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Peninsula Advanced Energy Community (PAEC)

Task 3.16: Final Economic Benefit-Cost Analysis of Electric Vehicle Charging Infrastructure

Prepared for
California Energy Commission
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About the Authors

Sven Thesen & Associates

Sven Thesen & Associates (STA) is a sole proprietor electric vehicle and energy consulting firm located in Palo Alto with over 20 years of experience in the energy/ environmental space and 12 years focusing on electric vehicles and the electric utility nexus. At present, the practice assists local and regional governments, private employers and non-profits make intelligent, cost conscious choices in deploying electric vehicle infrastructure. Recent activities in addition to the Clean Coalition Peninsula Advanced Energy Community include obtaining a $240k Bay Area Air Quality Management (BAAQMD) grant for the city of Palo Alto to install 40 Level 2 chargers and co-organizing/ co-writing the June 2017 EV Adoption Accelerator Charrette and associated White Paper.

About the Clean Coalition

The Clean Coalition is a nonprofit organization whose mission is to accelerate the transition to renewable energy and a modern grid through technical, policy, and project development expertise.

The Clean Coalition drives policy innovation to remove barriers to procurement and interconnection of distributed energy resources (DER)—such as local renewables, advanced inverters, demand response, and energy storage—and we establish market mechanisms that realize the full potential of integrating these solutions. The Clean Coalition also collaborates with utilities and municipalities to create near-term deployment opportunities that prove the technical and financial viability of local renewables and other DER.

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I. Introduction

Sven Thesen & Associates (STA) is supporting the Clean Coalition in evaluating the cost effectiveness of the various types of electric vehicle charging infrastructure (EVCI) that offer the best value in terms of economic, environmental and technical performance in relationship to the actual electric vehicle (EV) user. In this report, STA presents the results of the economic analysis of EVCI in both existing and new single family dwellings, and multi-family dwellings to the typical EV user in San Mateo County.

In summary, STA completed the following analytical steps:

- Evaluated the potential accuracy, relevancy, and impact of calculating the benefits-cost analysis of installing/ operating EVCI in single family dwellings, multi-family dwellings, workplace and public parking
- Identified and surveyed both new and existing single family dwellings and multi-family dwellings to determine the install costs associated with retrofitting these building types with EVCI
- Calculated the economic benefit of electric vehicles for a typical San Mateo EV user
- Evaluated the cost-effectiveness of each category both for integrated and retrofitted EVCI

Table 1 summarizes the cost benefit and payback period of EVCI installations for new single family dwellings and multi-family dwellings, for both Level One (L1) and Level Two (L2) charging scenarios. Table 2 summarizes the cost benefit of EVCI installations for retrofitting single family dwellings and multi-family dwellings, for both L1 and L2 charging scenarios.

Table 1: Results, EVCI, New Construction

NEW CONSTRUCTION	Average, $	Accuracy	Payback, Months
Single Family Dwelling, 110V, L1	$ 264	High	1
Single Family Dwelling, 240V, L2	$ 450	High	2
Multi-Family Dwelling, 110V, L1	$ 500	Medium	2
Multi-Family Dwelling, 240V, L2	$ 800	Medium	3

Table 2: Results, EVCI, Retrofitting

RETROFITTING	Low, $	High, $	Accuracy	Payback-Low, Months	Payback-High, Months
Single Family Dwelling, 110v	$ 388	$ 2,250	Medium	1	8
Single Family Dwelling, 240V	$ 650	$ 5,125	Medium	2	19
Multi-Family Dwelling, 110V	$ 2,475	$ 7,750	Low	9	29
Multi-Family Dwelling, 240V	$ 2,950	$ 9,000	Low	11	33

II. Background: Peninsula Advanced Energy Community (PAEC)

The Clean Coalition's Peninsula Advanced Energy Community (PAEC), supported by numerous local governments and PG&E, will accelerate the planning, approval, and deployment of an Advanced Energy Community (AEC) within a diverse community in the southern portion of San Mateo County. The core PAEC region encompasses the cities of Atherton, East Palo Alto, Menlo Park, and Redwood City as well as surrounding unincorporated areas. The PAEC region -largely built-out yet also experiencing enormous commercial and residential growth pressure - is representative of similar regions throughout California, ensuring that the PAEC's success can be replicated statewide. The PAEC project will include the key components necessary to define an AEC: abundant solar electricity, energy storage, and other Distributed Energy Resources (DER,) low or zero net energy (ZNE) buildings, Solar Emergency Microgrids (SEM) for power management and islanding of critical loads during outages, and charging infrastructure to support the rapid growth in electric vehicles.

