ELECTRIC VEHICLES IN SONOMA COUNTY

WHITE PAPER ON EV STATUS AND PATHS TO ADOPTION

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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
FCEV	Fuel Cell Electric Vehicle
GHG	Greenhouse Gas
PEV	Plug-In Electric Vehicle
PHEV	Plug-In Hybrid Electric Vehicle
VMT	Vehicle Miles Travelled
ZEV	Zero Emission Vehicle

Note about the Scope of this White Paper

This white paper focuses on the development of infrastructure for battery-electric vehicles and the increase in the numbers of these vehicles within Sonoma County. It is the authors' intent to describe what is happening, offer possible recommendations for action, and spur the conversation to accelerate EV adoption.

Currently, related technologies are emerging, such as fuel cell electric vehicles (FCEVs), for which an entirely different infrastructure is required, presenting several significant technical and driver-experiential differences. Although FCEVs are mentioned in this paper, a thorough discussion is beyond the scope of the paper. Concepts for integration of battery-electric vehicles into the electricity grid, known as "Vehicle-to-Grid" or V2G, are also emerging, whereby two-way electronic communication may allow a critical mass of EVs to provide grid services.

Both of these topics, and other emerging technologies, are worthy of further investigation and may be addressed in more detail in future revisions of the paper.

This white paper is intended to be a work in progress. Input, feedback, and suggestions are invited, and should be directed to Doron Amiran at the Center for Climate Protection (doron@climateprotection.org).

Executive Summary

This paper describes Sonoma County's status and progress in adopting electric vehicles (EVs), and identifies the greatest opportunities to accelerate the transition to an electric-powered transportation system.

Transportation accounts for well over half of the greenhouse gas (GHG) emissions produced in Sonoma County. Nearly 80% of all trips are made by single-occupant, fossil-fuel powered automobiles. Every year Sonoma County spends $850 million dollars to pay for those fossil fuels.

EVs offer one of the biggest opportunities to address GHG emissions from transportation, and will help strengthen both the local environment and economy. In 2013, Governor Brown set a goal for 1 million EVs to be sold in California by 2023.

Sonoma County had 1,500 electric cars by the end of March 2015, and over half of those EVs were purchased or leased in 2014 alone. This accounts for 1.6% of California's EV sales, which is ahead of its share of the population. 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] Given today's growth trend, Sonoma County will meet its share of the Governor's EV goal. However, more rapid EV uptake is needed for Sonoma County to achieve its GHG goal and align with the scientific imperative for a life-sustaining climate.

This paper identifies eight key findings. Among these is that fuel shift – switching from gasoline to electric – is significantly more promising for reducing GHG emissions than mode shift – switching from a personal automobile to a different mode of transportation like a bike or a bus. Also, the availability of workplace chargers dramatically increases the likelihood that employees will purchase EVs, while also increasing the amount of electric vehicle miles they will travel.

Barriers to more rapid EV adoption include vehicle range, availability of charging, and education of both the car-buying public and the sales force who serve them.

To overcome these barriers, this paper makes four recommendations including the need for stronger policies and increased funding to accelerate EV use; expansion of EV charging, especially at workplaces, multi-family units, and along main transportation corridors; increased coordination for EV charger expansion; and the development of an EV awareness campaign.

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

1 Introduction

Transportation is the largest and fastest growing source of greenhouse gas (GHG) emissions in Sonoma County, accounting for about 65 percent of total emissions in 2014.[2] 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.[3]

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

More than 1,500 plug-in hybrids and battery electric cars have been sold in Sonoma County since the latest generation of 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.[4]

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 continues to increase.

[2] Center for Climate Protection. "Sonoma County Greenhouse Gas Report for 2014." (July 2015) Online. Available: http://climateprotection.org/GHG-REPORT- 072815
[3] Center for Climate Protection. "Sonoma County Community Climate Action Plan." (Nov 2008) Online. Available : http://coolplan.org/ccap-report/CCAP_Final_11-05-08.pdf.
[4] Center for Sustainable Energy. "Clean Vehicle Rebate Project Rebate Statistics." Prepared for the California Air Resource Board. Available: http://energycenter.org/clean-vehicle-rebate-project/rebate-statistics.

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

ZAP (Zero Air Pollution) is thought to be the world's first electric bicycle company. By 1999, they employed over 100 people in Sebastopol and built more than 30,000 bikes and powered 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, a unique electric automobile alternative. Hundreds of students have experienced their hands-on training to build and design electric vehicles.

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.[5]

Senate Bill 1275 (September, 2014) was the first significant bill to address Electric Vehicles (EV) in California. SB1275 states: "It is 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."[6]

[5] National Renewable Energy Laboratory. "California Statewide Plug-In Electric Vehicle Infrastructure Assessment." Prepared for the California Energy Commission (May 2014) Online. Available: http://www.energy.ca.gov/2014publications/CEC-600-2014-003/CEC-600-2014-003.pdf.

[6] California Senate Bill 1275, Section 1(k), (September 21, 2014). Online. Available: http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140SB1275

The California Air Resources Board (CARB) is in charge of carrying out the mission of SB1275, with the support 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 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 SB1275 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 offer driving opportunities.
3. Transform fleets
    a. Take necessary steps to ensure that at least 10 percent of state's light-duty vehicle purchases are ZEVs by 2015 and that at least 25 percent 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.

[7] Office of Governor Edmund G. Brown Jr. "The State of California's 2013 ZEV Action Plan." (Feb 2014) Online. Available: http://opr.ca.gov/docs/Governor%27s_Office_ZEV_Action_Plan_%2802-13%29.pdf.

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.
    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

EV sales in Sonoma County are growing. Certain communities within the County are adopting EVs at a higher rate than others, and certain vehicles have proven the most popular. Sonoma County also 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). This is significant because BEVs have a higher impact than PHEVs on reducing emissions and saving money on fuel.[9] The following tables break down the patterns of EV Sales in Sonoma County.

[8] Bay Area Air Quality Management District. "Bay Area Plug-In Electric Vehicle Readiness Plan" (Dec. 2013) Online. Available: http://www.bayareapevready.org/assets/Bay-Area-PEV-Readiness-Plan-Summary-2013-web.pdf.

[9] Gil Tal, Michael A. Nicholas, Jamie Davies and Justin Woodjack. "Charging Behavior Impacts on Electric Vehicle Miles Travel: Who is Not Plugging in?" Institute of Transportation Studies, University of California, Davis (Nov. 2013): 17 pp. Online. Available: http://www.its.ucdavis.edu/wp-content/themes/ucdavis/pubs/download_pdf.php?id=2098.

