Drive Clean and Save

Electric Vehicles Are a Good Deal for California Consumers and the Environment

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Executive Summary

Electric vehicles (EVs) are clean, fun to drive, never require a stop at the gas station, and are a key part of California's strategy for reducing greenhouse gas emissions from transportation, the state's biggest source of climate-altering pollution. Fortunately, helped by strong state and federal incentives put into place over the past five years, electric vehicle adoption is growing rapidly: California now is home to almost half of the nation's EVs, including fully battery electric vehicles, plug-in hybrids and fuel cell vehicles. For the purposes of this report, we compared the cost savings of battery electric vehicles to their gasoline-powered counterparts.

Today's mass-market battery electric vehicles are also a good deal and will likely save money for consumers compared to similar gasoline-powered vehicles. Battery-powered EVs cost less to own than comparable gasoline-powered vehicles once the full life-cycle costs of car ownership and federal and state incentives for EV purchases are accounted for. Low-income buyers stand to gain the most from these savings, since Americans in the bottom 30 percent of the income scale spend nearly 30 percent of their annual income on transportation.

By fully implementing and expanding upon the state's electric vehicle policies, California can speed the introduction of electric vehicles, bringing a future of 100 percent clean, electric vehicles within sight.

Replacing gasoline-powered vehicles with electric ones reduces global warming pollution.

- When EVs are charged using renewable sources of energy, like solar panels or wind turbines, they are an almost entirely emission-free form of transportation.
- A California Air Resources Board-commissioned study found that an EV produces about half of the lifecycle greenhouse gas pollution as a gasoline-powered vehicle, based on California's 2012 energy mix. As the California electric grid gets cleaner by incorporating renewable energy sources, so too will driving electric vehicles.
- A recent study from the Natural Resources Defense Council and the Electric Power Research Institute found that widespread vehicle electrification across the country could reduce greenhouse gas emissions by between 430 million metric tons and 550 million metric tons annually by 2050.

This analysis finds that electric vehicles are a cost-effective way for Californians to go green. Even if gas prices remain at or near today's low levels, California consumers can expect to save money by buying a battery electric vehicle instead of a comparable gasoline-powered vehicle, once incentives and other savings, including reduced fuel costs, are taken into account. In this analysis, we compare ownership costs between car models for which both battery electric and gasoline-powered versions exist: the Chevy Spark and Spark EV; the Ford Focus and Focus EV; the Kia Soul and Soul EV; and the Volkswagen Golf and e-Golf. We find that:

- The lifetime cost of ownership for each EV analyzed is cheaper than for its gasoline-powered counterpart, when taking into account fuel costs and incentives.
- Compared to a similar gasoline-powered vehicle, the average EV in this analysis will save its owner more than $3,500 over its lifetime if gas prices fall to a low of $2.50 per gallon. If gas prices go back up to a more typical recent

price of $3.50 per gallon, the average electric vehicle will save its owner nearly $9,000 over the vehicle's lifetime.

These cost savings come on top of significant environmental benefits. The average electric vehicle in this study would emit 31 fewer metric tons of greenhouse gases over the vehicle's lifetime than its gasoline-powered counterpart. If one million such EVs were used instead of their gasoline-powered counterparts, the greenhouse gas emissions averted would be equivalent to taking California's two biggest fossil fuel-fired power plants offline.

Current state and federal incentives do more than make EVs affordable today—they are also critical tools to help the EV industry achieve the economies of scale and technological changes needed to reduce the cost of EVs over the long run in order to compete with the prices of gasoline-powered vehicles, which have long benefitted from government subsidies.

Despite EVs' rising popularity, there is a long way to go: to meet California's air quality and greenhouse gas goals, the state's transportation sector needs to be largely converted to zero-emission vehicles, while today less than one percent of the vehicles on the road in California are electric. **In order to achieve these goals, policy action by the state, air districts, municipalities and utilities will be necessary.**

Specifically, state decision-makers should ensure that California meets the twin goals codified by

Figure ES1. Lifetime Ownership Cost (Net Present Value) of Battery Electric Vehicles vs. Gasoline-Powered Vehicles, Including Incentives