AEC projects can provide significant energy, environmental, economic, and security benefits, but significant barriers too often impede their planning and deployment. Finding viable sites, securing project financing, and connecting AEC projects to the grid all represent significant challenges. The PAEC project is designed to overcome these barriers and establish a replicable model that can be used by other communities across California and beyond. The results of the PAEC will inform future action by policymakers, municipalities and other governmental agencies, utility executives, and other relevant audiences.

The goals and objectives of this project are to:

- Incentivize and accelerate the planning, approval, financing, and deployment of AECs
- Reduce the time, cost, and uncertainty associated with permitting and interconnecting commercial-scale solar and other DER
- Leverage ZNE, efficiency, local renewables, energy storage, and other DER to reduce 25 MW of peak energy across San Mateo County, which will strengthen the grid
- Reduce use of natural gas, gasoline and other fossil fuels via fuel switching to electricity and minimize the need for new energy infrastructure
- Create a model project and project elements that can be replicated throughout California and beyond

In addition to EVCI recommendations, this report also helps local governments to meet State of California climate goals by accelerating EV adoption, which decreases carbon emissions and minimize other risks associated with gasoline and its production from oil. This is doubly important as the carbon footprint of oil is increasing over time as it becomes more and more energy and carbon intensive to extract while the carbon footprint of electricity in the United States and particularly in California with our renewable portfolio standard requirements is only decreasing. Further, should SB 100, the California Clean Energy Act of 2017, pass, California will have 100 percent carbon free energy by 2045. Therefore, it is critical to shift away from gasoline based transportation and towards electric based transportation.

Environmental risks associated with oil and its extraction and production into gasoline/diesel is significant. These include:

- Contaminated Drinking Water: from hydraulic fracturing (fracking)
- Spills and Explosions: since 2010, over 3,300 incidents of crude oil and liquefied natural gas leaks or ruptures have occurred on U.S. pipelines. These incidents have killed 80 people, injured 389 more, and cost $2.8 billion in damages. They also released toxic, polluting chemicals in local soil, waterways, and air.
- Land Impacts: erosion, loss of soil productivity, flooding, increased runoffs, and landslides due to drilling and exploration
- Water Impacts: the biggest and latest large marine oil spill occurred in the Gulf of Mexico in April 2010 with the release of an estimated 4.9 million gallons of crude oil from BP's Deepwater Horizon drilling rig.
- Air Impacts: the extraction, refining, transportation, and combustion of oil and its primary product gasoline releases multiple types of air pollutants including: carbon dioxide, carbon monoxide, nitrogen oxides, sulfur dioxides, particulates, mercury and a variety of hazardous air pollutants

Additionally, from an energy perspective, internal combustion engine (ICE) based transportation is inefficient. Approximately, 75% of the energy resulting from the combustion in an ICE vehicle is wasted as heat. In 2015, the California Total Gasoline Retail Sales by Refiners was 1.58 billion gallons which approximately correlates to 40 billon driven miles. Likewise, this gasoline use equates to 53 terawatt-hours and had this energy been used to power electric vehicles, they could have driven 214 billion miles.

Finally, in regard to the electrical grid having enough electricity to fuel these EVs, the DOE's Pacific Northwest National Laboratory reported that there is enough off peak electrical generation capacity to fuel 70% percent of the U.S. light-duty vehicle (LDV) fleet.

Given all the above, it is critical that California leave a petroleum based transportation system and switch to one based on renewable energy. As such, the solution is to electrify our transportation system.

Within the context of electrifying the transportation system, STA is supporting the Clean Coalition in evaluating the cost effectiveness of the various types of electric vehicle charging infrastructure (EVCI) that offer the best value in terms of economic and environmental performance. In this report, STA presents the results of the economic analysis of EVCI in single family dwellings, multi-family dwellings, workplace, and public parking lots in San Mateo County.