Figure 1: Locations with highest number of EV rebates (by ZIP code)

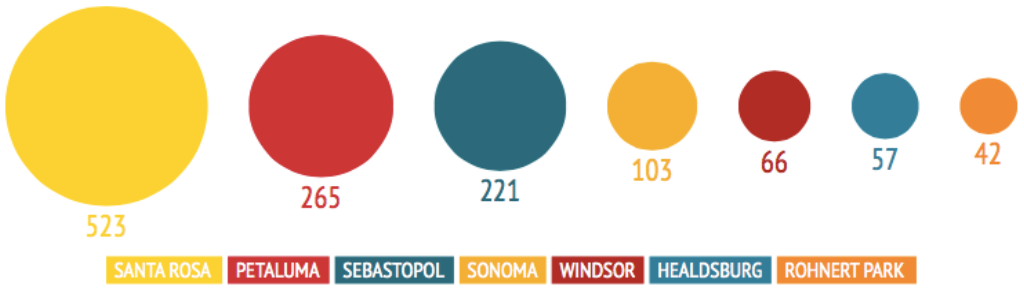
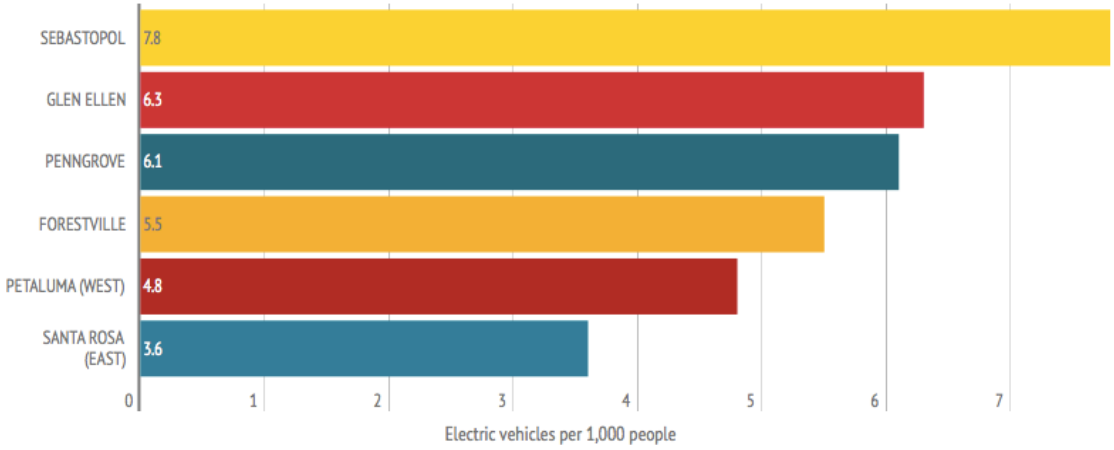
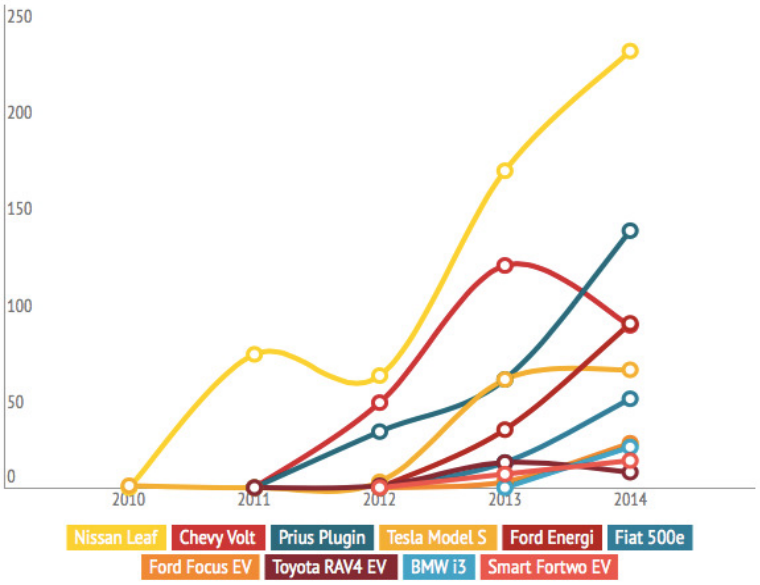


Figure 2: Density of EV rebate redemption (top 5 locations in Sonoma County)



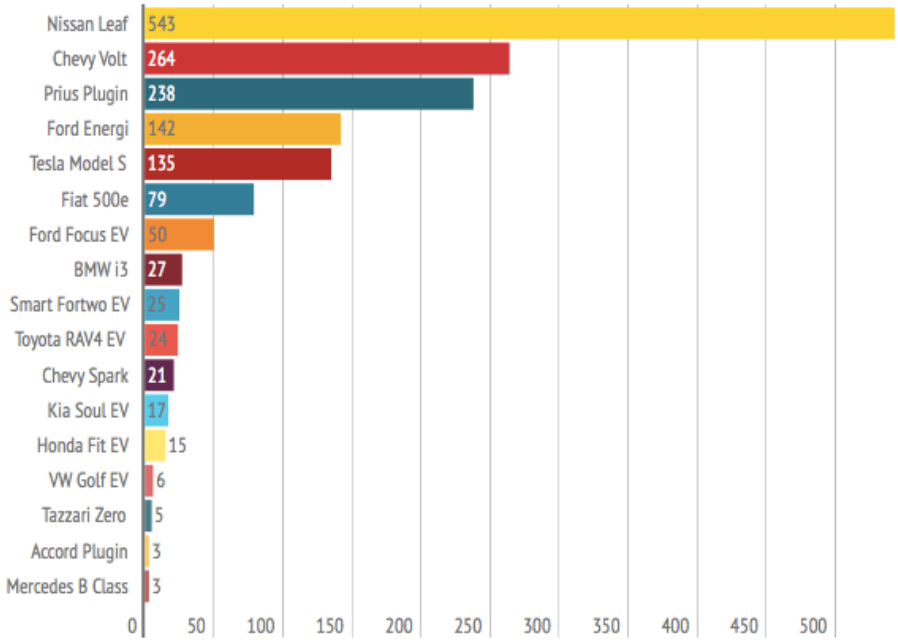
The two most popular brands have been the Nissan Leaf, a full battery-electric vehicle, and the Chevy Volt, with a gasoline range extender. Both have been available for a number of years. More new models are coming on the market as additional carmakers have begun producing EVs.

Figure 3: Annual EV sales by model in Sonoma County[10]



All EVs listed in Figure 4 (below) can be purchased or leased through Sonoma County dealers with the exception of Smart and Tesla.

Figure 4: Total EV sales in Sonoma County through 3/30/15

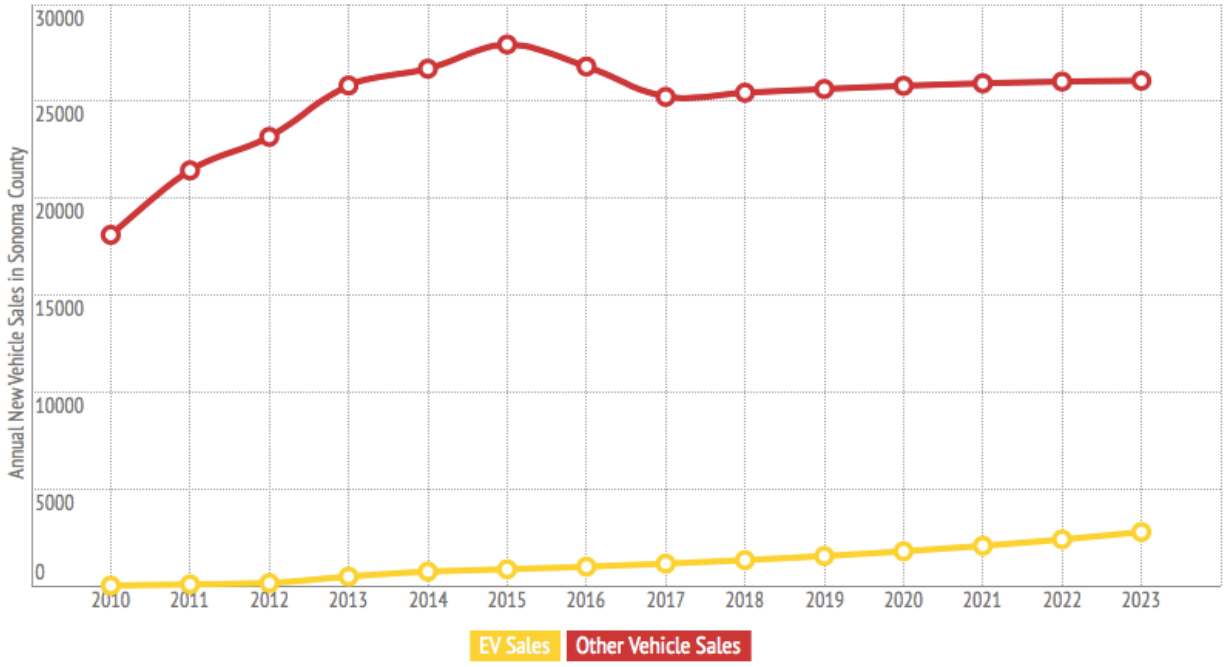


[10] Center for Sustainable Energy. "Clean Vehicle Rebate Project Rebate Statistics." Prepared for the California Air Resource Board. Online. Available: http://energycenter.org/clean-vehicle-rebate-project/rebate-statistics.