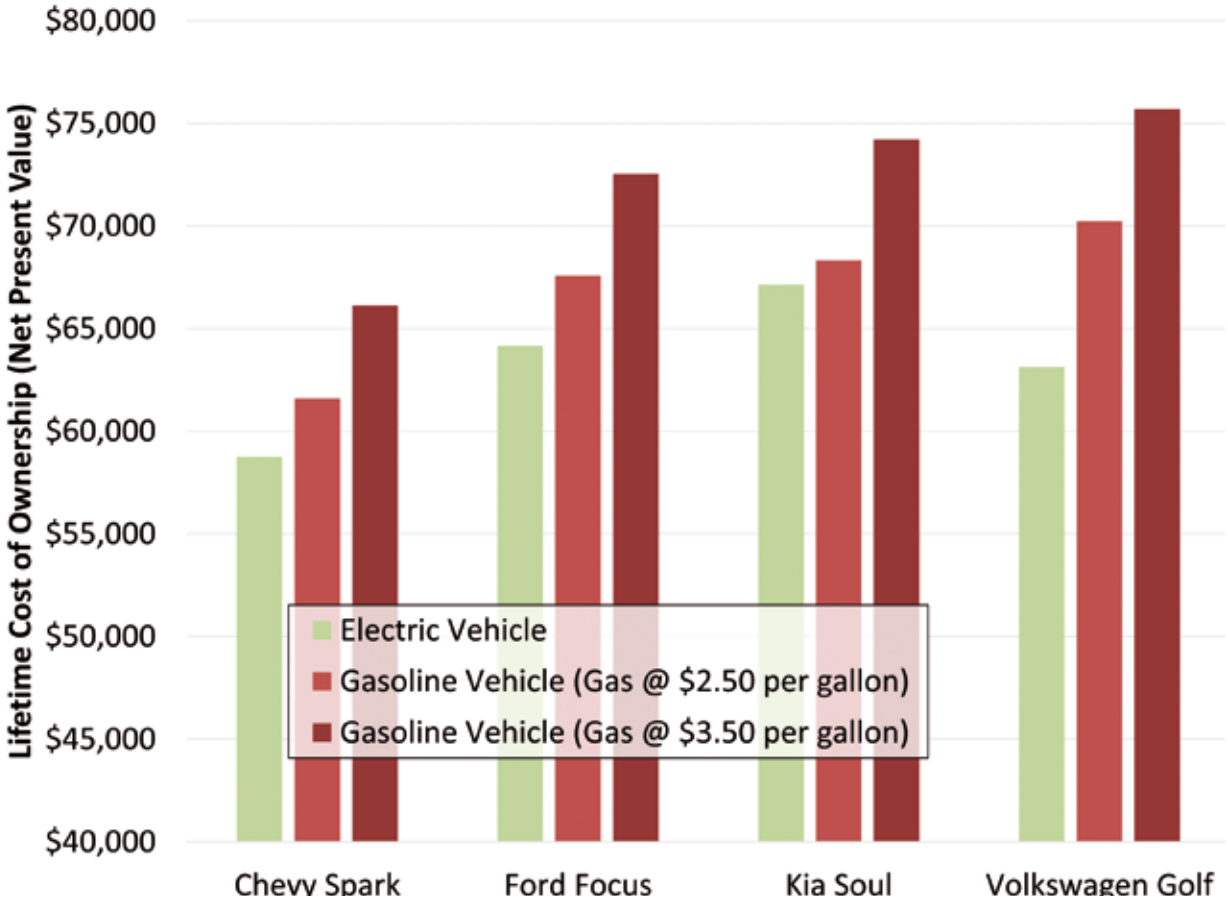
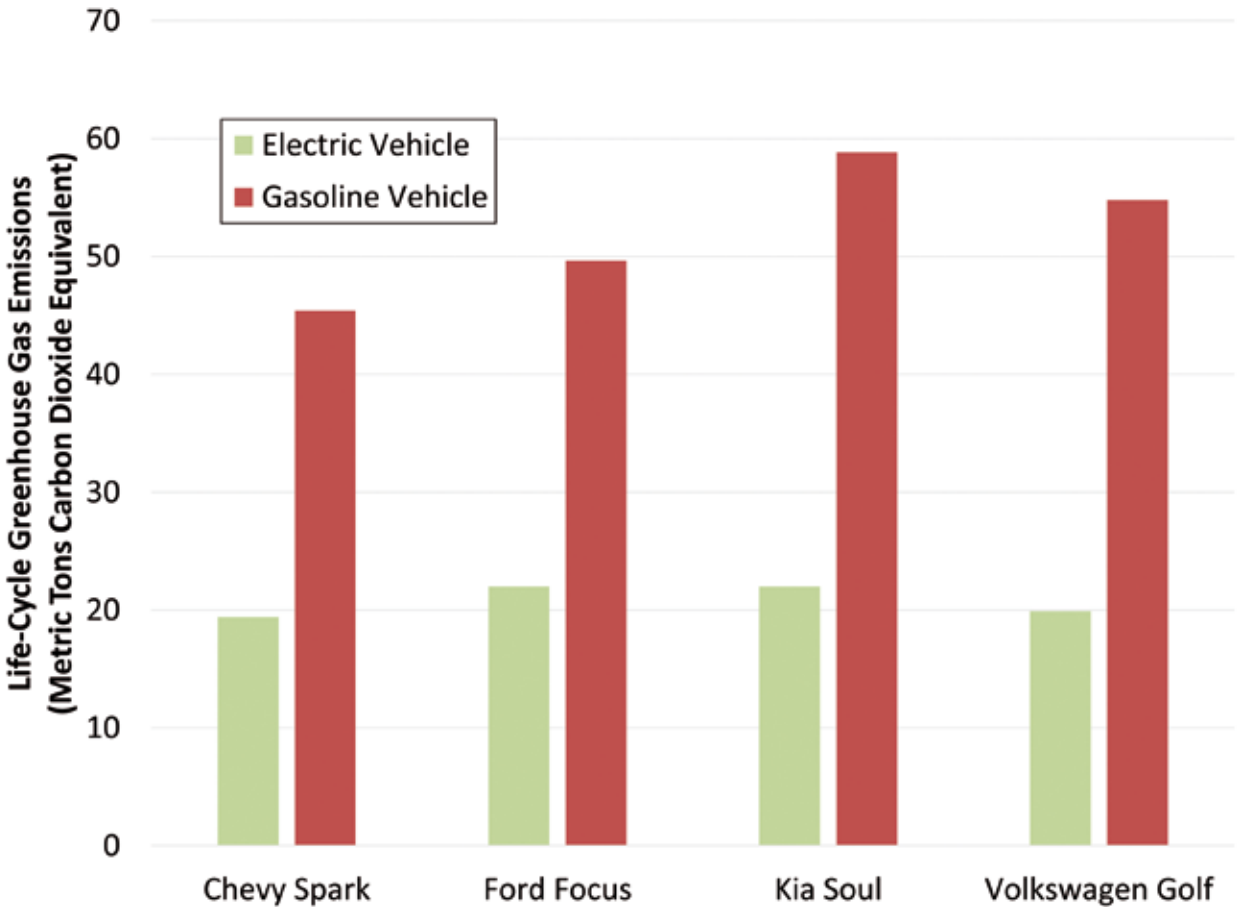


Figure ES2. Life-Cycle Greenhouse Gas Emissions of Gasoline-Powered Vehicles vs. Electric Vehicles (EV Emissions Assume 2015 Western U.S. Electricity Mix)



the Charge Ahead California Initiative (De León, 2014) of deploying one million zero and near-zero emission vehicles by 2023, and ensuring that disadvantaged, low-income, and moderate-income communities benefit from the transition to zero tailpipe emissions. Decision-makers should also continue efforts to meet Governor Brown's Executive Order for California to achieve 1.5 million zero-emission vehicles by 2025. Meeting all of California's long-term climate goals will require encouraging widespread electric vehicle adoption in underserved markets, including in low- and moderate-income communities.

Introduction

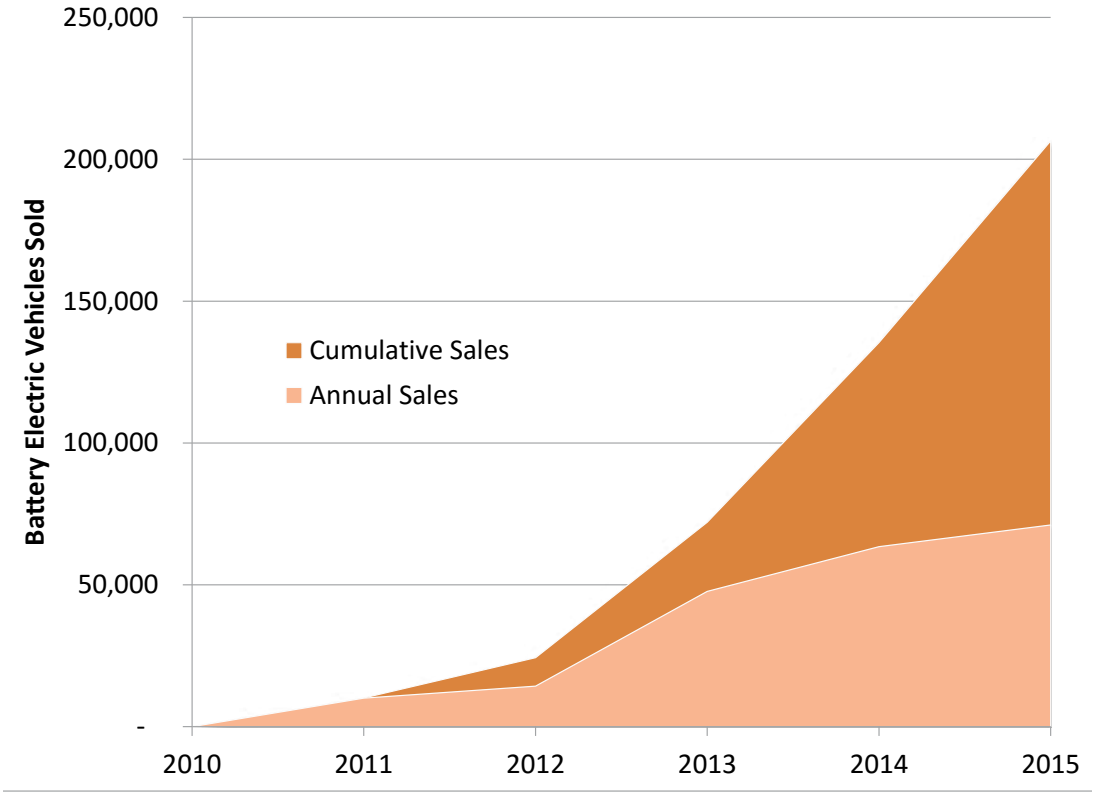
Consumers are ready for electric vehicles.

