

ELECTRIC VEHICLES IN SONOMA COUNTY

WHITE PAPER ON EV STATUS AND PATHS TO ADOPTION

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Prepared by the Center for Climate Protection

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ABBREVIATIONS

BEV	Battery Electric Vehicle
DCFC	Direct Current Fast Charger
EV	Electric Vehicle
EVSE	Electric Vehicle Supply Equipment
eVMT	Electric Vehicle Miles Travelled
GHG	Greenhouse Gas
PEV	Plug-In Electric Vehicle
PHEV	Plug-In Hybrid Electric Vehicle
VMT	Vehicle Miles Travelled
ZEV	Zero Emission Vehicle

Executive Summary

In the late 1990s, several pioneering companies introduced electric vehicles (EVs) in Sonoma County. Starting in 2011, EVs gained wider adoption as new models were mass-marketed, such as the Chevrolet Volt and Nissan Leaf. Since then sales of EVs have continued to grow. Customers say they purchase EVs to save money on fuel, to save time via access to high occupancy vehicle lanes, and to have an environmentally friendly mode of transportation.¹

In 2013 Governor Brown set a goal for 1 million EVs to be sold in California by 2023. In meeting this goal alone, California would reverse the growth in gas-powered vehicle miles traveled (VMT) and GHG emissions (GHGs) by 2021. Given today's growth trend, California will surpass the Governor's EV goal, and Sonoma County will also meet its share of the goal.

Findings

1. For reducing GHG emissions, fuel shift is significantly more powerful than mode shift.

Reducing GHGs from transportation is a complex problem that requires a variety of solutions. Mode shift, for example switching from driving to biking, is essential for GHG reduction, and brings co-benefits like congestion and safety improvements. However, to rapidly reduce GHGs at scale in transportation, fuel shift is a more powerful solution. Total emissions reduced from EVs in Sonoma County through March 2015 exceed 7,000 mtCO₂, a significant amount compared to any other single measure to reduce GHGs from transportation.

2. Workplace chargers significantly increase electric vehicle miles travelled.

Plug-in hybrid vehicles are likely to remain a significant portion of EV sales, as shown by the Sonoma County market share of Chevy, Ford, and BMW sales. Larger battery sizes for plug-in hybrid vehicles (PHEVs) are also expected to increase their uptake. Evidence exists that additional workplace charging would significantly increase the number of electric vehicle miles travelled (eVMT) from PHEVs. Based on Sonoma County's current vehicle mix, we could expect a 24 percent increase in eVMT from PHEVs if workplace charging were widely available.

3. Renewable power boosts GHG reductions from EVs.

With a choice of electrical service widely available through Sonoma Clean Power starting in 2014, Sonoma County drivers can charge their electric vehicles with greener electricity, even 100 percent green. Having a 100 percent green option is rare outside of a few places, like Iceland, and gives Sonoma County a new advantage in reducing its emissions produced by transportation. Switching EV charging from PG&E's current power mix to 100 percent renewable electricity would result in nearly a 13 percent reduction in GHG emissions.

¹ Center for Sustainable Energy Feb 2014 Plug-in Electric Vehicle (PEV) Owner Survey
<http://energycenter.org/clean-vehicle-rebate-project/vehicle-owner-survey/feb-2014-survey>

4. More affordable, desirable EVs are on the horizon.

While EV sales lag behind projections, battery price reductions are running ahead of schedule. New EV models coming on the market are expected to have lower prices and longer ranges, and promise to boost EV sales significantly beginning in 2017-18.

5. Meeting state goals requires significantly more EV chargers in Sonoma County.

Governor Brown set bold goals for developing California's EV charging infrastructure. To do its part, by 2020 Sonoma County needs to have installed about 14,600 home chargers, 1,700 workplace chargers, 365 public chargers, and 9 fast chargers. For a sense of scale, these Sonoma County amounts overshadow the approximately 2,000 total chargers installed in the San Francisco Bay Area region through the end of 2014. This is roughly 25 percent of the chargers needed to be on track to meet our region's 2025 goal of 36,000 chargers.²

6. Local and regional policies can accelerate EV use.

Local and regional governments can accelerate EV use with policies that augment state and national EV incentives. Such policies should offer EV users tangible and immediate benefits, for example, more EV-friendly electricity rates, particularly at advantageous times of the day.

7. Many potential EV users are unaware of EVs and related infrastructure.

EV adoption is hampered because many drivers are unaware of the availability and benefits of EVs. A marketing campaign to increase public awareness and emphasize the quality of the experience should be mounted. This recommendation echoes one made in the Bay Area Plug-in Electric Vehicle Readiness Plan, but not yet implemented.

8. Increased funding to accelerate EV adoption will soon be available.

New funds available through California's cap and trade program, and new directives from Governor Brown are expected to result in more funding in California to continue incentives and pilot programs for EV adoption. In addition, the Bay Area Air Quality Management District is planning to target more regional funds to increase Zero Emission Vehicle adoption, for example, through the Transportation Fund for Clean Air. Communities that develop plans for increased EV infrastructure and public outreach will be competitively positioned for anticipated funding.

Recommendations

While developing concrete next steps is yet to be done, several general recommendations – offered below – emerged in writing this white paper. As with most big, new endeavors,

² California Statewide Plug-In Electric Vehicle Infrastructure Assessment (5/4/14): <http://www.energy.ca.gov/2014publications/CEC-600-2014-003/CEC-600-2014-003.pdf>

collaboration among government, business, and community stakeholders is required to ensure success. The Center for Climate Protection has recently convened EV stakeholders for this purpose, and will continue to do so as appropriate. This group of EV stakeholders will focus on developing and implementing the recommendations described below, at least in the short term.

1. Advocate for policies and funding, especially at the state level, to accelerate EV use

Examples of desired policy include continuing EV rebates, HOV access for EVs, discounted electricity rates, and programs to make EVs more accessible for low-income populations. Exploration of local and regional policies that accelerate EV use should also be pursued.

2. Expand EV charging, especially at workplaces, multi-family units, and along main transportation corridors

To meet the demand expected in 2017-18 from increased EV use, Sonoma County needs much more EV charging infrastructure including home and work chargers, fast and slow chargers.

- Install Level 2 chargers at workplaces, multi-unit dwellings, and other locations where EV drivers would be parked for 2 hours or more. Potential partners include PG&E, SCP, and commercial EVSE operators.
- Install DC fast chargers in locations convenient for EV drivers who are travelling beyond the range of their daily charge. As noted above, potential partners include PG&E, SCP, and commercial EVSE operators.
- Coordinate employers and address the cost barrier with specific state and private funding solutions to increase workplace charging.

3. Develop and implement an EV awareness campaign

Research indicates that many potential EV buyers are unaware that such vehicles are available. Sonoma County should run a public awareness campaign and/or be part of a regional campaign to accelerate EV adoption. An EV awareness campaign could include:

- EV demonstrations, shows, and fairs where the public can view EVs and ask non-affiliated EV drivers about their experiences
- Education and promotion of the benefits of driving an EV through media channels
- Websites containing comprehensive EV information
- Clear, uniform signage noting the location of charging stations

4. Develop EV charging infrastructure through increased coordination

Sonoma County needs more coordination among the many EV players to develop needed EV charging infrastructure. Charging station locations must be planned and prioritized to have the greatest positive impact on EV market penetration, tourism, and EV range. The Sonoma County Regional Climate Protection Authority's Fuel Shift Plan currently under development is intended to provide such coordination.

1. Introduction

Transportation is the largest and fastest growing source of GHG emissions in Sonoma County, accounting for about 60 percent of total emissions in 2013.³ Nearly four out of five trips in Sonoma County are made by single occupant, fossil fuel powered automobiles. Approximately \$850 million leaves the County annually to pay for the fossil fuel that powers Sonoma County vehicles.⁴

EVs offer one of the biggest opportunities to reduce GHG emissions from transportation. By transitioning transportation fuel from petroleum to electricity we reduce GHG emissions and help residents and businesses save money. Such a shift has already begun. The State of California actively promotes EVs, and the San Francisco Bay Area is one of the top selling regions for EVs in the world.

Many planning efforts and research studies have addressed strategies to increase EV use. Drawing from these efforts and studies, this paper describes Sonoma County's status and progress, and identifies the greatest opportunities to accelerate the transition to an electric-powered transportation system.

1.1 History of Electric Vehicles in Sonoma County

Sonoma County installed its first EV charging station in 1990 at the Northern Sonoma County Air Pollution Control District (NSCAPCD) building. In 2009 the County installed seven charging stations. The County's continued commitment to EV charging has led to an expanded network of more than 25 public charging stations whose use continue to increase.

Over 1,500 plug-in hybrids and battery electric cars have been sold in Sonoma County since electric cars went on sale in 2010. Sonoma County accounts for 1.6 percent of California EV sales to date — just ahead of its share of the population. Although Sonoma County has been a strong performer for EV sales, it still lags behind leaders like San Mateo County which accounts for 4.2 percent of all EV sales in California – roughly double its share of the population.⁵

Sonoma County has also been home to a number of electric vehicle manufacturing efforts, with several notable companies:

ZAP (Zero Air Pollution) was started in 1991 in Oakland, CA. They moved to Sonoma County in 1995. ZAP is thought to be the world's first electric bicycle company. By 1999 they employed over 100 people in Sebastopol and built over 30,000 bikes and powered

³ Sonoma County Greenhouse Gas Report for 2011: <http://climateprotection.org/wp-content/uploads/2012/12/2011-GHG-Report-for-Sonoma-County-Nov-12-2012.pdf>

⁴ 2008 Sonoma County Community Climate Action Plan: http://coolplan.org/ccap-report/CCAP_Final_11-05-08.pdf

⁵ Center for Sustainable Energy on behalf of the California Air Resource Board's Clean Vehicle Rebate Project <http://energycenter.org/clean-vehicle-rebate-project/rebate-statistics>

scooters. In 1997, ZAP delivered their power system to the Forever Bicycle Company of Shanghai, helping start the electric bike revolution in China. World production of electric bicycles is now approximately 40 million bikes per year.

Transmagnetics is a Sonoma County maker of specialty brushless motor drive systems for boats.

Make Mine Electric was a gas-to-electric car conversion company based in Sebastopol.