EV sales in Sonoma County have surged since 2014. Nearly half of all EV sales in the county occurred in 2014. The trend continued in the first quarter of 2015 despite low gas prices. January 2015 sales of EVs doubled from the prior year based on data from the Clean Vehicle Rebate Project. EV use in Sonoma County, however, is likely to be markedly higher than the data suggests. According to recent estimates, only 70 percent of eligible vehicles are rebated.[11]

If Sonoma County plays its part in meeting Governor Brown's goal of selling 1 million EVs in California, then Sonoma County will put at least 16,000 EVs on the road by 2023. In this scenario, EVs would account for more than 10% of new vehicle sales in Sonoma County by 2023.

Figure 5: Sonoma vehicle sales by type and future sales to meet Brown's 2023 goal



Barriers to EV adoption

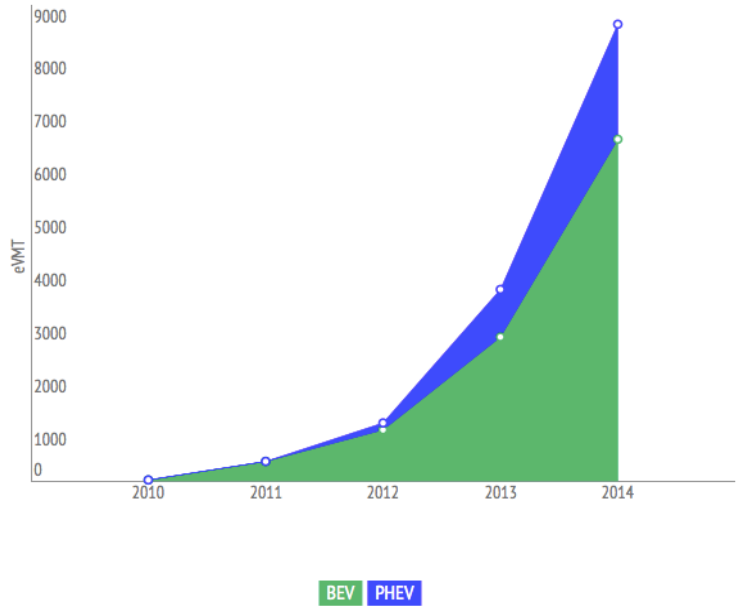
One barrier to accelerated EV adoption is the lack of knowledge in the vehicle sales force about these vehicles. While most people are familiar with conventional internal combustion engine (ICE) vehicles, the same is not true for EVs. Some EV dealerships have not trained their sales staff in the operation of the EVs that they sell. As a result, sales staff may give false information about the EVs to potential customers, and encourage them to consider an ICE vehicle.[12]

[11] Air Resources Board. "Second Public Workshop on the Fiscal Year (FY) 2015-16 Funding Plan for the Air Quality Improvement Program (AQIP) & Low Carbon Transportation Investments." (Jan. 2015) Online. Available: http://www.arb.ca.gov/msprog/aqip/fundplan/fundingplan_workshop_presentation_012315.pdf.
[12] Eric Cahill, "Innovation, Retail Performance and Zero Emission Vehicle Policy" Institute of Transportation Studies, University of California, Davis (April 2015) Online. Available: http://phev.ucdavis.edu/files/Dealer-Study-Brief_Short_2015-4-8.pdf.

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

Figure 6: 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 is primarily plug-in hybrid owners who can get more eVMT by plugging in at work.

2.2 Infrastructure

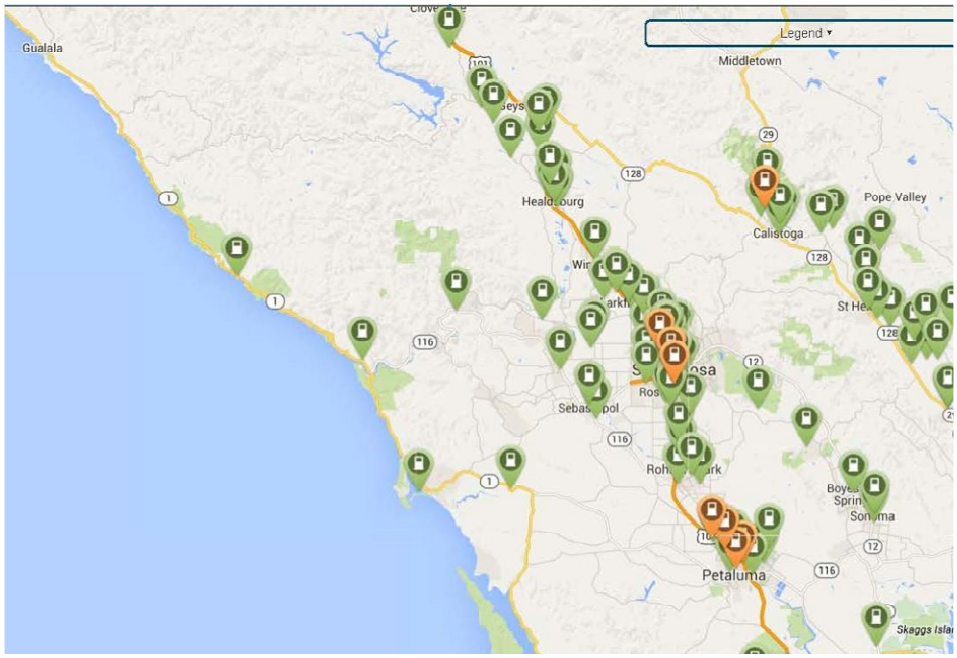
A major challenge for EV market penetration is the relatively short range of the current choices in commercial EVs. All models except the Tesla have an effective range of about 80 miles. The Tesla, a relatively high-cost EV, can go 200 miles. Therefore, an affordable EV can venture about 40 miles from home in Sonoma County without the need to return home for a charge. Indeed, EV chargers are

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.

beginning to be installed at the workplace and at shopping centers in Sonoma County. However, EV drivers consistently assert the need for more rapid and widespread deployment of chargers.

Sonoma County has 76 public charging locations that have Level 2 (240 volt) electric vehicle supply equipment (EVSE or chargers) and 8 public charging locations that have DC Fast Chargers (DCFC, which operate at 480 volts). Many of these locations have multiple EVSEs. The map below shows the currently available public charging locations. Public charging locations are also available on carstations.com and Google, while each EV manufacturer and charging station operator has a website to locate public charging stations.

Figure 7: Locations of EV Chargers according to PlugShare.com



Some public EVSEs provide free charging while others charge a fee. 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.

