$11,000	$42,310
Pickup truck	2015	GMC	Sierra 2500 HD 2WD	Bi-Fuel NG	6.0L, V8	-	-	-	$ 31,565.00	$11,000	$42,565
Pickup truck	2015	GMC	Sierra 2500 HD 4WD	Bi-Fuel NG	6.0L, V8	-	-	-	$ 31,565.00	$11,000	$42,565
Pickup truck	2014	Chrysler	Ram 2500	Bi-Fuel NG	5.7L, V8	-	-	-	$ 29,785.00	$11,000	$40,785
Pickup truck	2013	Chevrolet	Silverado 1500 Hybrid 2WD	Hybrid	6.0L, V8	20	23	-	$ 41,135.00	$11,000	$52,135
Pickup truck	2013	Chevrolet	Silverado 1500 Hybrid 4WD	Hybrid	6.0L, V8	20	23	-	$ 44,710.00	$11,000	$55,710
Pickup truck	2013	GMC	Sierra 1500 Hybrid 2WD	Hybrid	6.0L, V8	20	23	-	$ 41,555.00	$11,000	$52,555
Pickup truck	2013	GMC	Sierra 1500 Hybrid 4WD	Hybrid	6.0L, V8	20	23	-	$ 45,155.00	$11,000	$56,155

Horsepower (hp)	Torque (lb-ft)	Payload (lb)	5 yr Maint. ***	Annual ICE Maint.	Annual Bi-fuel Maint. ****	5 yr Repairs ***	Annual ICE Repairs	Annual Bi-fuel Repairs Cost ****	5 yr Fuel ***	Annual ICE Fuel	LifeCycle Cost
420	460	1944	$2,422	$484.40	$290.64	$2,217	$443.40	$266.04	$20,725	$4,145	$ 68,183.00
420	460	1823	$2,422	$484.40	$290.64	$2,343	$468.60	$281.16	$22,395	$4,479	$ 70,149.00
285	305	2088	$2,422	$484.40	$290.64	$2,217	$443.40	$266.04	$20,725	$4,145	$ 64,158.00
285	305	2088	$2,422	$484.40	$290.64	$2,343	$468.60	$281.16	$22,395	$4,479	$ 66,124.00
-	765	7374	$2,406	$481.20	$288.72	$2,430	$486.00	$291.60	$20,725	$4,145	-
302	278	1670	$3,269	$653.80	$392.28	$2,217	$443.40	$266.04	$14,882	$2,976	$ 56,209.00
385	405	3640	$3,569	$713.80	$428.28	$3,237	$647.40	$388.44	$20,725	$4,145	$ 69,587.00
385	405	3670	$3,577	$715.40	$429.24	$3,111	$622.20	$373.32	$17,711	$3,542	$ 67,037.00
360	380	3670	$2,577	$515.40	$309.24	$2,670	$534.00	$320.40	$20,725	$4,145	$ 70,516.00
360	380	3544	$2,577	$515.40	$309.24	$2,793	$558.60	$335.16	$22,395	$4,479	$ 72,478.00
360	380	3760	$2,577	$515.40	$309.24	$2,670	$534.00	$320.40	$20,725	$4,145	$ 70,771.00
360	380	3633	$2,577	$515.40	$309.24	$2,793	$558.60	$335.16	$22,395	$4,479	$ 72,733.00
383	400	3030	$2,745	$549.00	$329.40	$2,553	$510.60	$306.36	$18,917	$3,783	$ 67,051.00
332	367	1527	-	-	-	-	-	-	-	-	-
332	367	-	-	-	-	-	-	-	-	-	-
332	367	-	-	-	-	-	-	-	-	-	-
332	367	-	-	-	-	-	-	-	-	-	-

AFV MEDIUM-DUTY TRUCKS

*The Manufacturer's Suggested Retail Price excludes destination freight charge, tax, title, license, dealer fees and optional equipment. Prices shown reflect pre-bifuel conversion.