After years of declining prices, increasing driving range, and improving technology, electric vehicles (EVs) are primed to take off. The most public evidence comes from Tesla, whose newly announced Model 3 will come with a 215 mile range, an anticipated 5-star safety rating, 6-second zero to 60 mph acceleration, and a $35,000 starting price.[1] Just one week after unveiling its new Model 3 electric car, Tesla had received more than 325,000 reservations, in what Tesla called "the biggest one-week launch of any product ever."[2]

Meanwhile, national sales of pure battery EVs have increased every year since 2010, with 2016 on pace to be another record year.[3] And here in California, where residents have seen the impacts of global warming firsthand through years of brown lawns, dead trees and water use restrictions, and where rebates have helped jumpstart the market, electric vehicles make up a larger share of total vehicles than anywhere else in the country.[4]

For consumers that rely on their cars, the appeal of EVs is easy to see. They are fun to drive, with

Figure 1. Nationally, Annual Sales of Battery Electric Vehicles Have Increased Every Year Since 2010[5]



fast acceleration and great cornering. They are safe, with low centers of gravity that make them less likely to roll over.[6] And they are far cleaner than gasoline-powered vehicles, with lower greenhouse gas emissions and lower emissions of the pollutants that contribute to smog and particulate matter. Millions of Californians live in areas that exceed federal and state standards for smog and particulates, which contribute to excessive incidence of heart and lung diseases, including asthma, as well as premature death.

Every year, Californians have more options of EVs to choose from—with more than a dozen pure battery electric vehicle models on the market in 2016, compared to just a handful a few years ago.[g] Now, after years of falling prices, this analysis finds that EVs aren't just fun, safe, and good for the environment—they are also a good deal financially. In fact, Californians today can expect to spend less money on an EV than a similar gasoline car over the vehicle's lifetime, even if gas prices drop below current prices.

Despite increasing sales and excitement for EVs, there is a long way to go: to meet California's air quality and greenhouse gas goals, the state's transportation sector needs to be rapidly converted to zero-emission vehicles, while today less than one percent of the vehicles on the road in California are electric. To continue a speedy transition to electric vehicles and help the state to meet its climate commitments, California policy-makers should redouble their efforts in support of the commitment to put more than 1.5 million zero-emission vehicles (including battery electric vehicles, plug-in hybrid electric vehicles and fuel cell vehicles) on the road by 2025.

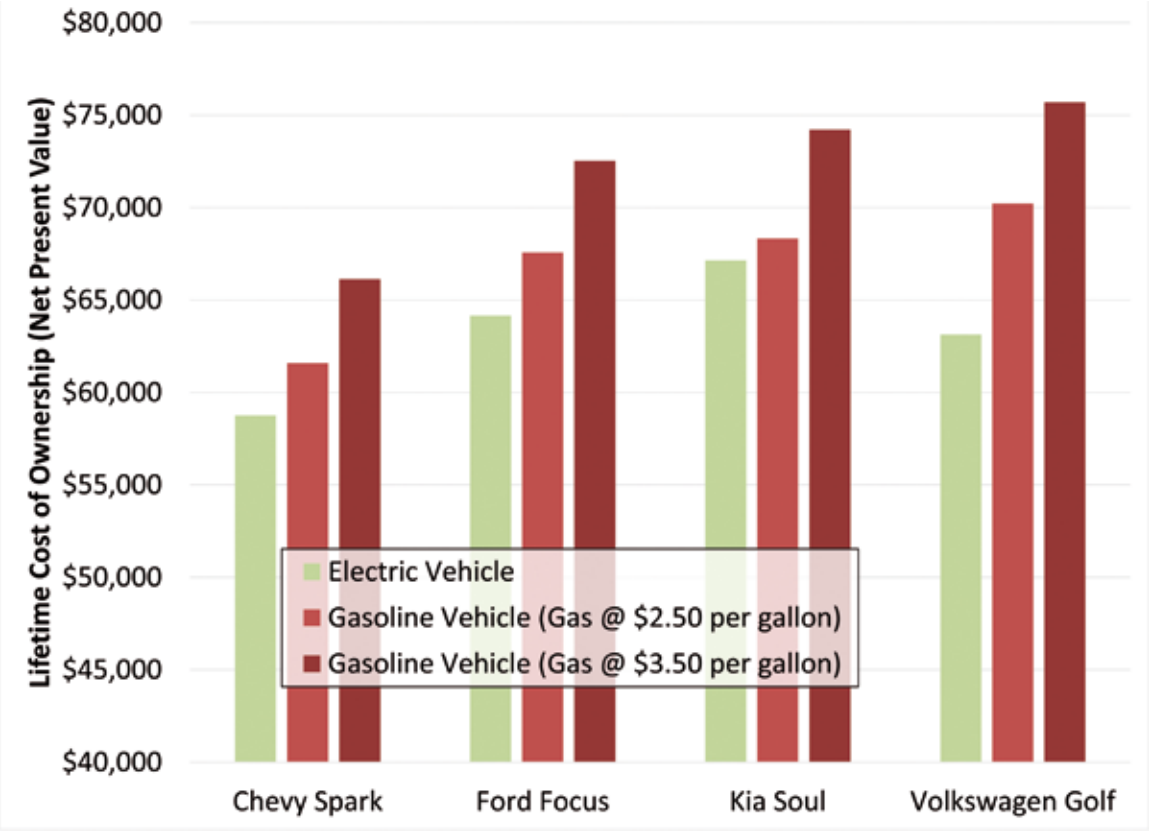
Electric Vehicles in California Are a Good Deal for Consumers, Even with Low Gas Prices

California leads the nation in the adoption of EVs. However, while the environmental benefits of EVs are clear (see "Electric Vehicles Can Help California Meet its Global Warming and Air Quality Goals" on page 11), the low gas prices of recent times have left some consumers wondering whether EVs are still a good deal financially.

To compare the lifetime costs of gasoline-powered vehicles with EVs, this report compares costs for four car models for which both battery-electric and gasoline-powered versions exist: the Chevy Spark and Spark EV; the Ford Focus and Focus EV; the Kia Soul and Soul EV; and the Volkswagen Golf and e-Golf.