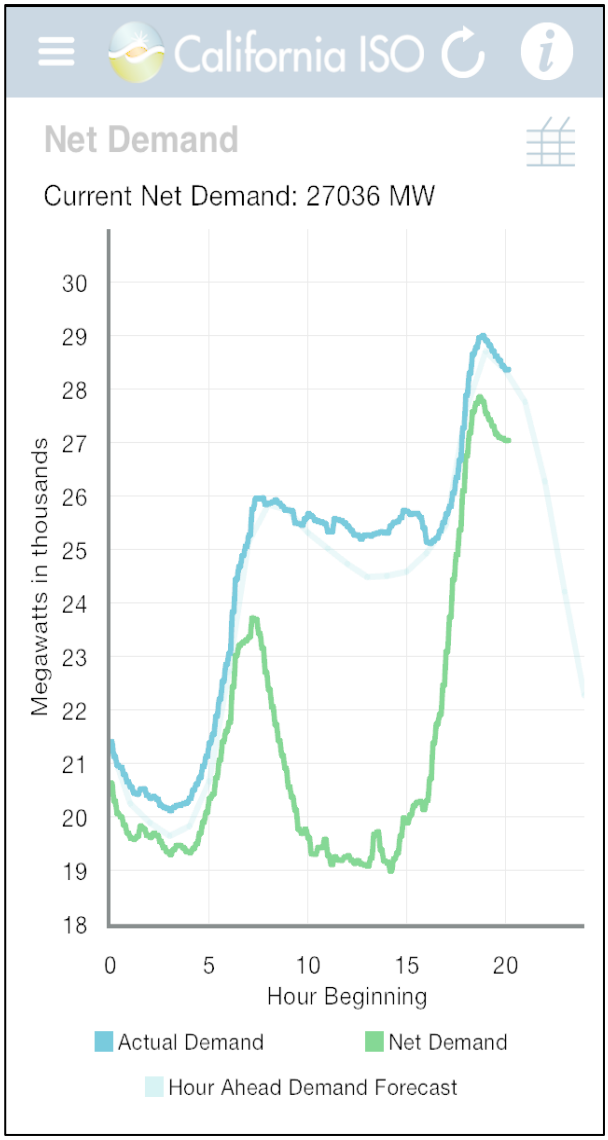
Fee-based charging stations are managed by an operator. Operators determine the cost of a charge according to the cost per kilowatt-hour (kWh) for the amount of kWhs used or for the amount of time the charger is used. In both cases, the operator charges EV drivers a flat fee to initiate the charge.

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 usually have a 50 kW capacity. The Tesla DCFCs more often have a 120 kW capacity. The battery capacity of all other current battery electric vehicles (BEV) varies from 22 to 28 kWh so a normal 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.[13] Charging at home provides the convenience of starting each day with a full charge. To facilitate home charging, California recently updated its building code to require that all new construction be "EV capable."

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.[14]

Figure 8: Actual and Net Demand for electric power in California



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 power capacity and 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

[13] PlugInsights, "U.S. PEV Charging Study: 4TH Quarter, 2013" Referenced by Inside EVs (Nov. 2013) Online. Available: http://insideevs.com/most-electric-vehicle-owners-charge-at-home-in-other-news-the-sky-is-blue/.

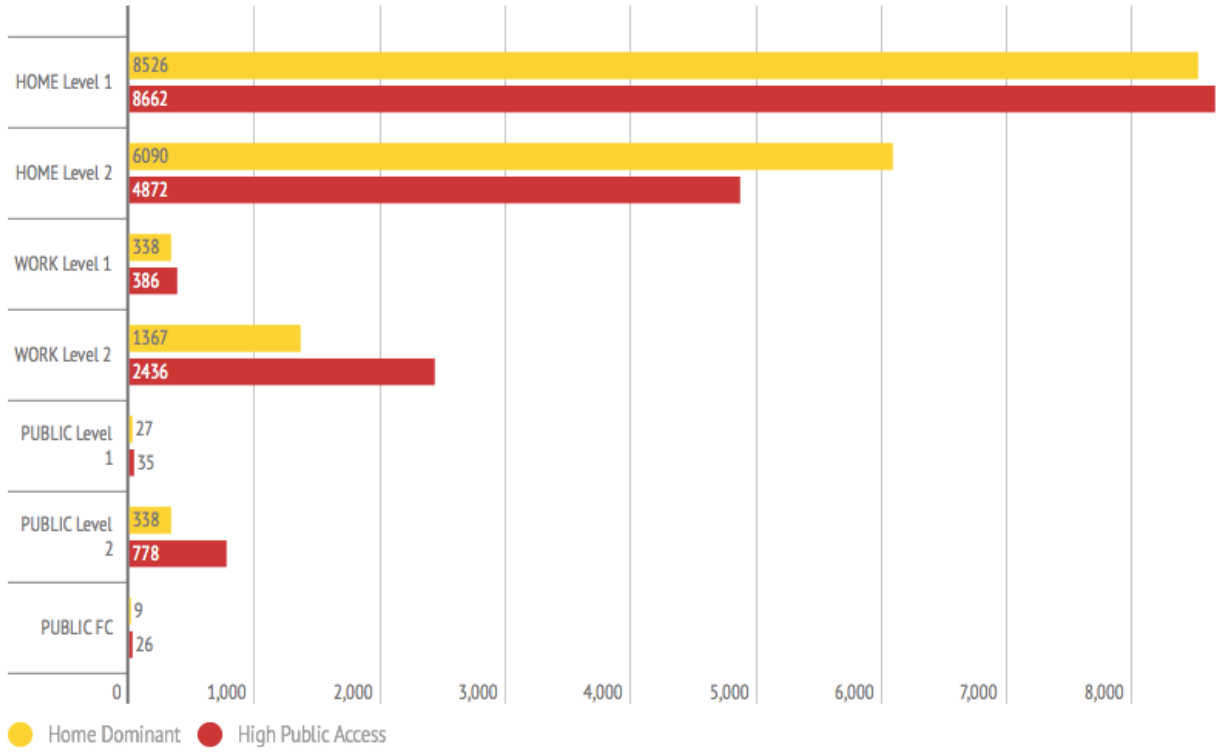
[14] U.S. Department of Energy, "EV Everywhere Workplace Charging Challenge, Progress Update 2014: Employers Take Charge." (Nov. 2014) Online. Available: http://energy.gov/sites/prod/files/2014/11/f19/progress_report_final.pdf.

energy on the grid. Figure 8, from California ISO, shows net energy demand for a typical 24-hour period. Because renewables, especially solar, come online around 8 AM, the net demand is significantly reduced from 10 AM until 3 PM. This will be an ideal time to charge EVs at workplaces, once utility rates are adjusted to reflect the fact that so much solar power is now available.

The California Energy Commission is the 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 – "home dominant" and "public-access dominant" charging -- that serve as a basis for the roll-out of PEV charging infrastructure capable of supporting 1 million PEVs by 2020.[15]

The following graph shows how many of each kind of charger would be required in Sonoma County by 2020 under a "home dominant" charging scenario. These projections are based on Sonoma County's population as a percentage of the Bay Area's total charging infrastructure recommended by the CEC EV Infrastructure Assessment.

Figure 9: Estimated build out of charging stations in Sonoma County for 2 scenarios



[15] National Renewable Energy Laboratory. "California Statewide Plug-In Electric Vehicle Infrastructure Assessment." Prepared for the California Energy Commission (May 2014) Online. Available: http://www.energy.ca.gov/2014publications/CEC-600-2014-003/CEC-600-2014-003.pdf.