Thunderstruck Motors is a Santa Rosa company supplying parts and construction services to EV sports and specialty markets. They are a founder of NEDRA (the National Electric Drag Racing Association).

The Switch Lab is an education, manufacturing and training facility in Sebastopol. Started in 2011, they build The SWITCH, an automobile alternative. Hundreds of students have experienced their hands on training.

1.2 State and Regional Government Actions

In March 2012, Governor Brown issued Executive Order B-16-2012, directing specific government agencies to establish benchmarks resulting in 1.5 million zero-emission vehicles (ZEVs) on California roadways by 2025. In response to the executive order, the Governor's Office published the 2013 ZEV Action Plan in February 2013. The 2013 ZEV Action Plan itemizes specific strategies and directives for achieving the executive order goals and identifies lead and supporting state agencies charged with implementing those strategies.⁶

Senate Bill 1275 (September, 2014) was the first significant bill to addresses Electric Vehicles (EV) issues in California. It states: "the goal of the state to place in service at least one million zero-emission and near-zero-emission vehicles, including cars, trucks, and buses, by January 1, 2023, and to establish a self-sustaining zero-emission and near-zero-emission vehicle market in which zero-emission and near-zero-emission vehicles are a viable mainstream option for individual vehicle purchasers, businesses, and public fleets."

The California Air Resources Board (CARB) has which been placed in charge of carrying out the mission of SB1275 echoes the intent of the legislature and the Governor:

The Charge Ahead California Initiative is hereby established and shall be administered by the state board. The goals of this initiative are to place in service at least 1,000,000 zero-emission and near-zero-emission vehicles by January 1, 2023, to establish a self-sustaining California market for zero-emission and near-zero-emission vehicles in which zero-emission and near-zero-emission vehicles are a viable mainstream option for

⁶ California Statewide Plug-In Electric Vehicle Infrastructure Assessment:
<http://www.energy.ca.gov/2014publications/CEC-600-2014-003/CEC-600-2014-003.pdf>

individual vehicle purchasers, businesses, and public fleets, to increase access for disadvantaged, low-income, and moderate-income communities and consumers to zero-emission and near-zero-emission vehicles, and to increase the placement of those vehicles in those communities and with those consumers to enhance the air quality, lower GHGs, and promote overall benefits for those communities and consumers.

Other significant findings of SB 1275 include: “Cars and trucks are the single largest source of GHG emissions in California. They also are the largest contributor to air pollution that harms public health.”

The State of California's 2013 ZEV Action Plan has four main goals with a number of recommended actions.⁷

1. Complete needed infrastructure and planning
 - a. Support and advocate for reauthorization of infrastructure funding programs to fund essential early PEV and FCEV infrastructure.
 - b. Ensure development of interoperability standards for electric vehicle charging stations that allow all drivers to charge at a station regardless of membership in a vehicle charging network.
 - c. Ensure adequate funding to build a minimum network of 68 hydrogen stations to support the commercial launch of FCEVs between 2015 and 2017, and expand the network to 100 stations to match FCEV market growth.
2. Expand consumer awareness and demand
 - a. Support and advocate for the reauthorization of funding programs to continue consumer rebates for purchase or lease of PEVs and FCEVs.
 - b. Maintain HOV lane access for ZEVs.
 - c. Participate in existing and planned consumer outreach campaigns to raise awareness about the availability and benefits of ZEVs and offering driving opportunities.
3. Transform fleets
 - a. Take necessary steps to ensure that at least 10percent of state’s light-duty vehicle purchases are ZEVs by 2015 and that at least 25percent are ZEVs by 2020.
 - b. Advance a statewide ZEV Fleets Users Forum or expand existing forums to support the efforts of companies and governments to integrate ZEVs into their fleets.
 - c. Develop a multi-agency strategy to accelerate the commercialization of medium and heavy-duty ZEVs.
4. Grow jobs and investment in the private sector
 - a. Conduct supply chain assessment of ZEVs, components and infrastructure to develop a strategic plan to attract promising areas of ZEV supply chains to California.

⁷ The State of California's 2013 ZEV Action Plan:
http://opr.ca.gov/docs/Governor%27s_Office_ZEV_Action_Plan_%2802-13%29.pdf

- b. Identify pre-permitted facilities that can be quickly repurposed for ZEV and component manufacturing or hydrogen stations.
- c. Provide workforce training funds to employers, trade associations, Joint Apprenticeship Training Committees, and Chambers of Commerce to address employer-driven, ZEV-related training needs for existing and new workers.

In 2013, the Bay Area Air Quality Management District (BAAQMD) released the Bay Area Plug-In Electric Vehicle Readiness Plan. With funding from the California Energy Commission, the goal of the plan was to ensure that the Bay Area is, “well positioned to handle large-scale adoption of PEVs over the next 10 years (2013–2023).”⁸

2. Status of EVs in Sonoma County

2.1 EV Sales and Use

EV sales in Sonoma County are taking off. In addition, Sonoma County has a higher percentage of sales of full battery electric vehicles (BEVs), compared to the state average which has a higher mix of plug-in hybrid electric vehicles (PHEVs). BEVs have a higher impact than PHEVs on reducing emissions and saving money on fuel.⁹

The two most popular brands have been the Nissan Leaf, a full battery electric vehicle, and the Chevy Volt. Both have been available for a number of years. More new models are coming on the market as additional carmakers have begun producing EVs.

In Sonoma County a new sales record for EVs was set in 2014 when nearly half of all EV sales ever occurred. The trend continued in the first quarter of 2015 despite low gas prices. January 2015 sales of EVs doubled from the year before based on data from the Clean Vehicle Rebate Project. Recent estimates are that only 70 percent of eligible vehicles are rebated.¹⁰ Therefore it is likely that EV use in Sonoma County is markedly higher than the estimates given in this paper.

⁸ Bay Area Plug-In Electric Vehicle Readiness Plan: <http://www.bayareapevready.org/assets/Bay-Area-PEV-Readiness-Plan-Summary-2013-web.pdf>

⁹ Charging Behavior Impacts on Electric Vehicle Miles Travel: Who is Not Plugging in? http://www.its.ucdavis.edu/wp-content/themes/ucdavis/pubs/download_pdf.php?id=2098

See Table 7: Average Daily Estimated eVMT Miles by Region and Model

¹⁰ Second Public Workshop on the Fiscal Year (FY) 2015-16 Funding Plan for the Air Quality Improvement Program (AQIP) & Low Carbon Transportation Investments, January 23, 2015: http://www.arb.ca.gov/msprog/aqip/fundplan/fundingplan_workshop_presentation_012315.pdf

Figure 1: Annual EV sales by vehicle type in Sonoma County¹¹

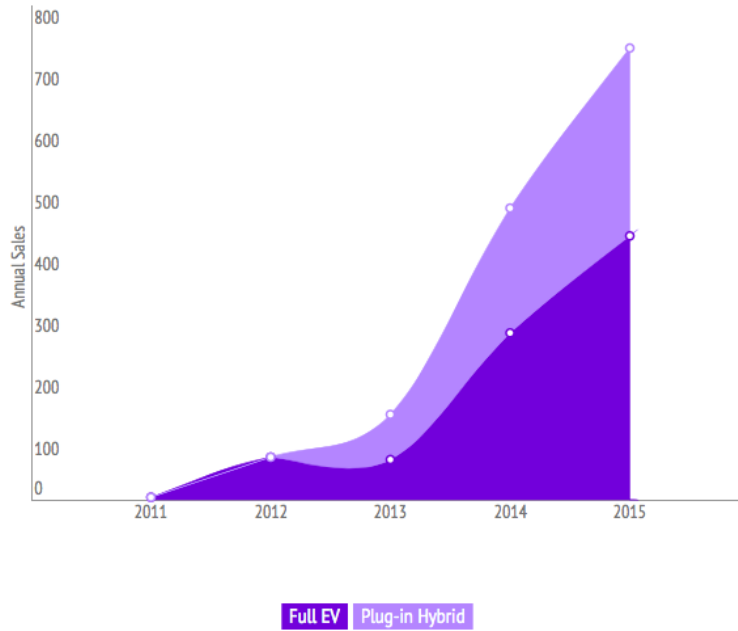
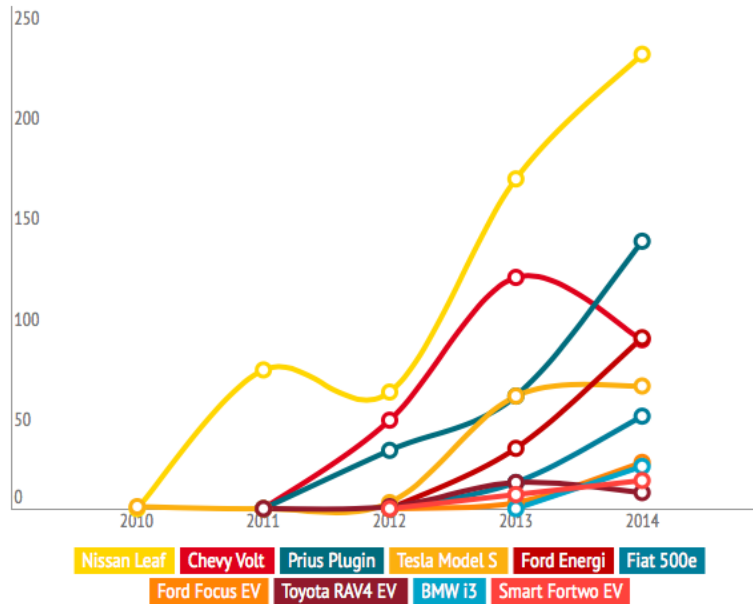