After taking into account the full lifetime costs of EVs, including federal and state incentives, this analysis finds that consumers buying an EV today can expect to save money, even with relatively low gas prices. Since Americans in the bottom

Figure 2. Lifetime Ownership Cost (Net Present Value) of Electric Vehicles vs. Gasoline-Powered Vehicles, Including Incentives



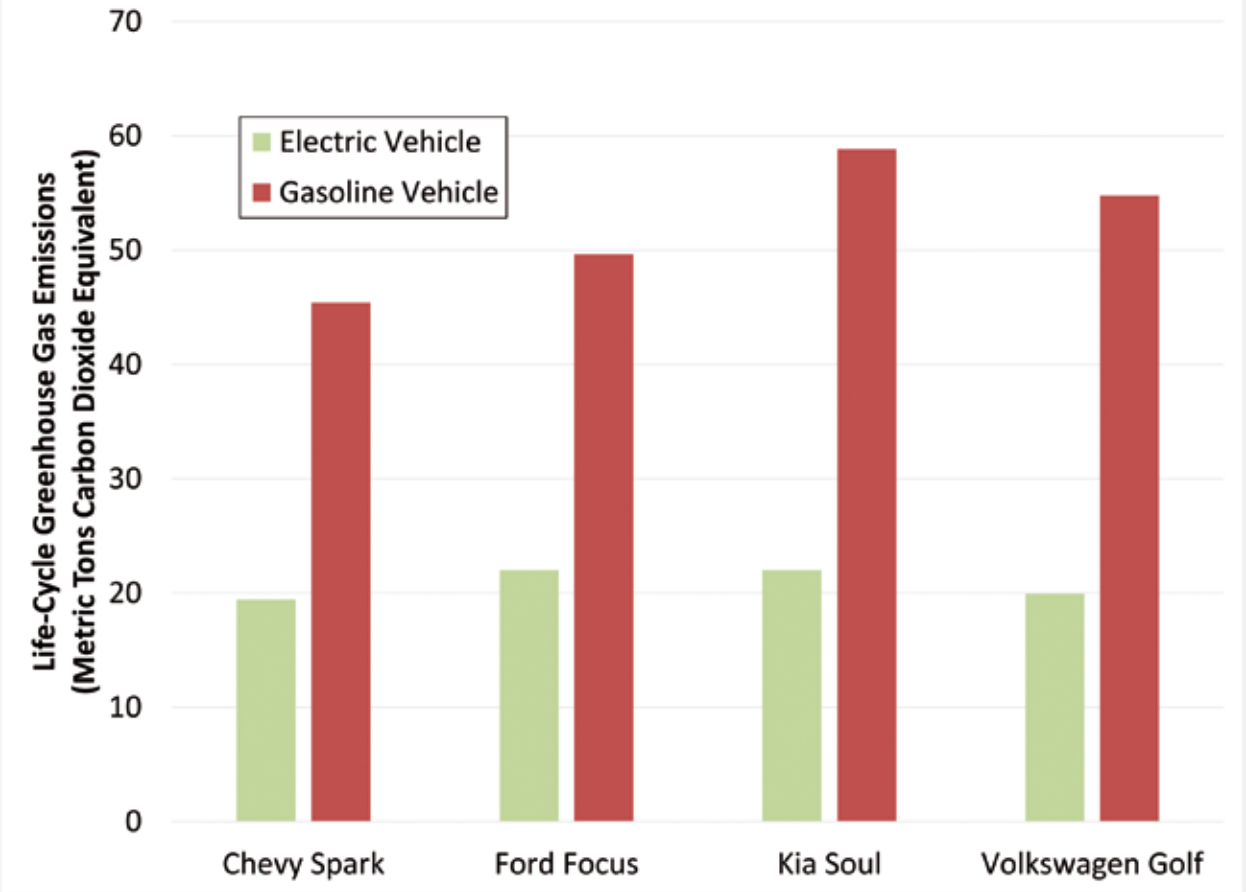
30 percent of the income scale spend nearly 30 percent of their annual income on transportation, these savings can be particularly important for low- and moderate-income buyers.[8]

Through the first five months of 2016, gas prices in California have been at their lowest in more than a decade, averaging $2.60 per gallon of regular grade. If gas prices stay near these low levels and average $2.50 per gallon, purchasers of EVs will save an average of $3,634 (net present value) over the lifetime of the vehicle compared with buyers of similar gasoline-powered counterparts, when taking into account lifetime vehicle costs including fuel, maintenance, and certain incentives (see "EVs' Higher Purchase Prices Are Offset by Incentives and Fuel Costs" below).

If gas prices return to a price more reflective of recent years, $3.50 per gallon, buyers will save an average of $8,844 (net present value) over the lifetime of the vehicle by purchasing an electric, rather than a gasoline-powered car. While the savings depend on the car model in question, EVs provided savings relative to gasoline-powered cars for each of the four models evaluated. (Details in Appendix B.)

These cost savings come on top of significant environmental benefits. The average EV in this study would emit 31 fewer metric tons of greenhouse gases over the vehicle's lifetime than its gasoline-powered counterpart. If one million such EVs were used instead of their gasoline-powered counterparts, the greenhouse gas emissions averted would be equivalent to taking

Figure 3. Life-Cycle Greenhouse Gas Emissions of Gasoline-Powered Vehicles vs. Electric Vehicles (EV Emissions Assume 2015 Western U.S. Electricity Mix)[10]



California's two biggest fossil fuel-fired power plants offline.[9] This reduction in greenhouse gases is estimated based on current power plant emissions in California. As California moves toward more renewable electricity generation, the environmental benefits of EVs will increase.

EVs' Higher Purchase Prices Are Offset by Incentives and Fuel Cost Savings

The four models of EVs surveyed here had an average initial purchase price $12,764 higher than their gasoline-powered counterparts.[11] But when factoring in $10,000 in state and federal incentives, along with thousands of dollars in fuel savings, these EVs had lower lifetime costs than their gasoline-powered counterparts.

Fuel and Other Savings

Electric vehicle owners will spend far less to charge their EVs with electricity than they would spend on gasoline to power a similar conventional vehicle. This is in large part due to the fact that EVs use energy much more efficiently than cars powered by internal combustion engines, which lose much of the energy in the fuel they consume in the form of heat.

If gas prices average $2.50 per gallon in 2016 dollars, somewhat below the abnormally low prices of recent months, electric car owners can expect to save nearly $5,000 in fuel costs (present value) over that vehicle's lifetime, compared with owning a gasoline-powered car. (These are fuel savings alone; for complete lifetime cost comparison results see above.) If gas prices average $3.50 per gallon, which is slightly less than the average price of gasoline in California over the last five years, EV owners could expect to save approximately $10,000 on fuel costs. (See Methodology for gas price details.) If gas prices return to previous high price points of well over $4 per gallon, EV owners will save even more, although those savings are not calculated in this report. The savings calculated in this report do not take into account the reduced electric rates available to some EV owners in California through programs like Southern California Edison's "Electric Vehicle Plan," in which consumers are billed lower-than-normal rates if they charge their EV during off-peak hours, using a separate meter.[12]

EV owners will also save on maintenance costs. According to the Department of Energy's Alternative Fuels Data Center (AFDC), EVs have lower maintenance costs because:[13]

- The battery, electric motor, and associated electronics require minimal maintenance.
- EVs have fewer fluids, like oil, that require regular changing.
- EVs have regenerative brakes, which require less maintenance.
- There are fewer moving parts than in a conventional vehicle.