Sonoma County may be overlooked by market forces when new charging 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 wants to include EV charging among its community benefit programs.

Visibility and Accessibility of EV Charging Stations

The ultimate goal of EV roll-out is to get people to use EVs as a *replacement* for their ICE vehicles, not simply a complement. Increasing range is important on this score, but another key factor is creating an ubiquitous EV charging infrastructure. People will be far more confident in making the switch to EVs if they can see with their own eyes, in their own community, that charging stations exist. Availability of stations and prominent, recognizable signage to identify those stations is critical to EV success.

Throughout Sonoma County, gasoline fueling stations are prominent and visible. This is not the case for EV charging stations, even though there are dozens in full public view in Sonoma County. Improving the signage and visibility of EV charging stations could be a significant and cost-effective component of an EV awareness effort for *future* EV owners/drivers who could see for themselves that EVs and charging infrastructure exist. A standard, aesthetically appealing, and recognizable "Electric Vehicle Charging Station" sign, such as has begun to appear on State highways, could engender broad confidence and facilitate the switch to electric at the scale desired.

Given that there are multiple stakeholders that stand to benefit from increased usage of EV charging stations anywhere (e.g., EV manufacturers, dealers, electricity service providers, charging station owners, policymakers, etc.), creative options for financing these signs may be developed. Appropriate signage serves multiple purposes: assisting current and future EV drivers, raising awareness, and introducing marketing/branding opportunities for multiple parties.

It should be noted that, when publicly accessible, electric vehicle charging infrastructure must make accommodations for people with disabilities, pursuant to the Americans with Disabilities Act (ADA). This may add to the cost of installing charging infrastructure, but will ensure that the benefits of public EV charging are available to everyone. Building codes and regulations are currently being developed throughout the country. California's Office of Planning and Research issued a "Guidelines and Best Practices" document that outlines voluntary code revisions, and offers guidance on the number of chargers that should be ADA-compliant.[16]

[16] State of California Governor's Office of Planning and Research, "Plug-In Electric Vehicles: Universal Charging Access Guidelines and Best Practices," (May 2013) Online. Available: http://opr.ca.gov/docs/PEV_Access_Guidelines.pdf

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, as described below:

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. This program will last as long as funding is available.

Administered by the Center for Sustainable Energy (CSE) for the California Air Resources Board, the Clean Vehicle Rebate Project (CVRP) 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 that 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 (100 percent 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.

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[17] Center for Sustainable Energy, "Clean Vehicle Rebate Project." Online. Available: http://energycenter.org/clean-vehicle-rebate-project.
[18] U.S. Department of Energy, "Federal Tax Credits for Electric Vehicles," Online. Available: https://www.fueleconomy.gov/feg/taxevb.shtml.
[19] California Air Resources Board, "Plugin-In Electric Vehicle Resource Center," Online. Available: http://driveclean.ca.gov/pev/Costs/Vehicles.php.

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

Several factors have major impacts on the adoption of EVs, including:

1. Convenient charging station availability
2. A larger variety of EVs with better range for drivers to choose from
3. Public awareness about the benefits of driving an EV.[20]

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

Convenient Charging Station Location

"Range anxiety" refers to drivers' concerns about needing a battery that can travel further between charges. To reduce range anxiety, charging infrastructure needs to be expanded: 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 show that employees at workplaces with available charging are 20 times more likely to be EV drivers.[21]

Better Range & Variety of EVs

EVs will soon have double the range at the same price as today's "economy" 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.

In less than two years, EVs will 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*

[20] Alan Soule, President, North San Francisco Bay Chapter of the Electric Auto Association.
[21] Idaho National Laboratory, "The EV Project" Online. Available: http://avt.inel.gov/evproject.shtml.

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."[22]

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, environmental, and financial benefits of driving an EV. The current government financial incentives are helpful, but governments and others must sponsor public awareness campaigns that explain the benefits of driving an EV and demonstrate the convenience of driving EVs. Also, EV manufacturers need to increase their marketing campaigns for their EVs to better compete with traditional gas-fueled vehicles.

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 Austin's Lyndon B. Johnson School of Public Affairs, and the UC Davis Institute of Transportation Studies – that illuminates some EV trends that could inform marketing campaigns.[23]

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 of EV drivers are displaying the HOV lane access sticker.

[22] Lux Research, "The New EV Battleground," Online. Available: http://web.luxresearchinc.com/the-new-ev-battleground-why-the-40000-200-mile-range-electric-vehicle-will-be-the-biggest-energy-storage-growth-opportunity-of-the-future.
[23] Center for Sustainable Energy. "Feb 2014 Plug-in Electric Vehicle (PEV) Owner Survey." Available: http://energycenter.org/clean-vehicle-rebate-project/vehicle-owner-survey/feb-2014-survey.

2.5 Economic 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."[24] This study shows that the higher upfront cost of a PEV is balanced by the lower ownership costs, and concludes that "financial factors should not be a deterrent to a PEV purchase for most buyers."

Moreover, Californians gain from economic growth associated with fuel cost savings due to vehicle electrification, whether they lease or buy an EV. As a result of vehicle electrification, money that is typically spent on fuel is spent in other ways that 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.[25]

Sonoma Clean Power, our local electricity provider, introduces an additional benefit to the EV economic analysis because electric "fuel" remains local.

Sonoma County has additional economic advantage over most other communities, in that we now have a local electricity provider, Sonoma Clean Power. Therefore a significant portion of the money that is spent on electric "fuel" via charging will remain local, and provide additional economic stimulus.

Economic gains may not be equally shared among 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 that EV sales are missing a significant and important segment of the population due to lack of charging infrastructure in multi-family housing.[26]

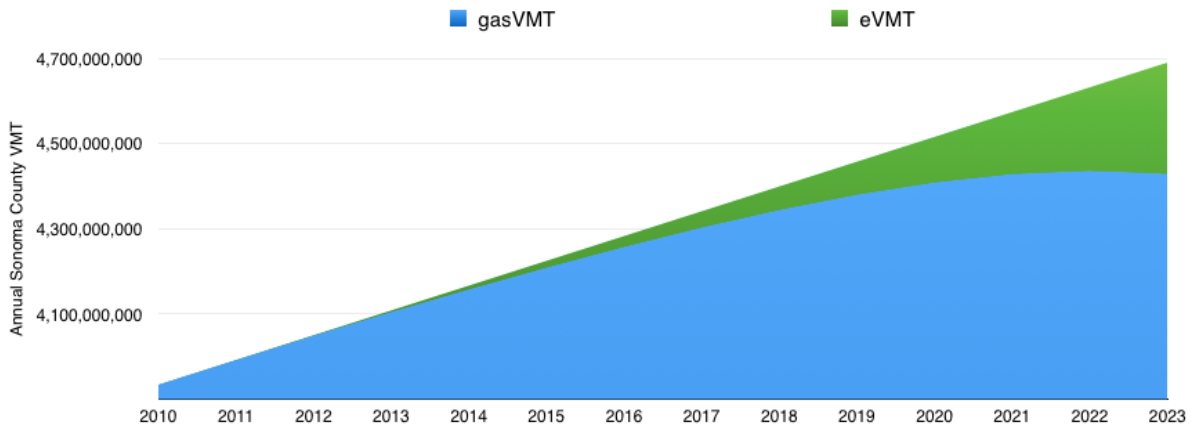
[24] Electric Power Research Institute, "Total Cost of Ownership for Current Plug-in Electric Vehicles" (May 2014) Online. Available: http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?productId=000000003002004054.
[25] David Roland-Holst, "Plug-in Electric Vehicle Deployment in California, an Economic Assessment," *UC Berkeley* (Sept. 2012) Online. Available: http://are.berkeley.edu/~dwrh/CERES_Web/Docs/ETC_PEV_RH_Final120920.pdf
[26] PlugInsights, "U.S. PEV Charging Study: 4TH Quarter, 2013" Referenced by Inside EVs (Nov. 2013) Online. Available: http://insideevs.com/most-electric-vehicle-owners-charge-at-home-in-other-news-the-sky-is-blue/.