**Cost is estimated based on the http://www.wingpowersystem.com/faq/ford

***Maintenance, Repairs, and Fuel costs are based on www.cars.com estimates.

****Maintenance Costs are reduced by as much as 40%. Estimated based on a natural gas feasibility study conducted by the Economic Research & Policy Institute of Oklahoma City University. (http://www.okcu.edu/erpi/naturalgasstudy.ppt)

*****Bi-Fuel Trucks provide up to 40% in fuel cost savings. Estimates is based on http://cngsoutheast.com/why-cng/.

******No longer in production

Category	Year	Make	Model	Fuel Type	Motor (kW)	MPG (city)	MPG (hwy)	MPG (combined)	MSRP
Existing chassis truck (w/ outfitting)	2014	Ford	F-450 Chassis Cab XL	Gas	6.8L Gas V10	-	-	10	$34,370.00
Existing chassis truck (w/ outfitting)	2014	Ford	F-750 Chassis Cab	Diesel	6.7L Cummins ISB	-	-	10	$69,135.00
Existing chassis truck (w/ outfitting)	2009	Chevy	Kodiak******	Diesel	6.6L Duramax V8	-	-	-	$55,000.00
Existing chassis truck (w/ outfitting)	1987	Chevy	60 Series******	Diesel	5.7L V8	-	-	-	N/A

Horsepower (hp)	Torque (lb-ft)	Payload (lb)	5yr Maint.***	Annual Maint.	5 yr Repairs	Annual Repairs	5 yr Fuel	Annual Fuel	Life Cycle Cost
362	457	12,666	$5,297.00	$1,059.40	$2,333.00	$466.60	$19,157.00	$3,831.40	$82,565.00
200	520	13,485 – 28,872	$5,297.00	$1,059.40	$2,333.00	$466.60	$19,157.00	$3,831.40	$117,330.00
300	605	16000	_	_	_	_	_	_	N/A
290	250	15,000	_	_	_	_	_	_	N/A

Category	Year	Make	Model	Fuel Type	Motor (kW)	MPG (city)	MPG (hwy)	MPG (combined)	MSRP*	Conversion Cost**	Total MSRP Cost
Medium Duty Truck	2014	Ford	F-450 Super Duty XL	CNG Bifuel Conversion	6.8L Gas V10			10	$50,560.00	$9,750.00	$60,310.00
Medium Duty Truck	2014	Ford	F-450 Chassis Cab XL	CNG Bifuel Conversion	6.8L Gas V10			10	$34,370.00	$9,750.00	$44,120.00
Medium Duty Truck	2014	Ford	F-550 Chassis Cab XL	CNG Bifuel Conversion	6.8L Gas V10			10	$35,470.00	$9,750.00	$45,220.00
Medium Duty Truck	2014	Ford	F-650 Chassis Cab	CNG Bifuel Conversion	6.8L Gas V10			10	$55,595.00	$9,750.00	$65,345.00
Medium Duty Truck	2014	Ford	F-650 Chassis Cab	CNG Bifuel Conversion	6.7L Cummins ISB			10	$66,560.00	$9,750.00	$76,310.00
Medium Duty Truck	2014	Ford	F-750 Chassis Cab	CNG Bifuel Conversion	6.7L Cummins ISB			10	$69,135.00	$9,750.00	$78,885.00
Medium Duty Truck	2014	Ford	F-750 Chassis Cab	Plug-in Hybrid Conversion	6.7L Cummins ISB	_	_	_	$69,135.00	$60,000.00	$129,135.00

Horsepower (hp)	Torque (lb-ft)	Payload (lb)	5yr Maint.***	Annual ICE Maint.	Annual Bi-fuel Maint.****	5 yr Repairs	Annual ICE Repairs	Annual Bi-fuel Repairs ****	5 yr Fuel	Annual ICE Fuel	Annual Bi-fuel Fuel Cost *****	Life Cycle Cost
362	457	7,260	$5,297.00	$1,059.40	$635.64	$2,333.00	$466.60	$279.96	$19,157.00	$3,831.40	$2,298.84	$89,227.00
362	457	12,666	$5,297.00	$1,059.40	$635.64	$2,333.00	$466.60	$279.96	$19,157.00	$3,831.40	$2,298.84	$73,037.00
362	457	12,666	$5,297.00	$1,059.40	$635.64	$2,333.00	$466.60	$279.96	$19,157.00	$3,831.40	$2,298.84	$74,137.00
362	457	13,485 – 28,872	$5,297.00	$1,059.40	$635.64	$2,333.00	$466.60	$279.96	$19,157.00	$3,831.40	$2,298.84	$94,262.00
200	520	13,485 – 28,872	$5,297.00	$1,059.40	$635.64	$2,333.00	$466.60	$279.96	$19,157.00	$3,831.40	$2,298.84	$105,227.00
200	520	13,485 – 28,872	$5,297.00	$1,059.40	$635.64	$2,333.00	$466.60	$279.96	$19,157.00	$3,831.40	$2,298.84	$107,802.00
200	520	13,485 – 28,872	_	_	_	_	_	_	_	_	_	N/A