Although concerns have been raised over the potential for replacement costs of batteries in EVs, according to the AFDC batteries are generally designed to last throughout the expected lifetime of their vehicles.[14] Toyota has reported that its post-warranty battery replacement rate for second-generation Prius hybrids (which have been on the road longer than most pure EVs, most of which are still under warranty) is 0.003 percent.[15]

The Argonne National Laboratory's Alternative Fuel Life-Cycle Environmental and Economic Transportation (AFLEET) Tool, which is used for calculating costs in this report (see Methodology for details), takes these lower maintenance costs into account and assumes that EVs have 12 percent lower maintenance costs per mile.

Other savings available to EV owners include:

- Special off-peak electricity rates for EV owners offered by most of California's major utilities.[16]
- Insurance discounts for EVs offered by many insurance providers in California.[17]

Incentive Savings

There are two primary incentive programs available to Californians buying EVs: the federal tax credit for plug-in EVs, and California's Clean Vehicle Rebate Project. For most buyers of EVs, the $7,500 federal tax credit and $2,500 state rebate combine to take $10,000 off the list price of all EVs in this report, reducing the average cost difference between new EVs and new gas vehicles by two thirds.[18]

The federal tax credit for plug-in electric vehicles provides up to a $7,500 tax credit for buyers of EVs and plug-in hybrids. The value of the tax credit is based on the battery capacity of the vehicle in question, equal to $2,500 plus $417 for each kilowatt-hour of battery capacity over 5 kilowatt-hours. All vehicles in this report have large enough battery capacity to qualify for the full tax credit. The biggest limiting factor for most consumers is the size of their tax liability—since the tax credit is

The Charge Ahead California Initiative Is Bringing Electric Vehicles to Low-Income Communities

In September 2014, Gov. Jerry Brown signed now-Senate President pro tempore Kevin de León's Charge Ahead California Initiative (SB 1275) into law, an important action to make electric vehicles accessible to more people in order to reduce greenhouse gas emissions and improve air quality. The Charge Ahead California Initiative contains a number of provisions aimed to put more EVs on the road, with a large emphasis on increasing their affordability for California's disadvantaged, low-income, and moderate-income communities and consumers. Among its key provisions, the Charge Ahead California Initiative:

- Codified the twin goals of putting one million zero- and near-zero-emission vehicles on the road in California by 2023 and ensuring that disadvantaged, low-income, and moderate-income communities benefit from the transition to zero tailpipe emissions.
- Directed the California Air Resources Board (CARB) to establish income eligibility limits for the Clean Vehicle Rebate Project in order to increase the program's effectiveness. As a result, CARB adopted an income cap, which went into effect in March 2016.[25] In addition, CARB increased the rebate amounts available to low- and moderate-income buyers.
- Directed CARB to create programs to increase access to clean transportation in disadvantaged, low-income and moderate-income communities, including financing mechanisms, electric vehicle carsharing programs that serve disadvantaged communities, and additional incentives for low- and moderate-income Californians who retire a high polluting vehicle and purchase a new or used electric vehicle (Enhanced Fleet Modernization Program Plus Up Pilot Project).
- Helped ensure the effectiveness of the Clean Vehicle Rebate Project by requiring that the CARB prepare a funding plan forecasting estimated funding needs, taking into account technology advancement, market readiness and consumer acceptance of EVs every three years.

California's low-income communities, which tend to be communities of color, are disproportionately impacted by air pollution from vehicles and by climate change. The Charge Ahead California Initiative helps ensure that these communities are front and center in state efforts to reduce transportation pollution, and will benefit sooner rather than later from the cleaner air and cost-savings that will result from a transition to an all-electric vehicle fleet.

nonrefundable, individuals with a taxable income of less than about $47,000 will not receive the full value of the credit.[19] The federal tax credit was originally enacted in the Energy Improvement and Extension Act of 2008 and begins to phase out for vehicles at the beginning of the second calendar quarter after the manufacturer produces 200,000 eligible plug-in EVs as counted from January 1, 2010.

California's Clean Vehicle Rebate Project provides $2,500 to most buyers of EVs (and different amounts for other clean vehicles like plug-in hybrids and fuel-cells). Recent changes to the California rebate program, which took effect in March 2016, raised the rebate to $4,000 for low- and moderate-income buyers, and created an income cap restricting very high-income Californians from receiving the rebate. This change reflects an effort to ensure that the program incentivizes electric vehicle purchases that would not otherwise occur and increases access to EVs for low- and moderate-income buyers who are disproportionately impacted by air pollution and can benefit the most from the cost-savings. The rebate program is funded by cap-and-trade auction proceeds appropriated from the Greenhouse Gas Reduction Funds.[20] Other government programs provide significant monetary and non-monetary incentives for EVs, which are not factored into this analysis. These include:

- High occupancy vehicle lane access.[21] A study by researchers at UC Davis found that providing HOV lane provides a strong incentive for consumers considering clean vehicles.[22]

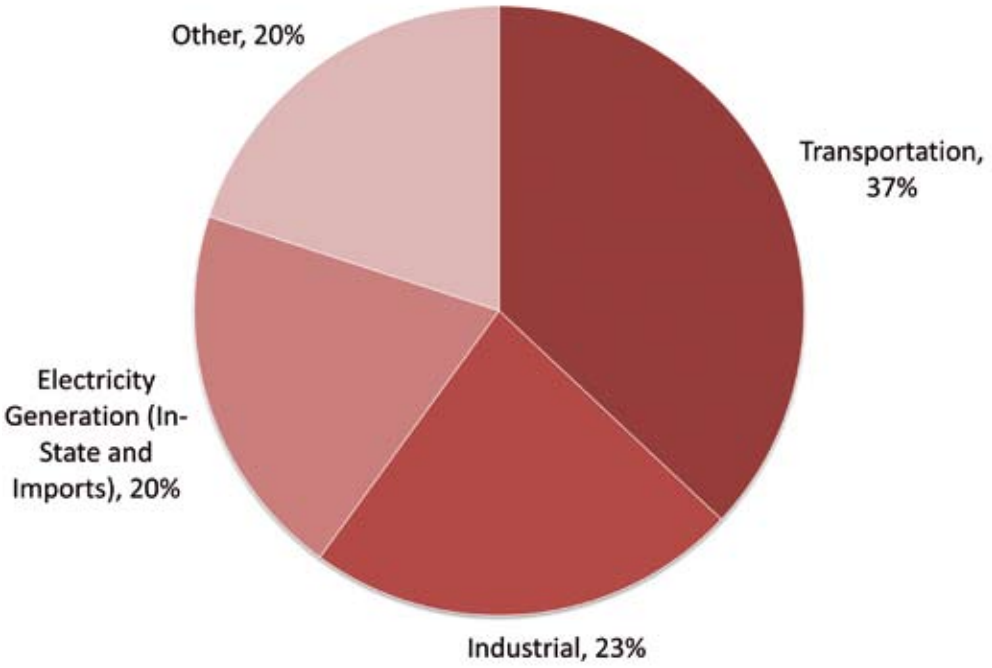
- The EFMP Plus-Up Program, which provides low-income buyers with up to $9,500 toward the purchase of a new or used EV in exchange for scrapping their old polluting vehicle (available as of November 2015 in the South Coast and San Joaquin Valley air districts).[23] Residents who scrap their old car but choose not to purchase a new vehicle are eligible for transit passes valued at up to $4,500, depending on their income.[24]

Electric Vehicles Can Help California Meet its Global Warming and Air Quality Goals

With rising sea levels, drought, and massive wildfires, Californians are on the front lines of climate change.