2.6 Environmental Benefits

Gas-powered VMT is forecasted to peak in 2022 and begin decreasing thanks solely to growing EV sales.

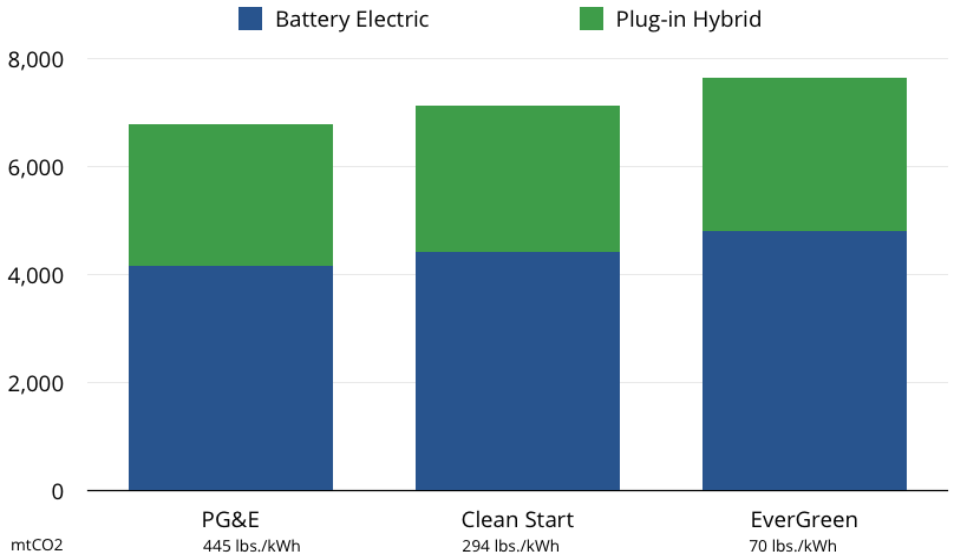
Electric vehicles produce no greenhouse gases. To quantify the capacity of EVs to reduce GHG emissions, we look at the potential for electric vehicle miles traveled (eVMT). Overall VMT for Sonoma County is forecasted to continue rising as the population increases. Gas-powered VMT is forecasted to peak in 2022 and begin decreasing thanks solely to growing EV sales.

Figure 10: GHG Reductions from Electric Vehicles in Sonoma County (2010-15)



The environmental benefits of EV driving are significant and can be enhanced by utilizing clean power sources for charging. The Center for Climate Protection calculates that plug-in vehicles have reduced a total of more than 6,700 mtCO2 in Sonoma County through March 2015. Charging those vehicles with EverGreen, a 100 percent green electricity option available through Sonoma Clean Power, would have reduced an additional 835 mtCO2.

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 the 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. These substances include motor oil, transmission fluid, and radiator antifreeze/coolant. Replacing gasoline vehicles with electric vehicles eliminates the need for these substances.

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, researchers 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]

[27] Office of Environmental Health Hazard Assessment, "Fuels and Your Health factsheet" Online. Available: http://www.oehha.ca.gov/public_info/facts/pdf/fuels4-02.pdf.
[28] Canbing Li, Yijia Cao, Mi Zhang, Jianhui Wang, Jianguo Liu, Haiqing Shi and Yinghui Geng, "Hidden Benefits of Electric Vehicles for Addressing Climate Change," *Scientific Reports* (March 2015) Online. Available: http://www.nature.com/srep/2015/150319/srep09213/pdf/srep09213.pdf.

2.7 Municipal Government Support

County of Sonoma

The County of Sonoma has established itself as a national leader in the 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 30 percent of the agencies' cars, vans, and light-duty trucks and creating one of the largest plug-in hybrid electric vehicle fleets in the country."

In April 2015, the EPA honored the County of Sonoma with an award, "for protecting air quality and fighting climate change with one of nation's largest hybrid vehicle fleets."[29] The award said:

> 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 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.

SONOMA COUNTY MUNICIPALITIES

Cloverdale

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

[29] U.S. Environmental Protection Agency, "EPA Clean Air Awards" Online. Available: http://www.epa.gov/air/cleanairawards/winners-current.html.

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 encourages 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, in addition to other locations throughout the city.

Rohnert Park
The city of Rohnert Park has an EV policy from 2012 that 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. Additionally, a renewable-energy-based hydrogen station is planned for installation in Rohnert Park in late 2015 to serve Fuel Cell Electric Vehicles (FCEVs).

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 10 percent of the City's fleet." The City of Santa Rosa has also installed multiple EV charging locations at City Hall and their Stony Point facility.

Sebastopol
The City of Sebastopol has two separate resolutions in support of municipal EV adoption. 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 and have installed multiple EV charging stations at City Hall.

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 more than 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.

2.8 Funding

Government

In addition to incentives, the State of California has targeted a number of different programs to use cap-and-trade funds from the California Global Warming Solutions Act of 2006 (AB32)[30] to boost the adoption of electric vehicles. For example, the *Low Carbon Transportation Program*, overseen by the California Air Resources Board, was given 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.

Additional sources of funding in California include AB 118 Air Quality Improvement Program (AQIP: http://www.arb.ca.gov/msprog/aqip/aqip.htm), and the California Alternative Energy and Advanced Transportation Financing Authority (http://www.treasurer.ca.gov/caeatfa/).

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.

Since that reversal, San Diego Gas and Electric offers a variety of EV-friendly information and programs for their customers (http://www.sdge.com/electric-vehicles), and has announced plans to install 30,000 chargers in their service area.

Pacific Gas and Electric also has a variety of information available (http://www.pge.com/en/myhome/saveenergymoney/pev/index.page), and has worked with the California Public Utilities Commission to obtain approval for the installation of 25,000 chargers

[30] AB 32: http://www.arb.ca.gov/cc/ab32/ab32.htm

within their service area.
(http://delaps1.cpuc.ca.gov/CPUCProceedingLookup/f?p=401:56:16662486962281::NO:RP,57,RIR:P5_PROCEEDING_SELECT:A1502009)

Other utilities are following a similar path, and can be expected to aggressively promote EVs, as they stand to expand their market for electricity dramatically as we make the fuel shift from liquid petroleum fuels to electric.

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 build-out for the private networks. Additionally, ChargePoint has begun offering financing options for businesses interested in installed EV charging infrastructure.[31] Recently, companies like Volta have begun offering ad-supported public charging stations.[32]

3 Technical, Social and Policy 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. Level 1 is 120 volts and adds about 5 miles of range per hour of charging. Level 2 is 208/240 volts and adds about 20 miles of range per hour of charging. DC Fast Charging adds anywhere from 100 miles of range to 240 miles of range per hour of charging depending on the charger's power level.

Home chargers are 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

[31] Jeff St. John, "ChargePoint Launches $100M Public EV Charger Finance Program," *Greentech Media* (Oct. 2013) Online. Available: http://www.greentechmedia.com/articles/read/chargepoint-launches-100m-public-ev-charger-finance-program.
[32] Jordan Golson, "These EV Chargers Are Free. The Catch? They've Got Ads," *Wired* (June 2015) Online. Available: http://www.wired.com/2015/06/ev-chargers-free-catch-theyve-got-ads/.