Appendix H: Life-Cycle Cost Tool

Vehicle type	Fuel intakes
BEV	Electric
Bi-Fuel	Gas + CNG
Conventional	Diesel / Gas
Hybrid	Gas
PHEV	Gas + Electric

Fuel Cost Calculation	
Inputted	Manually input an average annual fuel cost
Calculated	Calculations based on fluctuating fuel prices and fuel economy

Inputs are highlighted cells		
Type of Vehicle by fuel	BEV	
Will you 'input' or 'calculate' fuel cost?	Inputted	
Calculating Fuel Costs		**Units**
CNG Price	$ 1.52	$/gal
Electricity Price	$ 0.66	$/kWh
Diesel / Gas Price	$ 3.75	$/gal
Annual Mileage	15000	miles/year
Other Costs and Assumptions		
MSRP	$ 28,800.00	$
Annual Maintenance Cost	$ 375.20	$
Annual Repair Cost	$ 486.00	$
Federal Incentive	$ -	$
State Incentive	$ 2,500.00	$
Salvage/Auction Cost	$ -	$
Number of years	10	
Real Discount Rate	10%	
For BEV		
Fuel Economy	30	kWh/100mi
Inputted Annual BEV Fuel Cost	$ 550.00	$
Calculated Annual BEV Fuel Cost	$ 2,949.03	$
Annual BEV Fuel Cost used in spreadsheet	$ 550.00	$
For Bi-Fuel		
Fuel Economy on CNG engine	19	miles/gal
Fuel Economy on gas engine	19	miles/gal
Avg. daily mileage on CNG engine	28.85	miles
Avg. daily mileage on gas engine	28.85	miles
Inputted Annual Bi-Fuel Fuel Cost		$
Calculated Annual Bi-Fuel Fuel Cost	$ 2,082.12	$
Annual Bi-Fuel Fuel Cost used in spreadsheet	$ -	$
For Conventional		
Fuel Economy	19	miles/gal
Inputted Annual Conventional Fuel Cost		$
Calculated Annual Conventional Fuel Cost	$ 2,960.53	$
Annual Conventional Fuel Cost used in spreadsheet	$ -	
For Hybrid		
Fuel Economy	35	miles/gal
Inputted Annual Hybrid Fuel Cost	$ -	$
Calculated Annual Hybrid Fuel Cost	$ 1,607.14	$
Annual Hybrid Fuel Cost used in spreadsheet	$ -	$
For PHEV		
Fuel Economy for electric engine	29	kWh/100mi
Fuel Economy for gas engine	50	miles/gal
Avg. daily mileage on electric engine	28.85	miles
Avg. daily mileage on gas engine	28.85	miles
Inputted Annual PHEV Fuel Cost		$
Calculated Annual PHEV Fuel Cost	$ 732.08	$
Annual PHEV Fuel Cost used in spreadsheet	$ -	$

US DOE 2013 Fuel Price Index*	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Motor Gasoline (Transportation)	0.97	0.95	0.95	0.96	0.98	1.00	1.02	1.04	1.05	1.06	1.07
Electricity (Commercial)	1.00	1.00	1.01	1.02	1.01	1.01	1.01	1.02	1.01	1.00	0.99
Natural Gas (Commercial)	1.01	1.01	1.06	1.11	1.17	1.21	1.23	1.26	1.29	1.32	1.34

*http://www1.eere.energy.gov/femp/pdfs/ashb13.pdf

Vehicle Lifecycle Cost Analysis

Year	0	1	2	3	4	5	6	7	8	9	10
Costs											
MSRP	$ 28,800.00										
BEV Fuel Index		0.91	0.83	0.76	0.70	0.63	0.57	0.52	0.48	0.43	0.39
BEV Fuel Cost	$ 3,407.96										
Bi-Fuel Index - CNG		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bi-Fuel Index - Gasoline		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bi-Fuel Fuel Cost	$ -										
Conventional Fuel Index		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Conventional Fuel Cost	$ -										
Hybrid Fuel Index		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Hybrid Fuel Cost	$ -										
PHEV Fuel Index - Gasoline		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PHEV Fuel Index - Electricity		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PHEV Fuel Cost	$ -										
Present Value of Maintenance and Repair Co:	$ 5,291.70										
Rebates											
Federal Incentive	$ -										
State Incentive	$ 2,500.00										
Savings											
Salvage/Auction Cost	$ -										
Final Lifecycle Cost over 10 years:	$ 34,999.66										