Figure 2: Annual EV sales by model in Sonoma County¹²

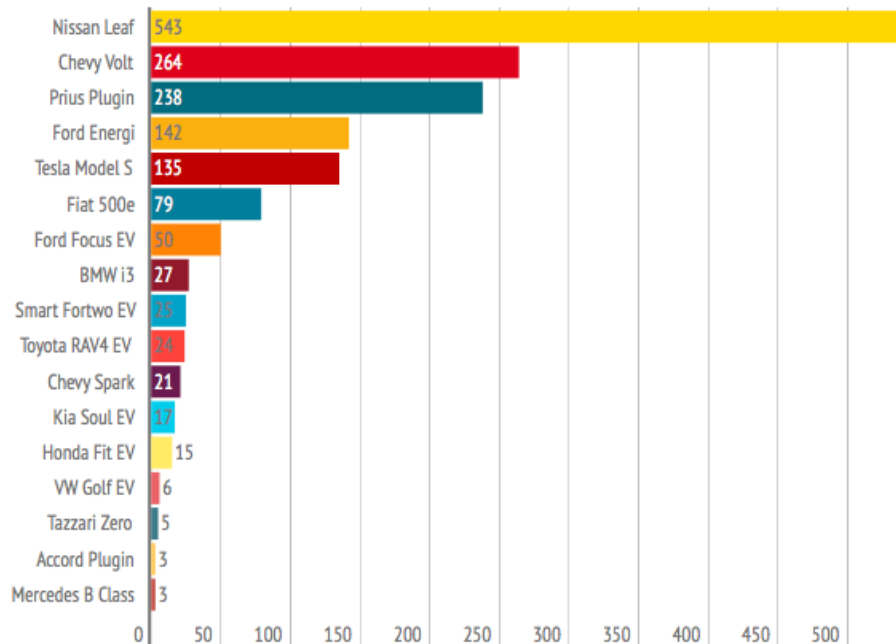


¹¹ Center for Sustainable Energy on behalf of the California Air Resource Board's Clean Vehicle Rebate Project <http://energycenter.org/clean-vehicle-rebate-project/rebate-statistics>

¹² Center for Sustainable Energy on behalf of the California Air Resource Board's Clean Vehicle Rebate Project <http://energycenter.org/clean-vehicle-rebate-project/rebate-statistics>

All EVs listed in Figure 3 can be purchased or leased through Sonoma County dealers with the exception of Smart and Tesla.

Figure 3: EV model preference by rebates redeemed in Sonoma County



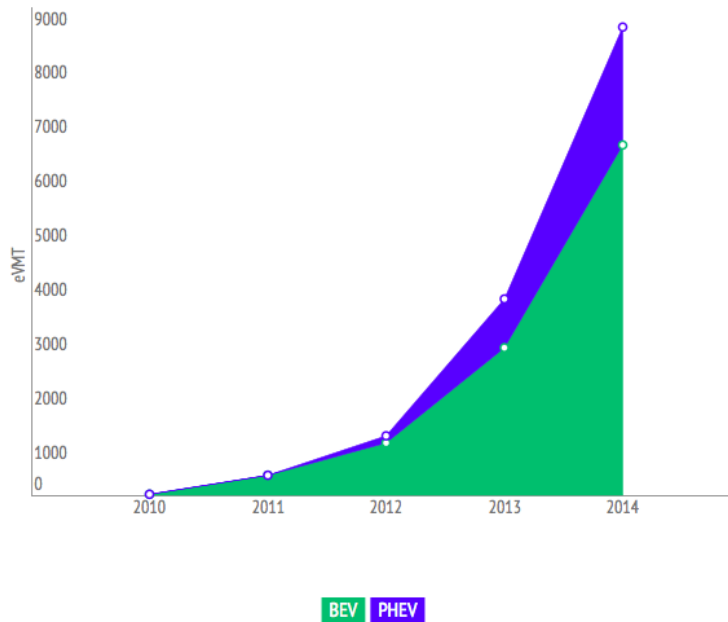
One barrier to accelerated EV adoption is the lack of knowledge in the vehicle sales force about these vehicles. While most people are familiar with conventional internal combustion engine (ICE) vehicles, the same is not true for EVs. Most EV dealerships have not trained their sales staff in the operation of the EVs that they sell. As a result, sales staff often gives false information about the EVs to potential customers, and direct them to consider an ICE vehicle.¹³

Several Sonoma County dealerships have made a concerted effort to provide a positive customer experience. Some of the sales practices that have led to a high-level customer experience are:

- Training one or two of their sales staff in all aspects of operating and charging an EV (which includes proficiency in driving an EV)
- Spending more time with the customer explaining how to operate and charge an EV (this would include explaining the limitations of the EV)
- Completing the paperwork required to receive the tax credits, rebates and HOV stickers
- Providing assistance for installing a charging station at the customer's home

¹³ Innovation, Retail Performance and Zero Emission Vehicle Policy: http://phev.ucdavis.edu/files/Dealer-Study-Brief_Short_2015-4-8.pdf

Figure 4: Annual eVMT for Electric Vehicles sold in Sonoma County



The same paper notes that almost half of all Leaf and Volt owners have workplace chargers, compared to only 38 percent of Prius owners. Interestingly, only 4 percent of the Leaf commuters needed workplace chargers to complete their trip home, compared to 33 percent of Volt owners, and about 70 percent of Prius owners. This data indicates that it's primarily plug-in hybrid owners who can get more eVMT by plugging in at work.

Figure 5: Location of EV owners redeeming EV rebates (by ZIP code)

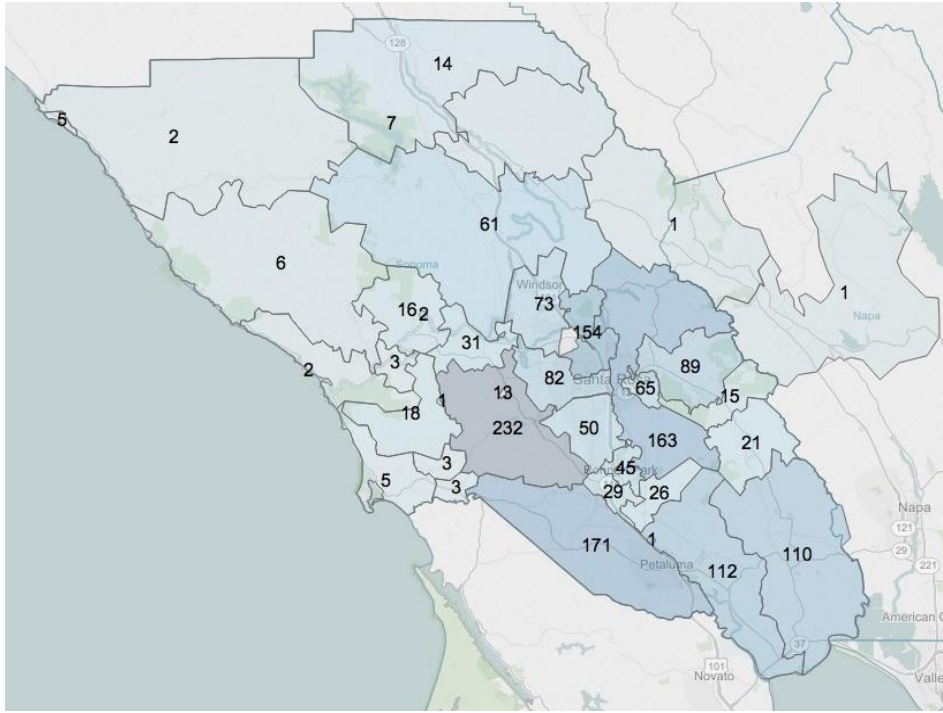


Figure 6: Locations with highest number of EV rebates (by ZIP code)

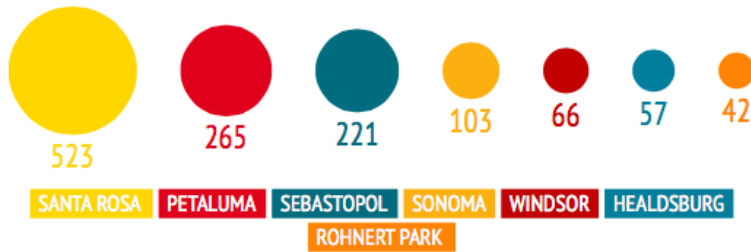
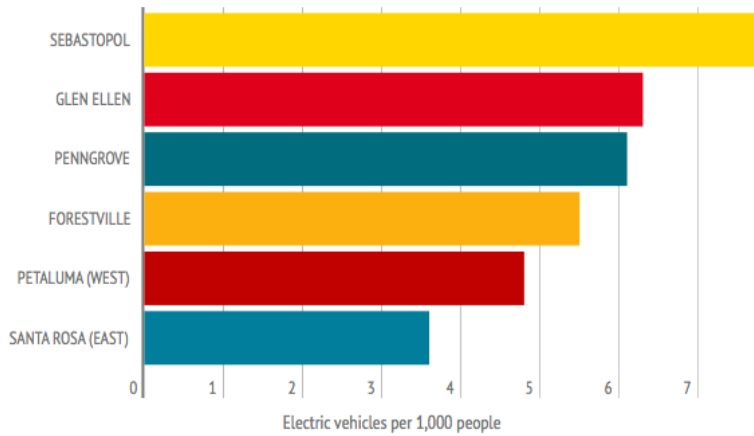


Figure 7: Density of owners redeeming EV rebates (top 5 locations in Sonoma County)

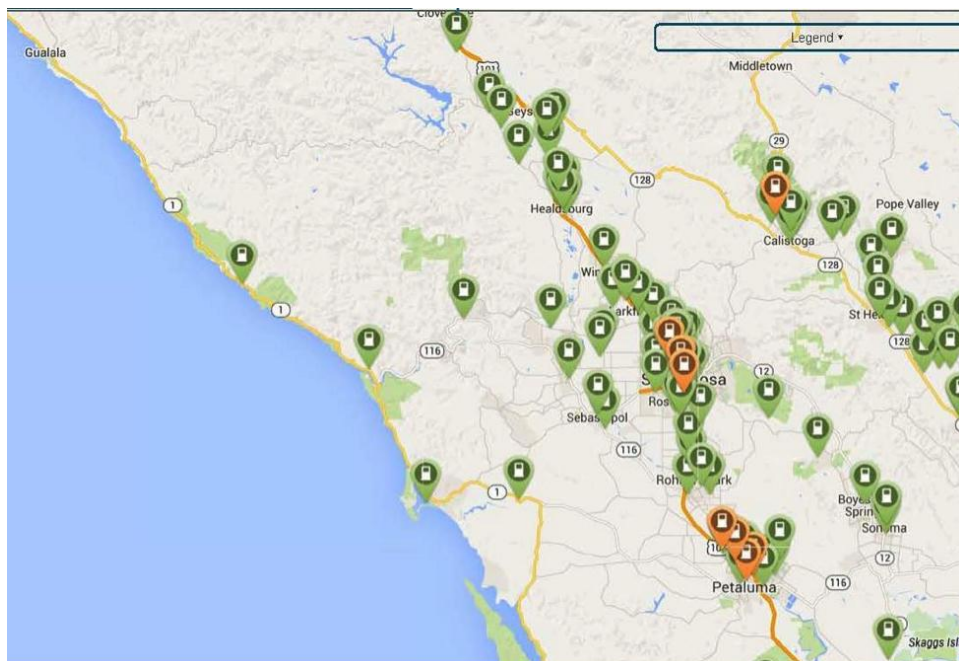


2.2 Infrastructure

A major challenge for EV market penetration is the relative short range of the current choices in commercial EVs. All models except the Tesla have an effective range of about 80 miles. The Tesla, a relatively high cost EV, can go 200 miles. Therefore, an affordable EV can venture about 40 miles from home in Sonoma County without the need to return home for a charge. Indeed, EV charges are beginning to be installed at the workplace and at shopping centers in Sonoma County. However, charger installation continues to fall short of the need in the County.