The distance that you can travel in an economical EV is often limited to forty miles each way 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 most significant goal of battery development is to reduce the costs of manufacturing to the level where EVs can compete with Internal Combustion Engine Vehicles (ICEVs) based on the sticker price. To reach this goal, it is believed that battery manufacturers need to produce batteries that cost less than $150 per kilowatt-hour in the mid-term and as low as $100 per kilowatt-hour in the long-term.[33]

The researchers behind one study developed a model to look at the economics behind battery manufacturing, which indicated that the price could drop for lithium-ion battery packs from about $500 to $600 per kilowatt hour and approach the mid-term goal of $200 per kilowatt hour by 2020 and $160 per kilowatt hour by 2025.[34]

Competition with ICEV based on battery price

In order for EVs to overtake ICEVs, more than cheaper battery prices are needed.[35] These factors include overall economic and regulatory conditions, vehicle range and reliability, and customer preferences. The speed that new vehicles achieve these lower battery prices could vary by three to five years — typically the length of a product-development cycle.

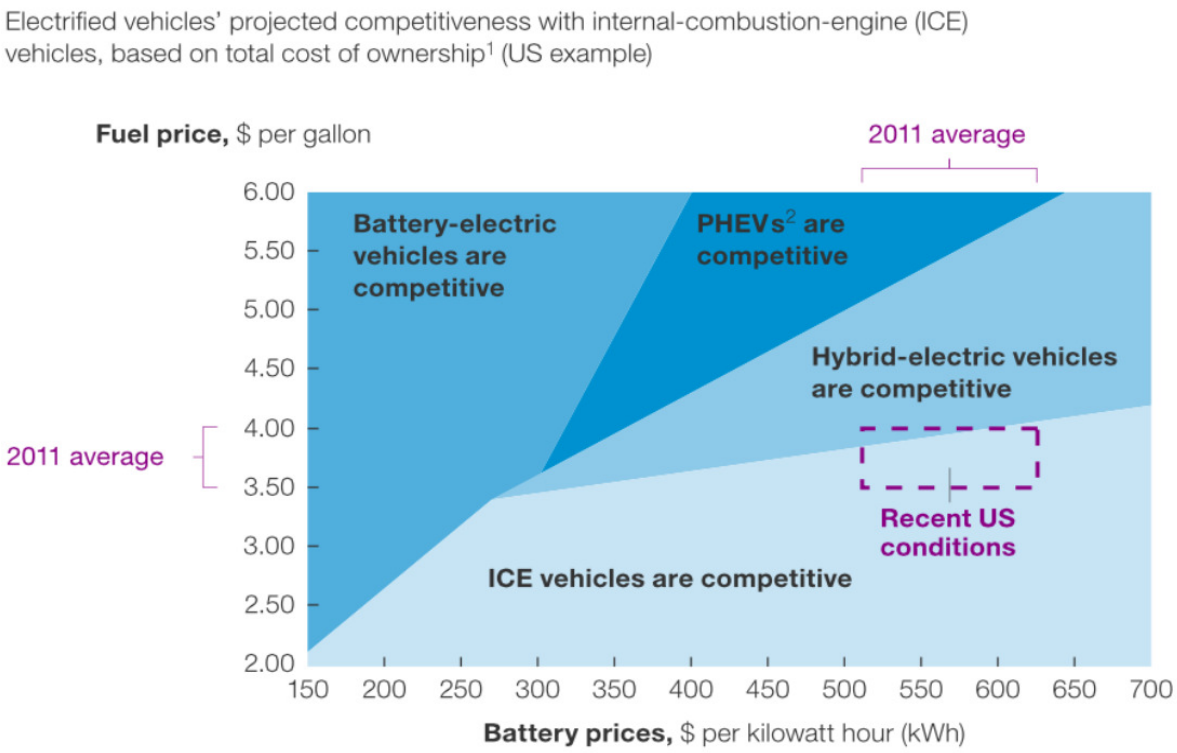
While progress in the design of batteries is limited compared to other technology, an 80 to 110 percent increase in battery capacity is still possible by 2025 through technical advances. These efforts represent 40 to 45 percent of the identified price reductions. New battery cathodes that incorporate 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.

[33] Simon Evans, "Electric vehicle batteries 'already cheaper than 2020 projections'," *The Carbon Brief* (March 2015) Online. Available: http://www.carbonbrief.org/blog/2015/03/electric-vehicle-batteries-already-cheaper-than-2020-projections/.

[34] Marc Carter, "Declining Lithium-Ion Battery Costs Could Knock Thousands Off the Price of Electric Cars," *Inhabitat* (July 2012) Online. Available: http://inhabitat.com/declining-lithium-ion-battery-costs-could-knock-thousands-off-the-cost-of-electric-cars/.

[35] Russell Hensley, John Newman, and Matt Rogers, "Battery technology charges ahead," *McKinsey Quarterly* (July 2012) Online. Available: http://www.mckinsey.com/insights/energy_resources_materials/battery_technology_charges_ahead.

Figure 12: EVs versus ICEs at Various Fuel and Battery Prices

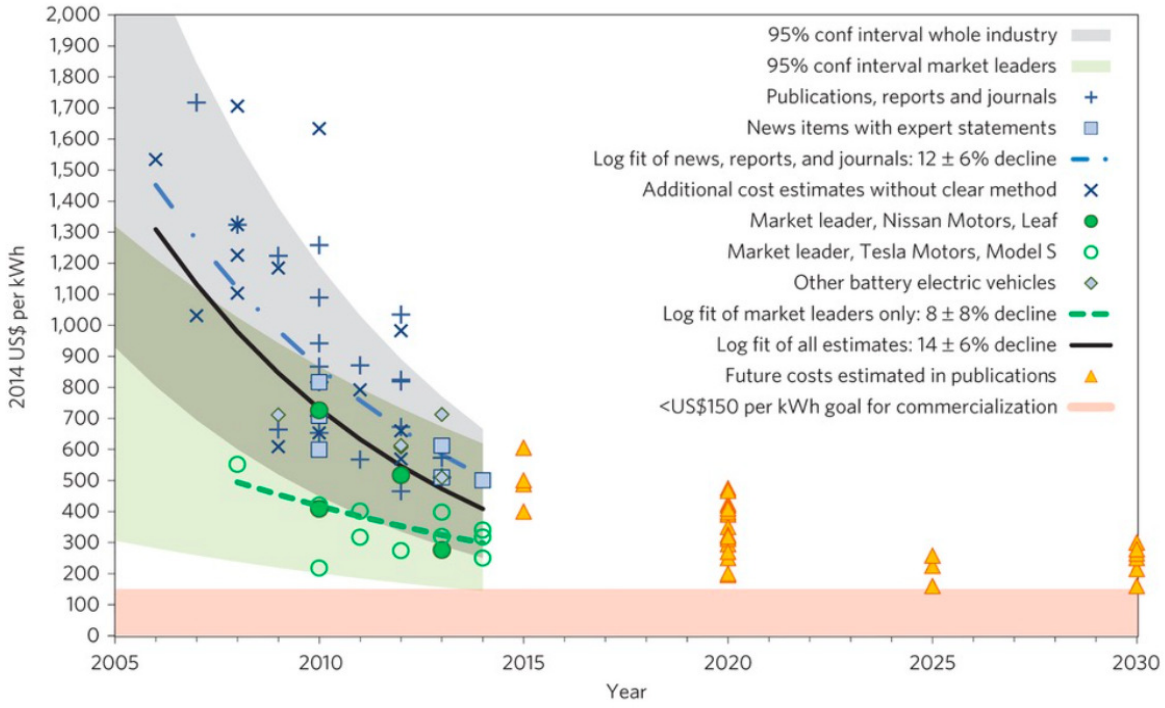


Price reduction of batteries[36]

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

[36] Björn Nykvist & Måns Nilsson, "Rapidly falling costs of battery packs for electric vehicles," *Nature Climate Change* (March 2015) Online. Available: http://www.nature.com/nclimate/journal/v5/n4/full/nclimate2564.html.