Thankfully, California policy-makers have taken action to curb greenhouse gas emissions. In 2006, California passed the Global Warming Solutions Act (AB 32-Nunez/Pavley), requiring California to reduce greenhouse gas emissions to 1990 levels by 2020. That legislation has been bolstered by executive orders from governors Arnold Schwarzenegger and Jerry Brown, setting targets for California to reduce its emissions by 40 percent by 2030 and by 80 percent by 2050, relative to 1990 levels. And in 2015, Gov. Brown signed Senate President pro tempore Kevin de León's Clean Energy and Pollution Reduction Act of 2015 (SB 350), which requires 50 percent of California electricity sales to come from renewable energy by 2050 and makes reducing reliance on oil (including for transportation) a principal goal of the California electric industry. Preventing the worst impacts of global warming will require dramatically reducing the state's carbon emissions, and that means tackling emissions from transportation. In 2013, transportation was responsible for 37 percent of California's greenhouse gas emissions, more than any other sector of the state's economy.[26] California's transportation sector emits more

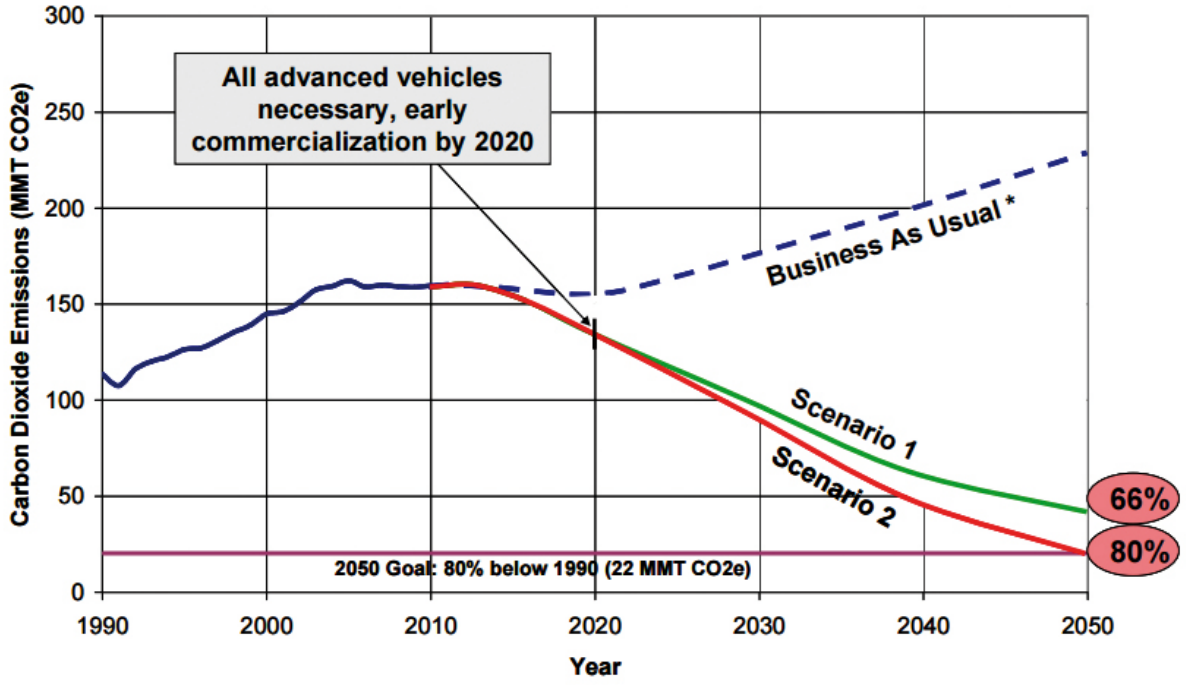
Figure 4. California Emissions of Carbon Dioxide Equivalent by Sector in 2013[30]



carbon dioxide pollution than the entire economies of all but six U.S. states.[27] Light-duty vehicles, which include cars, light trucks, and motorcycles, make up nearly 70 percent of California's transportation emissions.[28] According to the Environmental Protection Agency (EPA), the typical passenger vehicle in the United States emits nearly 5 metric tons of greenhouse gases per year.[29]

Electric vehicles are an important piece of the puzzle for reducing transportation emissions. When EVs are charged using renewable sources of energy, like solar panels or wind turbines, they are an almost entirely emission-free form of transportation. But even when charged from the current electricity grid, the cumulative lifetime emissions of an EV—including emissions from vehicle production and electricity generation—are significantly lower than emissions from a gasoline vehicle. A California Air Resources Board-commissioned study found that, given California's 2012 energy mix, EVs produce just about half of the lifecycle greenhouse gas emissions of a comparable gasoline-powered vehicle.[31] And a recent study from the Natural Resources Defense Council and the Electric Power Research Institute found that widespread vehicle electrification in the U.S. could reduce greenhouse gas emissions by between 430 million metric tons and 550 million metric tons annually in 2050, depending on the carbon intensity of electric power plants.[32] Because of this, EVs make up an important piece of California's plans for meeting the AB 32 emission targets, and beyond: CARB found that, for the passenger vehicle sector to reduce

Figure 5. California Air Resources Board: For the Passenger Vehicle Sector to Reduce Emissions 80 Percent by 2050, Annual Sales Of Zero-Emission Vehicles Must Reach Half A Million Units By 2025



This figure, from a 2009 California Air Resources Board report, projects the emissions impacts of three scenarios for the growth of zero emission vehicle (ZEV) sales. Scenario 1, in which passenger vehicle emissions are reduced by 66 percent by 2050, assumes ZEV annual sales increase to 250,000 by 2025 and to 100 percent of passenger vehicle sales by 2050. Scenario 2, in which passenger vehicle emissions are reduced by 80 percent in line with California's 2050 goal, assumes annual ZEV sales increase to 500,000 by 2025 and to 100 percent of vehicle sales by 2040.

emissions 80 percent by 2050, annual sales of new zero-emission vehicles in California (including hydrogen fuel cell vehicles) will need to reach half a million units by 2025, and must make up 100 percent of passenger vehicle sales by 2040.[33]

In addition to their impact on greenhouse gas emissions, EVs are also important for meeting California's air quality goals, as well as strong new federal standards for ozone smog. Compared to gasoline-powered vehicles, EVs have lower lifetime emissions of carbon monoxide, which contributes to smog and can cause harmful health effects; volatile organic compounds, which contribute to smog and can cause trouble breathing; and sulfur oxides, which can exacerbate asthma.[34] In a cleaner electric grid, electric vehicles will also deliver reductions in NOx emissions.[35] As California's grid transitions to more cleaner and renewable sources, EVs' ability to reduce smog-forming emissions will continue to increase.