Sonoma County has 76 public charging locations that have Level 2 electric vehicle supply equipment (EVSE or chargers) and 8 public charging locations that have DC Fast Chargers (DCFC). Many of these locations have multiple EVSEs. The map below, which shows the currently available public charging locations, is from the plugshare.com website. Other websites which show public charging locations are www.carstations.com and Google while each EV manufacturer and charging station operator has a website to locate public charging stations.

Figure 8: Locations of EV Chargers according to PlugShare.com



Some public EVSEs provide free charging while others charge a fee for charging. Free charging can be found at some government owned charging locations and at commercial locations where the business owner is using the free charging to attract customers to their business. The owners that charge a fee have a charger operator manage the stations. EV drivers using the service register with the charger operator. The registration information would include the driver's payment information.

Two methods are used for determining the cost of a charge. One is to charge a flat fee for initiating the charge and add to that the cost per kilowatt-hour (kWh) for the amount of kWhs used. The other method is to charge a flat fee for initiating the charge and add to that a cost for the amount of time the charger is used.

The typical public Level 2 EVSE has a maximum power output of 6 kW while the power capacity of the current Direct Current Fast Chargers (DCFCs) varies from 50 kW to 120 kW. All EVs, except Teslas, use the CHAdeMO and CCS types of DCFCs, which typically have a 50 kW capacity. The Tesla DCFCs typically have a 120 kW capacity. The battery capacity of all other current battery electric vehicles (BEV) varies from 22 to 28 kWh so the typical full charge would be approximately 20 kWh and would take 3.5 hours using a Level 2 charger or 25 minutes using a 50 kW DCFC. Most Teslas have a battery capacity of 85 kWhs so a full charge would be approximately 65 kWhs and would take 30-40 minutes on a Tesla DCFC.

Nationwide, approximately 81 percent of EV drivers charge at home.¹⁴ Charging at home provides the convenience of starting each day with a full charge. In addition to home charging, workplace charging is growing in popularity. Studies show that employees who have access to workplace charging are 20 times more likely to drive an EV compared to employees who do not have access to workplace charging.¹⁵

Data from the federally funded EV Project shows that:

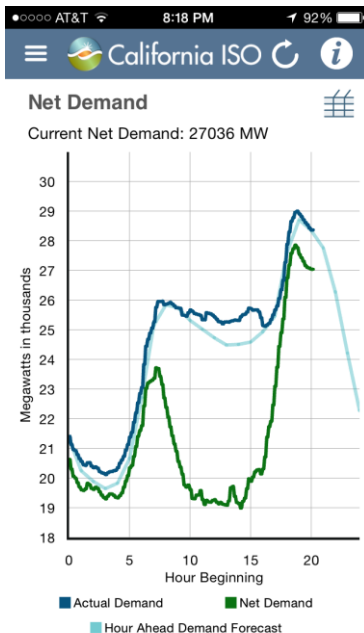
- 4 percent of public chargers are being used, while
- 42 percent of workplace chargers are being used

This suggests that the power capacity and the location are important considerations when installing a public charger. Workplace charging from the hours of 10 AM to 3 PM would also help level the demand for energy on the grid. The following graph from California ISO shows the net energy demand for a typical 24-hour period. Because renewables, especially solar, come on line around 8 AM, the net demand is significantly reduced from 10 AM until 3 PM. This would be an ideal time to charge EVs at workplaces.

¹⁴ PlugInsights U.S. PEV Charging Study: 4TH Quarter, 2013: <http://insideevs.com/most-electric-vehicle-owners-charge-at-home-in-other-news-the-sky-is-blue/>

¹⁵ Survey Says: Workplace Charging is Growing in Popularity and Impact (11/18/14): <http://energy.gov/eere/articles/survey-says-workplace-charging-growing-popularity-and-impact>

Figure 9: Actual and Net Demand for electric power in California

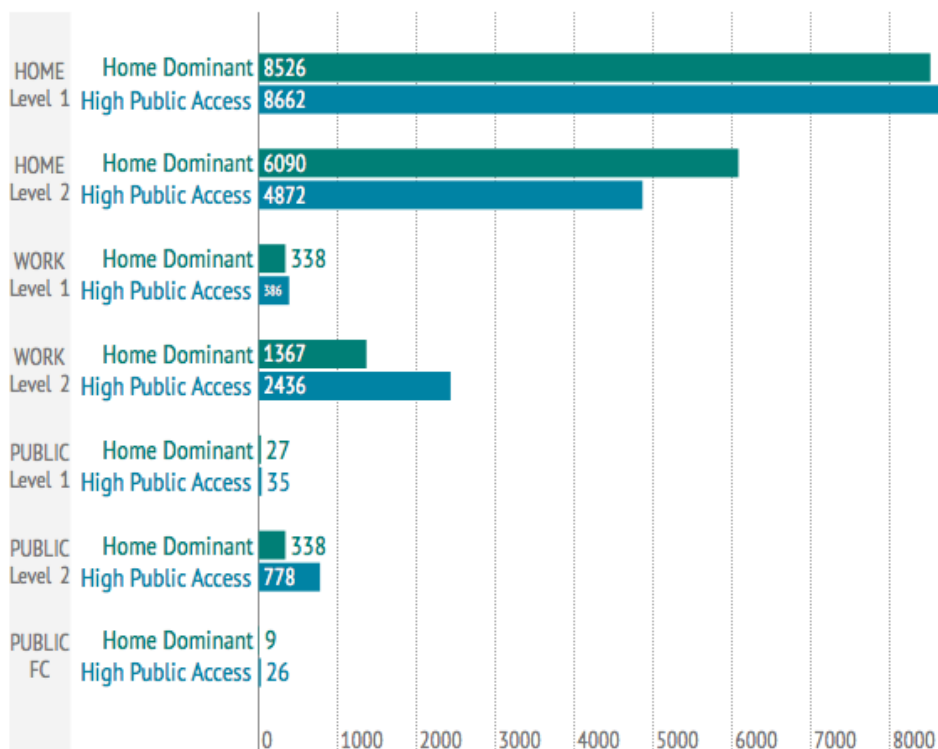


The California Energy Commission was identified as lead agency for a variety of initiatives, related to Governor Brown’s 2012 executive order to meet certain benchmarks for EVs. These include the development of a statewide plan for Plug-In Electric Vehicle (PEV) infrastructure. The California Statewide Plug-In Electric Vehicle Infrastructure Assessment proposes two scenarios that serve as a basis for the roll-out of PEV charging infrastructure capable of supporting 1 million PEVs by 2020.¹⁶

To project charging infrastructure for Sonoma County, the totals for Bay Area charger installations recommended by the CEC EV Infrastructure Assessment were adapted for Sonoma based on population.

¹⁶ California Statewide Plug-In Electric Vehicle Infrastructure Assessment (5/4/14): <http://www.energy.ca.gov/2014publications/CEC-600-2014-003/CEC-600-2014-003.pdf>

Figure 10: Estimated build out of charging stations in Sonoma County for 2 scenarios



Sonoma County may be overlooked by market forces when new charge stations are re-considered because private EV charging infrastructure companies tend to focus on more densely populated areas. It is unknown how PG&E will approach its anticipated large-scale installation of charge stations throughout its territory that includes Sonoma County.

Sonoma County’s newly-formed Sonoma Clean Power may give this community an EV advantage relative to other communities because it may decide that it want to include EV charging among its community benefit programs.

2.3 Incentives and Rebates

Financial incentives are a popular tool to promote adoption of new technologies, and EVs are no different. Numerous incentives are available for early adopters of EVs in California. The federal government, State of California, and regional entities provide these incentives, which include:

California Clean Vehicle Rebate

A single payment rebate check is mailed directly to the applicant on a first-come, first-served basis generally within 90 days of approval, regardless if the vehicle is purchased or leased. It is administered by CSE for the California Air Resources Board, the Clean Vehicle Rebate Project

(CVRP), and offers up to \$5,000 in electric vehicle rebates for the purchase or lease of new, eligible zero-emission and plug-in hybrid light-duty vehicles.¹⁷

Federal Tax Credit (Plug-In Electric Drive Vehicle Credit)

The Federal Government (Internal Revenue Code Section 30D) provides a credit for Qualified Plug-in Electric Drive Motor Vehicles including passenger vehicles and light trucks. For vehicles acquired after December 31, 2009, the credit is equal to \$2,500, and for a vehicle which draws propulsion energy from a battery with at least 5 kilowatt hours of capacity an added \$417 credit, plus an additional \$417 for each kilowatt hour of battery capacity in excess of 5 kilowatt hours. The total amount of the credit allowed for a vehicle is limited to \$7,500.

All BEVs currently qualify for the full \$7,500 rebate. The Chevy Volt, a plugin vehicle with a large battery, also qualifies for the full rebate. However, a Ford Fusion hybrid only qualifies for \$4,007 and the Prius Plugin qualifies for \$2,500.¹⁸ For leased vehicles, the tax credit is often claimed by the manufacturer and used to bring down the lease amount.