Figure 13: Battery Price Trends and Future Predictions



Market leaders 5 years ahead of battery cost projections

The figure above shows that the cost of electric vehicle battery packs is falling so rapidly that they are probably already cheaper than expected for 2020[37], 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."[38]

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 cheaper than ICEVs 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.

[37] Simon Evans, "Electric vehicle batteries 'already cheaper than 2020 projections'," *The Carbon Brief* (March 2015) Online. Available: http://www.carbonbrief.org/blog/2015/03/electric-vehicle-batteries-already-cheaper-than-2020-projections/.
[38] ibid

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.[39] 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.

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.
- Once non-EV drivers become aware, they first want to know about cost.
- Non-EV drivers don’t ask about incentives or infrastructure because they don’t know about them.
- In some areas there’s more awareness because of HOV stickers.
- Non-EV owners are not aware that we’re in a transition away from fossil fuels. Often they were not even aware that EVs are for sale.
- Many drivers are skeptical about completing all their driving needs in a BEV.
- Stories about the economics of EVs are a fragile narrative because if cheapness goes away the story collapses.
- A narrative that is more resilient than the economic one that could be based on vehicle options, the quality of the experience, incentives and infrastructure.

[39] Giles Parkinson, “How battery storage costs could plunge below $100/kWh,” *Renew Economy* (Oct. 2014) Online. Available: http://reneweconomy.com.au/2014/battery-storage-costs-plunge-below100kwh-19365.

While many current EV owners and advocates want to talk about economics, the authors suggest that EV owners should instead put the quality of the experience ahead of the rational economic argument. For example, owners could talk about how an EV is the best vehicle they've ever owned and as a bonus there are environmental rebates that make EVs even more affordable.

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.[40]

3.3 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. The first chargers opened in 2011 and the entire length of the highway in Oregon and Washington is now operational. Additional chargers to complete the California portion of the border-to-border route are still in development.

Portland, Oregon[41]

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 is free to participants who

[40] Lara Edwards, Jonathon Kemp, Nuwyy Ly, Maria Tran and Vinayak V. Dixit, "Framework to Evaluate Policy for Promotion of Electric Vehicles", *School of Civil and Environmental Engineering University of New South Wales* (Feb. 2013) Online. Available: http://trid.trb.org/view.aspx?id=1242407.
[41] International Energy Agency, "EV City Casebook, 2012," (Jan. 2012) Online. Available: http://www.iea.org/publications/freepublications/publication/EVCityCasebook.pdf.

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[42]

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
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.

[42] California Plug-In Electric Vehicle Collaborative, "Amping Up California Workplaces: 20 Case Studies On Plug-In Electric Vehicle Charging At Work," (Nov. 2013) Online. Available: http://www.pevcollaborative.org/sites/all/themes/pev/files/WPC_Report4web.pdf

Future Development

Automobile manufactures have made a number of recent announcements about new and higher-range vehicles expected to come to market in the 2017-18 time frame.[43] 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.[44]

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 - Many young people today are happy being social online instead of driving to hang out at the mall or to a friend's house.
3. Telecommuting – This is a growing commute solution, although 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.
5. Virtual reality - Technology enables people to connect electronically instead of traveling to connect in person.

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.

4 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

[43] Union of Concerned Scientists, "Timeline of electric vehicles," Online. Available: http://www.ucsusa.org/clean_vehicles/smart-transportation-solutions/advanced-vehicle-technologies/electric-cars/electric-vehicle-timeline.html.

[44] Stephen Edelstein, "Solid-State Batteries For Electric Cars: 'Great Potential,' VW CEO Says," *Green Car Reports* (Nov. 2014) Online. Available: http://www.greencarreports.com/news/1095609_solid-state-batteries-for-electric-cars-great-potential-vw-ceo-says.

transportation, fuel shift will produce more rapid results. Total emissions reduced from EVs sold in Sonoma County through March 2015 are estimated to be over 7,000 metric tons of equivalent carbon dioxide (mtCO2e). This is significant amount compared to any other single measure to reduce GHGs from transportation, and is equivalent to replacing over 180,000 incandescent bulbs with energy-efficient Compact Fluorescent Light bulbs

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. Accelerating the installation of workplace chargers represents a high-leverage opportunity for Sonoma County.

3. Renewable power boosts GHG reductions from EVs.

With the launch of Sonoma Clean Power in 2014, Sonoma County drivers can charge their electric vehicles with greener electricity, and even opt for the new, local utility's "Evergreen" option, which is sourced from 100 percent renewable energy. The Evergreen option is rare and gives Sonoma County a new advantage in reducing its transportation emissions. When accounting for the carbon content of electricity, switching EV charging from PG&E's current power mix to 100 percent Evergreen renewable electricity would result in an additional 13% GHG emission reduction per vehicle.

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

Battery price reductions are running ahead of schedule. New EV models coming on the market are expected to have lower prices and longer ranges, promising 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 to achieve this goal by 2020, Sonoma County needs to have installed about 14,600 home chargers, 1,700 workplace chargers, 365 public chargers, and 9 fast chargers. As of the end of 2014, there are approximately 2,000 total chargers installed throughout the whole San Francisco Bay Area region. This is roughly 25 percent of the chargers needed to be on track to meet our region's goal of 36,000 EV chargers by 2025.[45]

[45] National Renewable Energy Laboratory. "California Statewide Plug-In Electric Vehicle Infrastructure Assessment." Prepared for the California Energy Commission (May 2014) Online. Available: http://www.energy.ca.gov/2014publications/CEC-600-2014-003/CEC-600-2014-003.pdf.

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, or of the infrastructure, rebates, and incentives available to assist them in purchasing and driving EVs.

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. Additionally, 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 to take advantage of this anticipated funding.

5 Recommendations

The Center for Climate Protection and partners are still determining next steps, but throughout the writing of this white paper, several general recommendations emerged. 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 been convening EV stakeholders for this purpose, and will continue to do so to refine and enhance Sonoma County's strategy to reduce transportation emissions. 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 and expanding or adapting them to encourage broader adoption of EVs, continued 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, including alternative financing options, should also be pursued.

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

To meet the increased demand expected for EV use, Sonoma County needs to greatly expand its EV charging infrastructure, including home and workplace chargers, and 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 with employers and address the cost barriers with specific state and private funding solutions to increase workplace charging.

3. Develop and implement an EV awareness campaign

Research indicates that many car buyers are unaware that electric vehicles and charging stations even exist. A public awareness campaign should be run in Sonoma County and/or should be part of a regional campaign to accelerate EV adoption. Examples of elements to include in an EV awareness campaign are:

- 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 public and social media
- Websites containing comprehensive EV information
- Coordinate and educate car dealers to improve the EV buying experience and facilitate completion of rebate forms, the obtaining of HOV lane stickers, and obtaining qualified contractors for home or workplace charger installation
- Clear, uniform signage noting the location of charging stations visible from the street.

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.

6 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

Plug-in Electric Vehicle Resource Center
http://driveclean.ca.gov/pev/Costs/Vehicles.php