Conclusion and Recommendations

Electric vehicles are an essential tool to combat global warming and air pollution. Fortunately, with current policy incentives, EVs can deliver benefits for the environment while also saving money for consumers over the long run. But there is a long way to go: to meet California's air quality and greenhouse gas goals, the state's transportation sector needs to be rapidly converted to zero-emission vehicles, while today less than one percent of the vehicles on the road in California are electric. Meanwhile to attain ozone standards required by federal law, NOx emissions in the South Coast Air Basin must be cut by around 80 percent by 2023, and by almost 90 percent by 2032. According to the California Air Resources Board this longer-term goal will require "nearly complete transformation of passenger vehicles to zero-emission technologies, [and] approximately 80 percent of the truck fleet to zero-or near zero technology," along with efforts to clean up California's electric grid.[36]

Meeting these goals will take immediate and consistent policy action by the state of California, local air districts and municipalities, including a focus on the underserved communities that are disproportionately affected by air pollution and climate change, and whose access to clean transportation is necessary to achieve exponential growth in electric vehicle adoption.

The State of California should:

- Ensure that California meets the goal codified by the Charge Ahead California Initiative of deploying one million zero and near-zero emission vehicles by 2023, and that the state continues to accelerate the growth of EVs to help meet Governor Brown's Executive Order (B-16-2012) for California to achieve 1.5 million zero-emission vehicles (ZEVs) by 2025. California should also "strive to make all new passenger vehicles in [its jurisdiction] ZEVs by no later than 2050" as specified in the state's December 2015 agreement with the ZEV Alliance.[37] (The ZEV Alliance is a collaboration of national and subnational governments with the goal of accelerating adoption of zero-emission vehicles.)

- Ensure that CARB successfully implements the equity pilot programs required by the Charge Ahead California Initiative and expands upon these pilots to ensure that disadvantaged and low-income communities are able to access meaningful clean transportation options. This includes improving and expanding the electric vehicle car-sharing program in underserved communities, the Enhanced Fleet Modernization Program Plus-Up Pilot Project, and the financing assistance program to more areas around the state.

- Make certain that California meets its obligations under the multi-state Zero Emission Vehicle Action Plan, and encourage other states to meet their goals, ensuring that the auto industry sells the number of electric cars needed to help us achieve our climate goals.

- Support stronger fuel economy and greenhouse gas emission standards for cars in California and nationally. Such standards would further encourage the deployment of low-carbon vehicles such as EVs.

- Provide adequate and continuous funding for programs that incentivize manufacturers and buyers of electric vehicles (like the Clean Vehicle Rebate Project) through CARB's Air Quality Improvement Program and Low Carbon Transportation projects.

- Continue to support programs that focus on research, commercialization and deployment of medium and heavy-duty electric vehicles.

- Increase awareness and interest among the general public about the state's electric vehicle incentive programs and work with community-based organizations to facilitate meaningful public education in low-income communities.

- Ensure underserved communities are targeted and prioritized in electric vehicle infrastructure planning and investment.

- Create a recognition program for automakers and auto dealers who demonstrate an increased commitment to electric vehicles through their sales and marketing.

California's local air districts should:

- Seek to create and secure financing for vehicle retirement and replacement programs, modeled on the Enhanced Fleet Modernization Program Plus Up currently underway in the San Joaquin Valley Air Pollution Control District and the South Coast Air Quality Management District. These programs provide additional incentives to help low-income individuals and families scrap old, polluting clunkers and replace them with used or new advanced clean technology vehicles such as conventional hybrids, plug-in hybrids or EVs. Participants can also receive vouchers for public transit passes and carsharing.

- Provide additional rebates where feasible to further drive down the cost of electric vehicles.

California cities should:

- Buy zero-emission vehicles for public fleets and build publicly-accessible charging infrastructure to support those vehicles. This lead-by-example strategy can replace a large number of miles that would be driven in gasoline-powered vehicles, increase public familiarity with electric vehicles, introduce fleet drivers to EVs and perhaps encourage them to purchase such vehicles for their personal use, and potentially increase the number of publicly accessible charging stations.

- Ensure meaningful access to electric vehicle technology in low-income communities and communities of color by building charging infrastructure in diverse communities, creating electric vehicle carsharing programs in low-income neighborhoods and by working with community-based organization and ethnic media outlets to educate and guide interested community members on how to access electric vehicles.

- Encourage local businesses to transition commercial and industrial fleets to zero emission vehicles and to build complementary charging infrastructure.

California electric utilities also have a critical role to play. Senate Bill 350 (De León) codified a directive for the California Public Utilities Commission (CPUC) and the electric industry "to accelerate widespread transportation electrification to reduce dependence on petroleum, meet air quality standards, achieve the goals set forth in the Charge Ahead California Initiative, and reduce emissions of greenhouse gases to 40 percent below 1990 levels by 2030 and to 80 percent below 1990 levels by 2050." As such, California's utilities should invest in: charging infrastructure; outreach and education efforts; fleet purchases of EVs; purchase of medium- and heavy-duty vehicles, port electrification and equipment; and other areas as appropriate. California's investor-owned and municipal utilities should maximize the number of charging stations deployed in as short a timeframe as possible and to ensure that a sufficient number of charging stations are sited in low-income communities to achieve the requirements of the Charge Ahead California Initiative. To ensure sufficient charging infrastructure in low-income communities, electric utilities should work with community-based organizations. These organizations can help utilities best determine key details for installing charging stations in low-income communities, including where to site them, how to set charging costs, how to clearly mark stations in appropriate languages and how to conduct public outreach in an effective manner.

Methodology

This study calculated lifetime costs and greenhouse gas emissions of comparable electric and gasoline-powered vehicles using the 2016 version of Argonne National Library's Alternative Fuel Life-Cycle Environmental and Economic Transportation (AFLEET) model. AFLEET is available for download at greet.es.anl.gov/afleet. Unless otherwise noted, default values in AFLEET were used.

Vehicle Data (Gas Mileage and Purchase Price): Each vehicle's gas mileage (or corresponding electric mileage, or MPGe) was assumed to be EPA's "combined city/highway" fuel economy. EPA's combined mileage assumes 55 percent of driving is city, 45 percent is highway. Although EPA fuel economy ratings are not based on real-world driving and thus may suffer from inaccuracies, the automotive industry website Edmunds found that EPA's combined city/highway fuel economy was accurate within two miles per gallon of its fleet's real-world fuel economy.[38] Both mileage and vehicle purchase price were found using the search feature of www.fueleconomy.gov, a program of the U.S. Department of Energy. This analysis assumed the lowest MSRP provided by www.fueleconomy.gov for each vehicle given the year, make and model. Vehicle prices do not take any taxes into account.

Vehicle Lifetime and Miles Driven: This analysis assumes 12,400 miles driven per year, consistent with the default setting in AFLEET, and a 12-year vehicle lifetime. A 12-year lifetime with 12,400 miles driven per year reflects a lifetime mileage of approximately 150,000 miles, the lifetime mileage assumption made by the Electric Power Research Institute's *Total Cost of Ownership Model for Current Plug-In Electric Vehicles*.[39] This study assumes no resale value after a 12-year lifetime of both electric and gasoline-powered vehicles, although even EV batteries that are incapable of powering a vehicle are likely to have significant residual value as sources of backup energy storage on the grid.[40]

Electricity Price: This analysis assumes a starting electricity price of 17.7 cents per kilowatt hour, based on average residential retail price of electricity from the U.S. EIA's State Profile and Energy Estimates for February 2016.[41] This analysis assumes an annual nominal price growth rate for electricity of 2.01 percent, reflecting the 2015 to 2030 price projections for the Pacific region from the Energy Information Administration's *Annual Energy Outlook 2015*.[42]

Gas Prices: This study calculates the cost of owning a gasoline-powered vehicle under two gas-price scenarios: $2.50 per gallon and $3.50 per gallon, in 2016 dollars. $2.50 represents the approximate price of gasoline in the first five months of 2016, a period of low gas prices; $3.50 per gallon is in line with the average price of gasoline in California between 2010 and May 2016 (the average retail price of gasoline in California between weeks ending 1/4/2010 and 5/30/2016 was $3.56 per gallon, without adjusting for inflation).[43] The AFLEET tool's default gasoline escalation rate was adjusted to keep gasoline prices at constant real prices—the nominal price of gasoline increases at the assumed rate of inflation (2 percent).