California HOV Lane Access

Applicants may apply for decals that allow single-occupant access to HOV lanes once the vehicle has a license plate and registration. There are currently two types of valid decals.¹⁹

White Clean Air Vehicle decals are available to an unlimited number of qualifying Federal Inherently Low Emission Vehicles (ILEVs). Cars that meet these requirements are typically certified pure zero emission vehicles (100percent battery electric and hydrogen fuel cell) and compressed natural gas (CNG) vehicles. Per AB 266, the expiration date for the white stickers has been extended to January 1, 2019.

Green Clean Air Vehicle decals were originally available to the first 40,000 applicants that purchased or leased cars meeting California's transitional zero emission vehicles (TZEV) requirement, also known as the enhanced advanced technology partial zero emission vehicle (AT PZEV)* requirement. Per SB 286, the expiration date for the green decals has been extended to January 1, 2019. Per budget trailer bill, SB 853 (Statutes 2014, chapter 27), the green decal limit was increased by 15,000 to 55,000 decals effective July 1, 2014. Now, per AB 2013, effective January 1, 2015, an additional 15,000 decals will be available for a new maximum of 70,000.

2.4 Market Research

Three factors have major impacts on the adoption of EVs:

1. Convenient charging station availability
2. A larger variety of EVs with better range for drivers to choose from

¹⁷ Center for Sustainable Energy: <http://energycenter.org/clean-vehicle-rebate-project>

¹⁸ US Department of Energy: <https://www.fueleconomy.gov/feg/taxevb.shtml>

¹⁹ Plug-In Electric Vehicle Resource Center: <http://driveclean.ca.gov/pev/Costs/Vehicles.php>

3. Public awareness about the benefits of driving an EV.²⁰

To significantly increase EV adoption, all three of these factors must be addressed simultaneously.

Convenient Charging Station Location

Range anxiety could be reduced by greater availability of Level 2 charging stations at home and/or at the workplace, as well as locations where EV drivers will be parked for two or more hours, along with DCFCs in convenient locations similar to where gas stations are currently located. Since the average American driver drives 37 miles per day and all EVs have a range of at least 75 miles, either workplace charging or home charging would fulfill their typical charging needs. Studies have shown that employees at workplaces with available charging are 20 times more likely to have EV drivers.²¹

Better Range & Variety of EVs

A larger variety of EVs would allow people with different transportation needs to find a vehicle that works for them. The availability of EVs with increased battery capacity would also help people choose a car that would meet more of their needs. Currently all EVs are sedans or small SUVs. Within a year, Nissan and Tesla will be releasing their full size SUVs and vans each of which will have ranges of at least 150 miles. Also, Chevrolet, Tesla, and Nissan have announced that in 2017, each manufacturer will have an EV that sells for approximately \$35,000 and have a range of 200 miles.

This would make available EVs that have double the range at the same price as today's "economy" EVs. Lux Research states, "Pulling off this trick – double the range for the same price – will require dramatic lithium-ion (Li-ion) cost reduction, which battery developers are indeed gearing up for. Doing so will hit a real EV sweet spot, with a better compromise between driving range and price: 200 miles of range will cover far more drivers' use cases than today's more limited economy car EVs, while a \$40,000 or less price point will be affordable to enough buyers to eventually garner hundreds of thousands of annual vehicle sales."

Public Awareness

To accelerate EV sales, more is needed than convenient charging stations and a larger variety of EVs. The public needs to be made aware of the practical and financial benefits of driving an EV. The current government financial incentives are helpful, but governments could also sponsor public awareness campaigns that explain the benefits of driving an EV. Also, EV manufacturers need to increase their marketing campaigns for their EVs. Media advertising needs to be increased from an occasional spot to the frequency of spots similar to what gas cars currently have.

The Center for Sustainable Energy (CSE) produces an annual Plug-in Electric Vehicle (PEV) Owner Survey in coordination with the California Air Resources Board (ARB), researchers at UT

²⁰ Alan Soule, North San Francisco Bay Chapter of the Electric Auto Association

²¹ Alan Soule, North San Francisco Bay Chapter of the Electric Auto Association

Austin's Lyndon B. Johnson School of Public Affairs, and the UC Davis Institute of Transportation Studies.²²

Highlights from the February 2014 survey include:

1. The primary motivations for vehicle purchase vary significantly between models – Leaf drivers claimed environment as the primary motivator, Plug-in Prius owners indicate HOV lane access and Volt drivers said fuel savings.
2. Chevy Volt-driving respondents are more than four times as likely to have a level 2 charging station installed at their home than Toyota Prius Plug-In respondents.
3. Workplace charging availability is becoming more widespread, 46 percent of respondents reported access to workplace charging, an increase of 14 percent from March 2012.
4. Of those with access to workplace charging, 74 percent have access to this charging at no cost to the driver, down from 89 percent in March 2012.
5. Though low, driver satisfaction with public charging infrastructure continues to improve, rising from 17 percent in March 2012 to 29 percent in May 2013.
6. HOV lane access was an “extremely” or a “very important” purchase motivation for 59 percent of respondents; 84 percent are displaying the HOV lane access sticker.

2.5 Economic and Environmental Benefits

Electric vehicle costs are competitive with the life cycle costs of gasoline vehicles, and in some cases are lower, according to the study “Total Cost of Ownership Model for Current Electric Vehicles.”²³ Moreover, Californians gain from economic growth associated with fuel cost savings due to vehicle electrification, whether they or they buy an EV. As a result of vehicle electrification, money that is typically spent on fuel is spent in other ways which tend to benefit the local economy more than profits for fossil fuel companies which end up leaving the state. Both wages and employment increase across the economy and incomes grow faster for low-income communities who also typically spend a great percentage of their income on transportation.²⁴

Economic gains may not be equally shared with all income levels without policies to support EV charging in multi-family housing. Multi-family units have fewer home charging options because they rarely have private garages. Given that the average income for people getting rebates from for EVs is \$100,000 and that EVs have the potential to save users hundreds of dollars per year on fuel, it seems as if the EV sales are missing a significant and important segment of the

²² Center for Sustainable Energy Feb 2014 Plug-in Electric Vehicle (PEV) Owner Survey <http://energycenter.org/clean-vehicle-rebate-project/vehicle-owner-survey/feb-2014-survey>

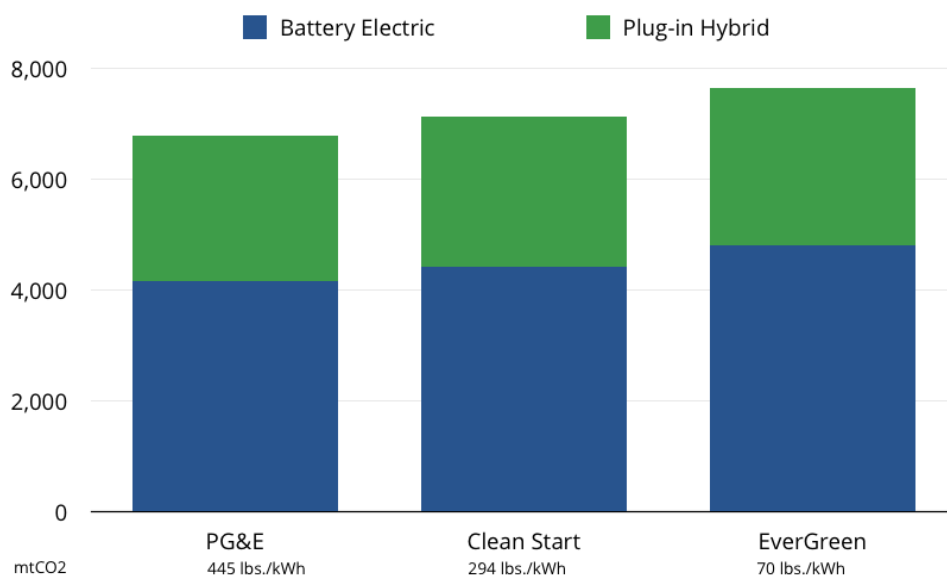
²³ Electric Power Research Institute, 2013

²⁴ Plug-in Electric Vehicle Deployment in California, An Economic Assessment: http://are.berkeley.edu/~dwrh/CERES_Web/Docs/ETC_PEV_RH_Final120920.pdf

population, because of a lack of home chargers which typically covers over 80 percent of the charging for EV owners.²⁵

The environmental benefits of EV driving are significant and can be enhanced by utilizing clean power sources for charging. To date, plug-in vehicles have reduced over 6.7 kilotons of CO2 in Sonoma County. Charging those vehicles with EverGreen, a 100 percent green electricity option available through Sonoma Clean Power, would have reduced an additional 835 mtCO2.²⁶

Figure 11: GHG Reductions from Electric Vehicles in Sonoma County (2010-15)



Gasoline vehicles emit GHGs, criteria pollutants (smog-forming compounds), and toxic air contaminants (TACs). In particular, relative to TACs, the California Office of Environmental Health Hazard Assessment and American Lung Association collaborated to produce a factsheet “Fuels and Your Health” that summarizes these TACs and their danger they pose to human health.²⁷

In addition to the gasoline required as fuel, gasoline automobiles require a variety of toxic and/or hazardous materials and liquids that electric vehicles do not require, and that pose a potential threat to the environment. These substances include motor oil, transmission fluid, and radiator antifreeze/coolant. Replacing gasoline vehicles with electric vehicles eliminates the need for these substances.

²⁵ 81% of Electric Vehicle Charging is Done at Home
<http://insideevs.com/most-electric-vehicle-owners-charge-at-home-in-other-news-the-sky-is-blue/>
²⁶ Based on primary research conducted for this white paper
²⁷ Fuels and Your Health factsheet - Office of Environmental Health Hazard Assessment:
http://www.oehha.ca.gov/public_info/facts/pdf/fuels4-02.pdf

There are also some less obvious benefits. A recent study showed that the urban 'heat island' effect can also be tempered by electric vehicle adoption. For example, in Beijing, China, they found that EVs emit only 19.8 percent of the total heat emitted by combustion vehicles (CVs) per mile. The replacement of CVs by EVs in 2012 could have mitigated the summer heat island intensity by about 0.946 Celsius, reduced the amount of electricity consumed daily by air conditioners in buildings by 14.44 million kilowatt-hours (kWh), and reduced daily CO2 emissions by 10,686 tonnes.²⁸

2.6 Municipal Government Support

County of Sonoma

The County of Sonoma has established itself as a national leader in adoption of EVs. A recent issue of Government Fleet magazine, dated July 9, 2014, stated: "Sonoma County and the Sonoma County Water Agency purchased 27 vehicles ... The addition brings the county's alternative fuel fleet vehicle total to more than 300, encompassing more than 30percent of the agencies' cars, vans, and light-duty trucks and creating one of the largest plug-in hybrid electric vehicle fleets in the country." The City of Sonoma has installed multiple EV charging stations at its City Hall.