Appendix I: Sensitivity Analysis on the Discount Rate

Existing Vehicles: Descriptions	Existing Vehicles: Make and Model	Recommended Alternative Fuel Vehicles: Make and Model
SEDANS	Chevy Malibu ($50,175)	Nissan Leaf ($38,379)
	Ford Fusion Hybrid ($47,704)	
SUVs	Ford Escape Hybrid*	Toyota Prius v ($43,903)
LIGHT-DUTY PICKUP TRUCKS	Ford F-150 ($59,063), Chevy 2500 ($68,665) Ford Ranger*, Chevy Colorado ($61,375), GMC Sonoma*	None
	Ford F-250 ($76,821), Ford F-250 SD**, Chevy 2500 ($68,665), Chevy 2500 HD**	None
MEDIUM-DUTY PICKUP TRUCKS	Ford F-450 ($79,901)	Ford F-450 Chassis Cab XL CNG Bi-Fuel ($73,037)
	Ford F-700*, Chevy Kodiak*, Chevy 60 Series*	Ford F-750 Chassis Cab CNG Bi-Fuel ($107,802)

Vehicles not considered: CNG Sweeper, Sewer Cleaner, Chipper, Loader, and Vacuum Truck
*Price not available because vehicle is out of production
**Only base MSRP available

Discount rate 5%

Existing Vehicles: Descriptions	Existing Vehicles: Make and Model	Recommended Alternative Fuel Vehicles: Make and Model
SEDANS	Chevy Malibu ($47,500)	Nissan Leaf ($37,234)
	Ford Fusion Hybrid ($45,812)	
SUVs	Ford Escape Hybrid*	Toyota Prius v ($42,249)
LIGHT-DUTY PICKUP TRUCKS	Ford F-150 ($55,735), Chevy 2500 ($64,516) Ford Ranger*, Chevy Colorado ($57,226), GMC Sonoma*	None
	Ford F-250 ($72,323), Ford F-250 SD**, Chevy 2500 ($64,516), Chevy 2500 HD**	None
MEDIUM-DUTY PICKUP TRUCKS	Ford F-450 ($75,526)	Ford F-450 Chassis Cab XL CNG Bi-Fuel ($70,226)
	Ford F-700*, Chevy Kodiak*, Chevy 60 Series*	Ford F-750 Chassis Cab CNG Bi-Fuel ($104,991)

Vehicles not considered: CNG Sweeper, Sewer Cleaner, Chipper, Loader, and Vacuum Truck
*Price not available because vehicle is out of production
**Only base MSRP available

Discount rate 10%

Existing Vehicles: Descriptions	Existing Vehicles: Make and Model	Recommended Alternative Fuel Vehicles: Make and Model
SEDANS	Chevy Malibu ($42,294)	Nissan Leaf ($35,000)
	Ford Fusion Hybrid ($42,128)	
SUVs	Ford Escape Hybrid*	Toyota Prius v ($39,029)
LIGHT-DUTY PICKUP TRUCKS	Ford F-150 ($49,259), Chevy 2500 ($56,444) Ford Ranger*, Chevy Colorado ($49,154), GMC Sonoma*	None
	Ford F-250 ($63,567), Ford F-250 SD**, Chevy 2500 ($56,444), Chevy 2500 HD**	None
MEDIUM-DUTY PICKUP TRUCKS	Ford F-450 ($67,010)	Ford F-450 Chassis Cab XL CNG Bi-Fuel ($64,762)
	Ford F-700*, Chevy Kodiak*, Chevy 60 Series*	Ford F-750 Chassis Cab CNG Bi-Fuel ($99,527)

Vehicles not considered: CNG Sweeper, Sewer Cleaner, Chipper, Loader, and Vacuum Truck
*Price not available because vehicle is out of production
**Only base MSRP available