Financial Assumptions: For the most part, this analysis used the default financial assumptions of the AFLEET tool: A five-year loan with an interest rate of 3.37 percent, and a discount rate (used for calculating net present value) of 0.83 percent. The percent down payment was changed from 0 percent to 10 percent. The inflation rate was changed from 2.2 to 2.0 percent, to reflect the

inflation rate used in the reference case from EIA's Annual Energy Outlook 2015.[44]

Incentives: As detailed in the body of the report, an incentive of $10,000 was assumed for each EV, based on the $2,500 state rebate and $7,500 federal tax credit. The incentive level was input through the incentive input cell of the AFLEET tool's "Payback" sheet.

Greenhouse Gas Emissions: This study relied on AFLEET's built-in model for calculating lifetime vehicle greenhouse gas emissions. Energy generation emissions as a result of EV charging are dependent on emissions generated by the local electric grid. The AFLEET tool provides an option for adjusting the regional energy generation mix, and for this study the tool was adjusted to reflect the energy mix of the Energy Information Administration's Western Electricity Coordinating Council region.

Appendix A: Accessing Electric Vehicle Incentives

Consumers interested in obtaining incentives for their electric vehicle can use the following instructions to find more information and to apply for rebates and HOV lane access.

California Clean Vehicle Rebate Project

Californians can claim a $2,500 rebate on purchases of new EVs (including all EVs in this report) through the Clean Vehicle Rebate Project. As of March 2016, this rebate was increased to $4,000 for low-income Californians and is restricted from very high income Californians. Full instructions, guidelines, and application forms for accessing a rebate under the California Clean Vehicle Rebate Project are available online at cleanvehiclerebate.org.

Federal Plug-in Electric Drive Motor Vehicle Credit

Californians (and all Americans) can claim up to a $7,500 credit on their federal taxes by filling out IRS Form 8936 and reporting the resulting credit on their Form 1040 income tax return. All EVs in this report are eligible for the full $7,500 tax credit, although the full value of the credit cannot be more than an individual's tax liability for the year the credit is claimed. More information is available at fueleconomy.gov/feg/taxevb.shtml. IRS Form 8936 is available at www.irs.gov/pub/irs-pdf/f8936.pdf.

Enhanced Fleet Modernization Program (EFMP) Plus-Up

The EFMP Plus-Up program allows residents living in the South Coast and San Joaquin Valley air quality districts to qualify for up to $9,500 toward a new vehicle, depending on household income and type of vehicle, when they trade in their old car for a new low-emission vehicle.[45] Residents living in the South Coast district, which includes much of the Los Angeles area, can apply through the Replace Your Ride program online at replaceyourride.com. Residents living in the San Joaquin Valley district can apply by bringing their vehicle to a Tune In Tune Up event for a free emissions test; event listings, along with further eligibility requirements, are online at valleyair.org/grants/pass.htm.

Carpool Lane Access Decals

Drivers of eligible low and zero-emission vehicles, including all EVs in this report, can apply for a vehicle decal that allows single occupancy access to high occupancy vehicle (HOV) lanes. There is a limit on the number of decals that can be issued by the Department of Motor Vehicles; to check availability, visit arb.ca.gov/msprog/carpool/carpool.htm. To apply for a decal, fill out and submit the form available online at dmv.ca.gov/portal/dmv/detail/forms/reg/reg1000.

Appendix B: Individual Vehicle Lifetime Costs

Chevy Spark (Type: Electric)	
Full vehicle name: 2016 Chevrolet Spark Automatic (A1)	
MSRP:	$25,120
Incentive:	$10,000
Lifetime fuel costs:	$7,760
Lifetime cost of ownership (net present value):	$58,758

Chevy Spark (Type: Gasoline)	
Full vehicle name: 2016 Chevrolet Spark 1.4 L, 4 cyl, Automatic (variable gear ratios)	
MSRP:	$12,660
Incentive:	$0
Scenario with gas at $2.50 per gallon	
Lifetime fuel costs:	$11,134
Lifetime cost of ownership (net present value):	$61,595
Scenario with gas at $3.50 per gallon	
Lifetime fuel costs:	$15,867
Lifetime cost of ownership (net present value):	$66,129

Ford Focus (Type: Electric)	
Full vehicle name: 2016 Ford Focus Automatic (A1)	
MSRP:	$29,170
Incentive:	$10,000
Lifetime fuel costs:	$8,795
Lifetime cost of ownership (net present value):	$64,154

Ford Focus (Type: Gasoline)	
Full vehicle name: 2016 Ford Focus 1.0 L, 3 cyl, Auto(S6), Turbo	
MSRP:	$17,225
Incentive:	$0
Scenario with gas at $2.50 per gallon	
Lifetime fuel costs:	$12,396
Lifetime cost of ownership (net present value):	$67,573
Scenario with gas at $3.50 per gallon	
Lifetime fuel costs:	$17,355
Lifetime cost of ownership (net present value):	$72,532

Kia Soul (Type: Electric)	
Full vehicle name: 2015 Kia Soul Automatic (A1)	
MSRP:	$31,950
Incentive:	$10,000
Lifetime fuel costs:	$8,795
Lifetime cost of ownership (net present value):	$67,147

Kia Soul (Type: Gasoline)	
Full vehicle name: 2016 Kia Soul 2.0 L, 4 cyl, Automatic (S6)	
MSRP:	$15,800
Incentive:	$0
Scenario with gas at $2.50 per gallon	
Lifetime fuel costs:	$14,692
Lifetime cost of ownership (net present value):	$68,334
Scenario with gas at $3.50 per gallon	
Lifetime fuel costs:	$20,569
Lifetime cost of ownership (net present value):	$74,211

Volkswagen e-Golf (Type: Electric)	
Full vehicle name: 2016 Volkswagen e-Golf, Automatic (A1)	
MSRP:	$28,995
Incentive:	$10,000
Lifetime fuel costs:	$7,961
Lifetime cost of ownership (net present value):	$63,131

Volkswagen Golf (Type: Gasoline)	
Full vehicle name: 2016 Volkswagen Golf 1.8 L, 4 cyl, Automatic (S6), Turbo	
MSRP:	$18,495
Incentive:	$0
Scenario with gas at $2.50 per gallon	
Lifetime fuel costs:	$13,679
Lifetime cost of ownership (net present value):	$70,223
Scenario with gas at $3.50 per gallon	
Lifetime fuel costs:	$19,150
Lifetime cost of ownership (net present value):	$75,695

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