In addition, in April 2015 the EPA honored the County of Sonoma with an award, "for protecting air quality, fighting climate change with one of nation's largest hybrid vehicle fleets."²⁹

TRANSPORTATION EFFICIENCY INNOVATIONS

Fleet Hybrid Electric and All Electric Vehicle Program

County of Sonoma Fleet Operations

<http://www.epa.gov/air/cleanairawards/winners-current.html>

The County of Sonoma has been a leader in transportation-related emission reductions in California for more than 24 years. Starting in 1990, the County tested a prototype all-electric van in a fleet environment. In 2006, the County adopted a Climate Protection Action Plan that established a target of reducing GHG emissions from its on-road fleet by 20percent before the end of 2010. The target was more aggressive than the State of California's AB 32 Global Warming Solutions Act of the same year with a compliance date 10 years sooner than the state. Fleet related GHG emissions have been reduced by over 1,815 tons even though overall vehicle miles traveled increased by 10 million miles during the last 11 of 13 years. The County's investment in hybrid electric and all-electric vehicle technology has resulted in one of the largest BEV, HEV, NEV and PHEV government fleets in North America. The hybrid fleet has reduced gasoline and diesel fuel usage by over 166,500 gallons while traveling over 10 million miles since 2002. The

²⁸ Hidden Benefits of Electric Vehicles for Addressing Climate Change, Scientific Reports Published 19 March 2015, <http://www.nature.com/srep/2015/150319/srep09213/pdf/srep09213.pdf>

²⁹ EPA Clean Air Awards: <http://www.epa.gov/air/cleanairawards/winners-current.html>

County took a lead role in creating one of the first comprehensive regulatory guideline documents in the nation addressing the installation of EV charging station infrastructure with the publication of the 'County of Sonoma Electric Vehicle Charging Station Program Installation Guidelines' in July of 2011. The document has been used as a reference by government agencies across the United States and in other parts of the world. The County received the California EPA Governor's Environmental and Economic Leadership Award in 2013 and The Bay Area Climate Collaborative's 'Most EV Ready Community in the Bay Area' award in 2011 and 2012.

Cloverdale

The City of Cloverdale does not mention of EV's in their 2008 General Plan Update and has no information on alternative fuel vehicles on their website. They have no EV's in their fleet of 14 vehicles.

Cotati

The City of Cotati does not mention EVs in its current general plan and only mentions emission reductions in the draft General Plan currently under development. The City offers EV charging at its community center.

Healdsburg

In 2011, the Healdsburg Green City Committee adopted a policy for a Zero Emission Vehicle (ZEV) Program. This program encourages investment in ZEVs (including hydrogen fuel cell and battery electric vehicles) and near-zero emission vehicles (including plug-in hybrids, conventional hybrids, and compressed natural gas vehicles). The City of Healdsburg offers EV charging at its City Hall.

Petaluma

The Petaluma General Plan 2025 encourage the use of battery-powered, electric, or other similar equipment that impacts local air quality. The city owns four Prius staff cars out of a fleet of about 220 vehicles. EV charging stations have been installed at the future SMART station and in addition to a number of other locations in the city.

Rohnert Park

The city of Rohnert Park has an EV policy from 2012 which states, "the City of Rohnert Park has committed to developing an electric vehicle program as part of the City's efforts to reduce greenhouse gas emissions." Currently the City does not have any electric or hybrid vehicles in the fleet, though EV charging is available at the City's library branch on 495 City Center Drive.

Santa Rosa

The City of Santa Rosa has a statement on their website, "Greening the City Fleet: The City of Santa Rosa Fleet Management Section is known locally as an industry leader in clean air technology. The City of Santa Rosa has one of the largest clean burning alternate fueled city fleets in the State of California. Currently we have nearly 100 pieces of hybrid, electric, compressed natural gas, or propane powered equipment. This number of vehicles and

equipment represents approximately 10percent of the City’s fleet.” The City of Santa Rosa has also installed multiple EV charging locations at the City Hall and their Stony Point facility.

Sebastopol

The City of Sebastopol has two separate resolutions in support of municipal EV adaptation. The first resolution came in 2002 and states that, “Cities are significant users of vehicles and equipment, and as public institutions, cities have a responsibility to serve the public interest; Cities can and should lead by example so that residents and businesses will also willingly participate in clean air programs. The City of Sebastopol City Council shall identify and give preference in its vehicle procurement to the lowest emission vehicles available.” The City of Sebastopol has installed multiple EV charging stations at its City Hall, while the city fleet currently has one Prius purchased in 2005.

City of Sonoma

The City of Sonoma’s policy, titled “City of Sonoma GHG Emissions Reduction Action Plan 2007,” states: “Battery powered electric vehicles pose opportunities for cost savings and enhanced convenience in an increasing number of applications where their unique properties can be used to advantage.” Currently they have yet to add EVs to the fleet, but offer several downtown charging stations.

Windsor

The Town of Windsor has a detailed policy in place under the Town of Windsor GHG Emissions Reduction Action Plan Update 2012. The resulting fleet changes are projected to save over 1,300 gallons of fuel annually, resulting in roughly 11.5 metric tons of CO₂e avoided annually. Windsor has 12 EVs out of 117 vehicles in their fleet. The Town of Windsor offers EV charging near its library on the Town Green.

3. Literature Review

3.1 Technology

Charging Levels (1,2,3)

There are three levels of commercial charges, Level 1, Level 2 and Direct Charge (DC). They provide different levels of charge with a different length of time to charge the battery. The Level 1 is 120 volts and adds about 5 miles of range per hour of charging. The Level 2 is 208/240 volts and adds about 20 miles of range per hour of charging. The DC Fast Charging adds anywhere from 100 miles of range to 240 miles of range depending on the power level of the charger.

The home charger is either Level 1 or Level 2. Many people install a Level 2 charger at home to reduce the time it takes to charge to 2-4 hours. Most EV charging is done at home. Charging standards (plug types) include:

- Level 1 and Level 2: SAE J1772 (universal)
- DC Fast Charging: CHAdeMO; Tesla; SAE CCS

The distance that you can travel in an economical EV is often limited to forty miles round trip without planning to get a charge during the trip. DC chargers are needed to expand both market penetration of the EV and use beyond that of a “second vehicle.” Currently all DC chargers in Sonoma County are located on the US 101 corridor. However, there are no DC charging stations north of Santa Rosa and most DC chargers are at EV dealerships. Widespread availability of DC chargers will make the use of EVs more convenient and more appealing.

Battery Development

The biggest goal in battery development is to reduce the manufacturing costs for batteries to the point where electric vehicles can compete with ICEVs at the point of sale. To reach this goal for manufacturers must produce batteries that cost less than \$150 per kilowatt-hour in the mid-term and less than \$100 per kilowatt-hour in the long-term.

The researchers behind one study developed a “should-cost” model, which suggests that the price of a lithium-ion battery pack could drop from today’s cost of about \$500 to \$600 per kilowatt hour to about \$200 by 2020 and \$160 by 2025.³⁰

Competition with ICEV based on battery price

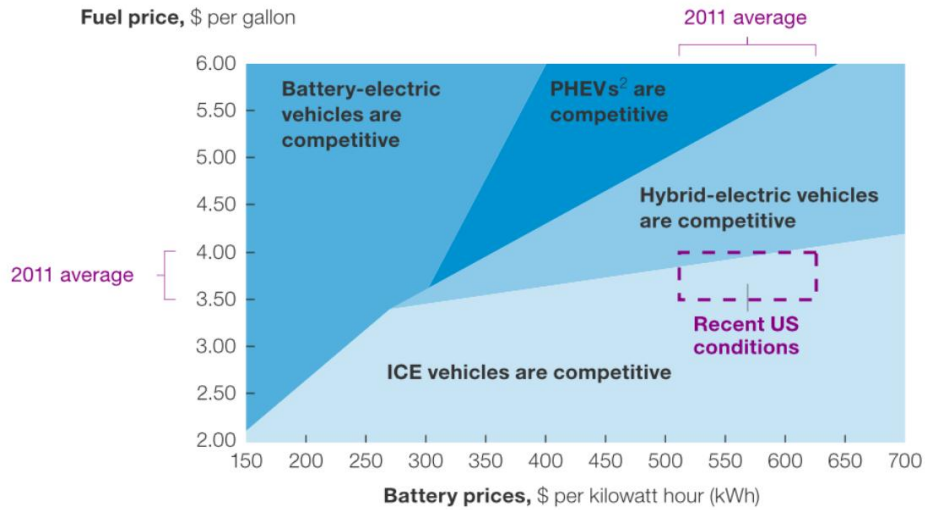
Of course, the pace of adoption will hinge on a range of factors in addition to battery prices.³¹ Macroeconomic and regulatory conditions, the performance and reliability of the vehicles, and customer preferences are important. The rate at which automakers realize lower battery prices could vary by three to five years, which is the length of a product-development cycle.

Technical advances in cathodes, anodes, and electrolytes could increase the capacity of batteries by 80 to 110 percent by 2020–25. These efforts represent 40 to 45 percent of the identified price reductions. New battery cathodes that incorporate layered–layered structures eliminate dead zones and could improve cell capacity by 40 percent. Manufacturers are developing high-capacity silicon anodes that could increase cell capacity by 30 percent over today’s graphite anodes. And researchers are developing cathode–electrolyte pairs that could increase cell voltage to 4.2 volts, from 3.6 volts, by 2025, thus increasing cell capacities by 17 percent over present-day standards—and potentially by much more.

³⁰ Marc Carter, “Declining Lithium-Ion Battery Costs Could Knock Thousands Off the Price of Electric Cars”, Inhabitat, 12 July 2012, retrieved 20 March 2015 from http://www.mckinsey.com/insights/energy_resources_materials/battery_technology_charges_ahead

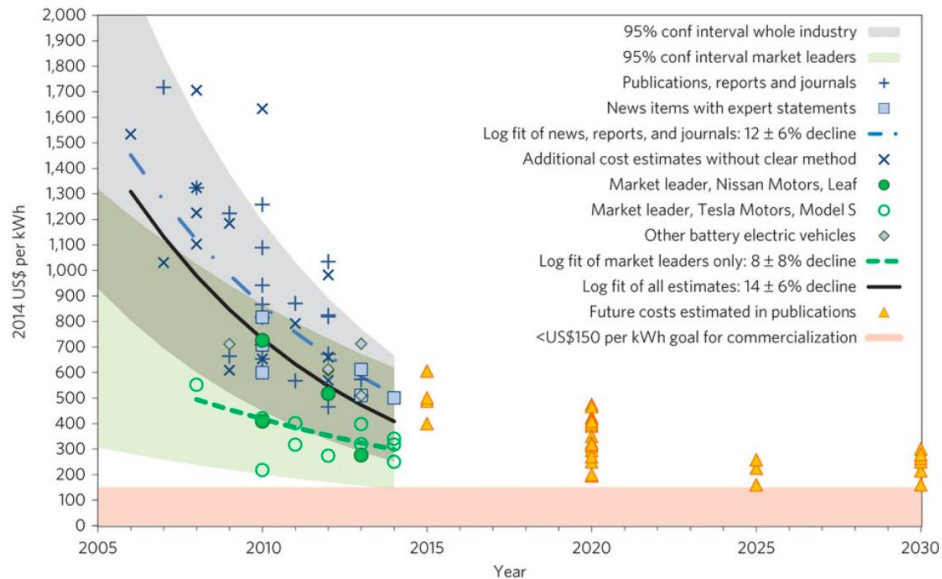
³¹ McKinsey Quarterly, Battery technology charges ahead, July 2012 http://www.mckinsey.com/insights/energy_resources_materials/battery_technology_charges_ahead

Electrified vehicles' projected competitiveness with internal-combustion-engine (ICE) vehicles, based on total cost of ownership¹ (US example)



Price reduction of batteries³²

A recent report showed that industry-wide battery cost estimates declined by approximately 14 percent annually between 2007 and 2014, from above US \$1,000 per kWh to around US \$410 per kWh, and that the cost of battery packs used by market-leading BEV manufacturers are even lower, at US \$300 per kWh.



³² Rapidly falling costs of battery packs for electric vehicles, Nature Climate Change 5, Published online 23 March 2015: <http://www.nature.com/nclimate/journal/v5/n4/full/nclimate2564.html>

*Market leaders 5 years ahead of battery cost projections*³³

The cost of electric vehicle battery packs is falling so rapidly they are probably already cheaper than expected for 2020, according to a new study in *Nature Climate Change*. Although electric vehicles remain more expensive than combustion-engine equivalents, largely because of battery costs, in 2013 the International Energy Agency (IEA) estimated cost-parity could be reached in 2020, with battery costs reaching \$300 per kilowatt-hour of capacity. But market-leading firms were probably already producing cheaper batteries last year, says today's new research. It says its figures are "two to four times lower than many recent peer-reviewed papers have suggested."

The authors estimate that prices will fall further to around \$230 per kilowatt-hour in 2017-18, "on a par with the most optimistic future estimate among analysts." The crossover point where electric cars become cheapest depends on electricity costs, vehicle taxes and prices at the pump. In the US, with current low oil prices, battery packs would need to fall below \$250 per kilowatt hour for electric cars to become competitive, the study says. Behavioral barriers, such as charging needs, present additional hurdles to widespread EV adoption.

According to the authors, "If costs reach as low as \$150 per kilowatt hour this means that electric vehicles will probably move beyond niche applications and begin to penetrate the market more widely, leading to a potential paradigm shift in vehicle technology."

The 30 percent cost reduction expected at Tesla Motors' planned "Gigafactory" battery plant by 2017 represents a "trajectory close to the trends projected in this paper." On the other hand Renault-Nissan's plans to build battery-manufacturing capacity for 1.5 million cars by 2016 have proven unrealistic, as electric car sales have trailed expectations.

There are large uncertainties in the paper's findings. Despite being the most comprehensive review to date, it relies on "sparse data" and acknowledges that a secretive industry might avoid revealing high costs, or conversely might subsidize battery packs to gain market share. Overall it is "possible" that economies of scale will push costs down towards \$200 kilowatt hour "in the near future even without further cell chemistry improvements," the authors conclude.

Citigroup has also declared a projected tipping point for vehicle price.³⁴ An analyst there points to \$230/kWh as the key mark where battery storage wins out over conventional generation and puts the fossil fuel incumbents into terminal decline. UBS, in a report based around a discussion with Navigant research, says the \$230/kWh mark will be reached by the broader market within two to three years, and will likely fall to 100/kWh.

³³ Electric vehicle batteries 'already cheaper than 2020 projections', 23 Mar 2015, *The Carbon Brief*, <http://www.carbonbrief.org/blog/2015/03/electric-vehicle-batteries-already-cheaper-than-2020-projections/>

³⁴ How battery storage costs could plunge below \$100/kWh, 7 October 2014 <http://reneweconomy.com.au/2014/battery-storage-costs-plunge-below100kwh-19365>

3.2 Social Aspects and Policy

Relatively little research exists on what persuades people to buy an electric vehicle, but a recent paper published from UC Davis reported the results from a controlled discussion between EV owners and non-EV owners. Some interesting points made by the authors include:

- EV owners see EVs and signs of them everywhere; owners of conventional vehicles don't see the signs anywhere. It's like they're living in two different worlds.
- Once we make non PEV drivers aware, they first want to know about cost. Probably because they don't know what to ask about — it's just a common metric.
- They don't ask about incentives or infrastructure because they don't know about it.
- In some areas (San Jose) there's more awareness because of HOV stickers
- Non-EV owners not aware that we're in a transition away from fossil fuels. Typically they were not even aware that EVs are for sale.
- Many drivers are skeptical about completing all their driving needs in a BEV.
- Over-emphasis on economic side in discussions.
- Thinking more broadly, these stories about economics are a fragile narrative because if cheapness goes away — then what happens?
- Doesn't seem that drivers are not communicating real reason they received incentives (Fresno resident did not make connection that he got funding from the Air District)
- Can we construct a narrative that's more resilient than the one we saw constructed?
- How do you roll that out?
- Something based on vehicle options, spending on incentives and infrastructure?
- Can we provide positive behind the wheel experiences?

The authors expressed interest in seeing more “interventions tried,” as long as good data is kept. As a new approach, they suggested that current EV owners and advocates want to talk about economics, but instead should talk about how it's the best vehicle they've ever owned and that you can get these environmental rebates that make EV even more affordable. They put the quality of the experience ahead of the rational economic arguments.

There has also been insightful research on the policies used to increase adoption of EVs. A 2013 paper from the University of New South Wales suggested that government policies that directly address consumers instead of manufacturers and retailers are the most effective in boosting EV sales. According to the paper, “Policies that offer benefits frequently as opposed to one off payments may also increase EV exposure.” The authors suggest that the most cost effective policy should be to offer 70 percent subsidies on electricity used to charge EVs.³⁵

³⁵ Framework to Evaluate Policy for Promotion of Electric Vehicles, 2013, Lara Edwards, Jonathon Kemp, Nuwyy Ly, Maria Tran and Vinayak V. Dixit, School of Civil and Environmental Engineering University of New South Wales

3.3 Future Development

Automobile manufactures have made a number of recent announcements about compelling vehicles expected to come to market in the 2017-18 time frame.³⁶

Some scenarios affecting electric vehicle adoption and growth are:

1. Transportation as a service with autonomous vehicles would impact how electric vehicles are charged, making it possible to optimize vehicle charging time across a fleet of autonomous EVs.
2. Solid state batteries with greater energy density and other beneficial attributes like lower susceptibility to fire. Volkswagen executives have suggested that solid state batteries would lead to 430 mile range and prices around \$100/kwh.³⁷

In addition to battery development, there may be significant evolutions in transportation where the solution is not to drive at all. Some of these are already happening:

1. Driving to shopping malls or outlets - Amazon and other online retailers are eliminating the need to drive to shop.
2. Socializing - Kids today are happy being social online instead of driving to hang out at the mall or to a friend's house.
3. Telecommuting - A growing commute solution, but still not widely adapted because of the need for informal social interaction in the work environment
4. Servitization of transportation - Zipcar and Uber are redefining transportation as a service.

Non-consumption of driving is proving to be a real trend. It could be enhanced by other disruptions, such as virtual reality allowing people to feel like they have presence in other places where they might otherwise travel.

3.4 Case Studies

West Coast Electric Highway

The "West Coast Electric Highway" is an extensive network of DC fast charging stations located every 25 to 50 miles along Interstate 5 and other major roadways in the Pacific Northwest. The Washington State Department of Transportation is responsible for the Washington segment, the Oregon Department of Transportation heads up the Oregon segment, and the California segment is coordinated by a Governor's Office interagency group.

³⁶ Timeline of electric vehicles: http://www.ucsusa.org/clean_vehicles/smart-transportation-solutions/advanced-vehicle-technologies/electric-cars/electric-vehicle-timeline.html#.VNKYT0KBs7Y

³⁷ Green Car Reports (11/24/14), Solid-State Batteries For Electric Cars: 'Great Potential,' VW CEO Says: http://www.greencarreports.com/news/1095609_solid-state-batteries-for-electric-cars-great-potential-vw-ceo-says

*Portland, Oregon*³⁸

The City of Portland, with a population similar to Sonoma County, has made considerable progress in laying the foundation for a shift to EVs. Also similar to Sonoma County, Portland has a number of favorable conditions for EV adoption:

- Short commutes (average: 18.5 miles)
- Affordable electricity prices
- A comparatively clean electricity system
- Good climate: warm, dry summers and wet, but mild, winters

In addition, Portland has an environmentally concerned public, with 58 percent of residents supporting the goals of their Climate Action Plan and 22 percent desiring more aggressive goals.

In terms of infrastructure, Portland received funding from the U.S. Department of Energy to deploy 2,000 stations in Portland and the surrounding area by 2013. Charging will be free to participants who agree to anonymous data collection and will be mostly offered at Level 2 (220V), with some DC Fast chargers available in select areas.

The State of Oregon is also assisting with targeted incentives. For example, the state offers rebates up to \$750 for residential charging installations and up to a 35 percent tax credit for businesses installing charging stations. Businesses are also eligible for up to 35 percent of the incremental cost between an ICE vehicle and an EV in Oregon Business Energy Tax Credits. The Oregon Transportation Commission has also approved a program that designates \$4 million for Oregon businesses interested in replacing diesel trucks with electric.

*Workplace Charging in California*³⁹

The California Plug-In Electric Vehicle Collaborative has a list of 20 case studies on plug-in electric vehicle charging at work. According to their report, the top challenge for installing charging stations at work was the cost of installation along with the cost of the charging equipment itself. Reported barriers to workplace charging include:

Issue	# of times stated
Cost of installation	58
Cost of equipment	43
Other	29
Equipment utilization	15

³⁸ EV City Casebook, 2012

<http://www.iea.org/publications/freepublications/publication/EVCityCasebook.pdf>

³⁹ California Plug-In Electric Vehicle Collaborative:

http://www.pevcollaborative.org/sites/all/themes/pev/files/WPC_Report4web.pdf

Equity in terms of employee benefits	15
Internal policy	12
Liability	8
Buy-in from senior management	2

The most frequent response was that the cost to the employer ranged from \$3,000 to \$5,000 per unit, not including installation. In more than one-third of the surveys, employers mentioned receiving federal, state or regional grants to offset their expenses. Thus, approximately two-thirds of the workplaces surveyed likely invested their own resources to install charging stations.

The report shows evidence that the availability of workplace charging factored into employees' decisions to purchase a PEV; in fact, most employers believe providing workplace charging will encourage more employees to become EV owners.

4. Funding

4.1 Government

In addition to incentives, the State of California has targeted a number of different programs to use cap and trade funds from AB32 to boost the adoption of electric vehicles. For example, the *Low Carbon Transportation Program*, overseen by the California Air Resources Board, with a \$200M budget in 2014-15 to “accelerate the transition to low carbon freight and passenger transportation.” The program’s budget is based on an annual appropriation and is currently the second largest program in the Cap and Trade Expenditure Plan (behind High Speed Rail).

4.2 Utilities

Chargers are slowly making their way into the mainstream. One impediment was that the California Public Utilities Commission denied public utilities the opportunity to install chargers due to issues of competition. Recently, they reversed that decision.

San Diego Gas and Electric is prepared to install 30,000 chargers in their service area. Pacific Gas and Electric recently announced that they will install 25,000 chargers within their service area.

4.3 Private Charging Networks

There are several companies in the EV charger business. Some prominence has been given to US Interstate 5 which has been referred to as the Electric Highway. Private charging companies

such as ChargePoint and Blink have also partnered with auto manufacturers to offer access to a network of chargers as an incentive to buy an EV. This has increased the buildout for the private networks. In addition, Chargepoint also offers financing options for businesses interested in installed EV charging infrastructure.

5. Findings

Findings

5.1. For reducing GHG emissions, fuel shift is significantly more powerful than mode shift.

Reducing GHGs from transportation is a complex problem that requires a variety of solutions. Mode shift, for example switching from driving to biking, is essential for GHG reduction, and brings co-benefits like congestion and safety improvements. However, to rapidly reduce GHGs at scale in transportation, fuel shift is a more powerful solution. Total emissions reduced from EVs in Sonoma County through March 2015 exceed 7,000 mtCO₂, a significant amount compared to any other single measure to reduce GHGs from transportation.

5.2. Workplace chargers significantly increase electric vehicle miles travelled.

Plug-in hybrid vehicles are likely to remain a significant portion of EV sales, as shown by the Sonoma County market share of Chevy, Ford, and BMW sales. Larger battery sizes for plug-in hybrid vehicles (PHEVs) are also expected to increase their uptake. Evidence exists that additional workplace charging would significantly increase the number of electric vehicle miles travelled (eVMT) from PHEVs. Based on Sonoma County's current vehicle mix, we could expect a 24 percent increase in eVMT from PHEVs if workplace charging were widely available.

5.3. Renewable power boosts GHG reductions from EVs.

With a choice of electrical service widely available through Sonoma Clean Power starting in 2014, Sonoma County drivers can charge their electric vehicles with greener electricity, even 100 percent green. Having a 100 percent green option is rare outside of a few places, like Iceland, and gives Sonoma County a new advantage in reducing its emissions produced by transportation. Switching EV charging from PG&E's current power mix to 100 percent renewable electricity would result in nearly a 13 percent reduction in GHG emissions.

5.4. More affordable, desirable EVs are on the horizon.

While EV sales lag behind projections, battery price reductions are running ahead of schedule. New EV models coming on the market are expected to have lower prices and longer ranges, and promise to boost EV sales significantly beginning in 2017-18.

5.5. Meeting state goals requires significantly more EV chargers in Sonoma County.

Governor Brown set bold goals for developing California's EV charging infrastructure. To do its part, by 2020 Sonoma County needs to have installed about 14,600 home chargers, 1,700 workplace chargers, 365 public chargers, and 9 fast chargers. For a sense of scale, these Sonoma County amounts overshadow the approximately 2,000 total chargers installed in the San Francisco Bay Area region through the end of 2014. This is roughly 25 percent of the chargers needed to be on track to meet our region's 2025 goal of 36,000 chargers.⁴⁰

5.6. Local and regional policies can accelerate EV use.

Local and regional governments can accelerate EV use with policies that augment state and national EV incentives. Such policies should offer EV users tangible and immediate benefits, for example, more EV-friendly electricity rates, particularly at advantageous times of the day.

5.7. Many potential EV users are unaware of EVs and related infrastructure.

EV adoption is hampered because many drivers are unaware of the availability and benefits of EVs. A marketing campaign to increase public awareness and emphasize the quality of the experience should be mounted. This recommendation echoes one made in the Bay Area Plug-in Electric Vehicle Readiness Plan, but not yet implemented.

5.8. Increased funding to accelerate EV adoption will soon be available.

New funds available through California's cap and trade program, and new directives from Governor Brown are expected to result in more funding in California to continue incentives and pilot programs for EV adoption. In addition, the Bay Area Air Quality Management District is planning to target more regional funds to increase Zero Emission Vehicle adoption, for example, through the Transportation Fund for Clean Air. Communities that develop plans for increased EV infrastructure and public outreach will be competitively positioned for anticipated funding.

6. Recommendations

While developing concrete next steps is yet to be done, several general recommendations – offered below – emerged in writing this white paper. As with most big, new endeavors, collaboration among government, business, and community stakeholders is required to ensure success. The Center for Climate Protection has recently convened EV stakeholders for this purpose, and will continue to do so as appropriate. This group of EV stakeholders will focus on developing and implementing the recommendations described below, at least in the short term.

6.1. Advocate for policies and funding, especially at the state level, to accelerate EV use

⁴⁰ California Statewide Plug-In Electric Vehicle Infrastructure Assessment (5/4/14): <http://www.energy.ca.gov/2014publications/CEC-600-2014-003/CEC-600-2014-003.pdf>

Examples of desired policy include continuing EV rebates, HOV access for EVs, discounted electricity rates, and programs to make EVs more accessible for low-income populations. Exploration of local and regional policies that accelerate EV use should also be pursued.

6.2. Expand EV charging, especially at workplaces, multi-family units, and along main transportation corridors

To meet the demand expected in 2017-18 from increased EV use, Sonoma County needs much more EV charging infrastructure including home and work chargers, fast and slow chargers.

- Install Level 2 chargers at workplaces, multi-unit dwellings, and other locations where EV drivers would be parked for 2 hours or more. Potential partners include PG&E, SCP, and commercial EVSE operators.
- Install DC fast chargers in locations convenient for EV drivers who are travelling beyond the range of their daily charge. As noted above, potential partners include PG&E, SCP, and commercial EVSE operators.
- Coordinate employers and address the cost barrier with specific state and private funding solutions to increase workplace charging.

6.3. Develop and implement an EV awareness campaign

Research indicates that many potential EV buyers are unaware that such vehicles are available. Sonoma County should run a public awareness campaign and/or be part of a regional campaign to accelerate EV adoption. An EV awareness campaign could include:

- EV demonstrations, shows, and fairs where the public can view EVs and ask non-affiliated EV drivers about their experiences
- Education and promotion of the benefits of driving an EV through media channels
- Websites containing comprehensive EV information
- Clear, uniform signage noting the location of charging stations

6.4. Develop EV charging infrastructure through increased coordination

Sonoma County needs more coordination among the many EV players to develop needed EV charging infrastructure. Charging station locations must be planned and prioritized to have the greatest positive impact on EV market penetration, tourism, and EV range. The Sonoma County Regional Climate Protection Authority's Fuel Shift Plan currently under development is intended to provide such coordination.

7. Resources

Center for Sustainable Energy data set on California Air Resource Board's Clean Vehicle Rebate Project

<https://energycenter.org/clean-vehicle-rebate-project/rebate-statistics>

California Plug-In Electric Vehicle Collaborative

<http://www.pevcollaborative.org/policy-makers>

Inside EVs — Monthly Plug-In Sales Scorecard

<http://insideevs.com/monthly-plug-in-sales-scorecard/>

Bay Area PEV Ready (BAAQMD)

<http://www.bayareapevready.org/participate/>

ADA electric vehicle charging stations in California (ADA Compliance Consultants)

<http://www.ada-pros.com/ada-electric-vehicle-charging-stations-in-california/>

Governor's Office of Planning and Research — Plug-In Electric Vehicles: Universal Charging Access Guidelines and Best Practices

http://opr.ca.gov/docs/PEV_Access_Guidelines.pdf

Plugin-in Electric Vehicle Resource Center

<http://driveclean.ca.gov/pev/Costs/Vehicles.php>