III. Electric Vehicle Overview

Currently, there are three classes of light duty electric vehicles available to the general public: Plug-in Hybrid Vehicles (PHEVs) commuter battery electric vehicles and long range electric vehicles. As discussed below, each of these has their own general functionality. For purposes of this report, the term electric vehicle (EV) refers to all three classes.

a. Plug-in Hybrid Vehicles

PHEVs use both gasoline/diesel and electricity as fuel. These cars have two fuel tanks, giving them the ability to run on electricity and a liquid, generally fossil based, fuel. Typically, local, short-distance miles run off the car's main battery pack, while longer distances are achieved via the internal combustion engine (ICE). In the United States, the best-selling PHEVs are the Chevy Volt and the Ford Fusion Energi. The Chevy Volt has a 53 mile all electric range with a 357 mile gasoline range. The Ford Fusion Energi has a 22 mile on electric range, with a 588 mile gasoline range.

Chevy *Volt 2017*

2017 Ford Fusion Energi

b. Commuter Battery Electric Vehicles

The commuter battery electric vehicle is a 100% electric EV with a range on the order of 100 miles. These vehicles were not designed for long-distance travel but are the ideal car for the commuter. The two most well-known are the Nissan Leaf, released in 2011 and the BMW i3 released in 2014. In the long term, given their range limitations, these vehicles are likely to be superseded by long range EVs.

Nissan Leaf

BMW i3

c. Long Range Electric Vehicles

Long-range electric vehicles, such as the Chevy Bolt and the Tesla Model 3, are the next generation of electric vehicles. These EVs have all electric ranges on the order of 200+ miles and are designed to be fully functional vehicles but with no tailpipe emissions and a lower energy/ carbon footprint. In addition to the General Motors and Tesla long range EVs, Volkswagen, Nissan and Hyundai have all announced plans for long range EVs, some with delivery dates of 2018.

Tesla Model 3

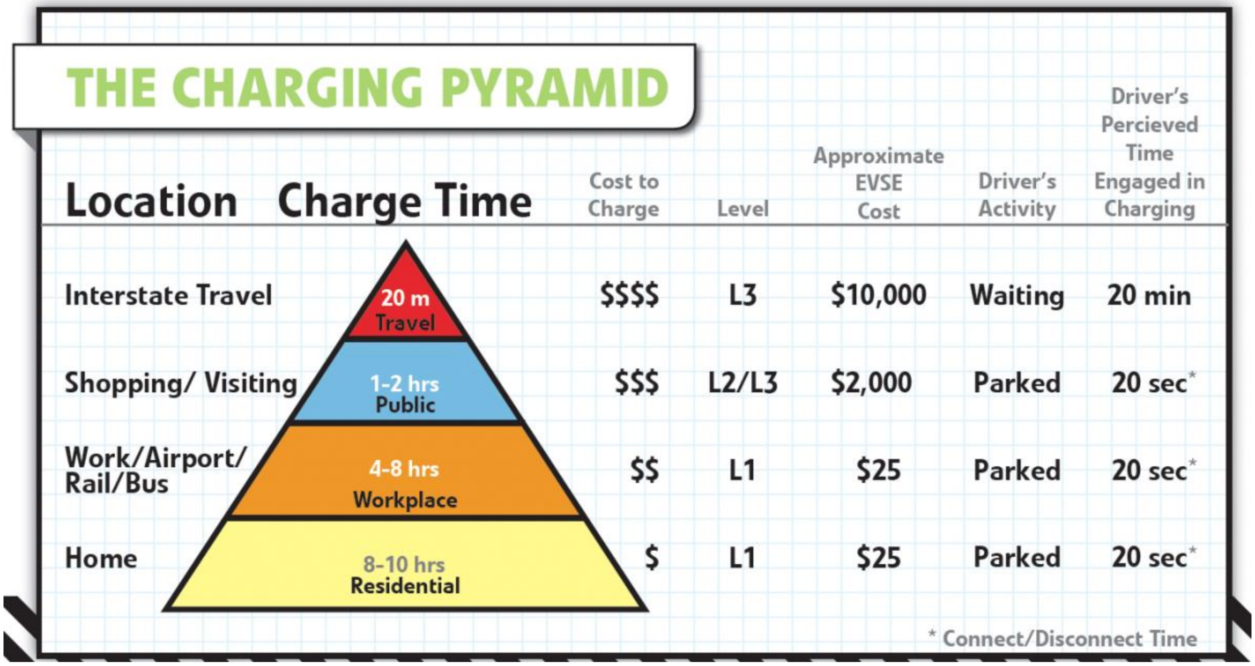
Chevy Bolt

Note: for purposes of this report Tesla Motors Model S, X and the Roadster are not included in the above category or addressed in this report due to their much greater price point compared to the typical automobile, electric or otherwise. It should be clear, however, that these EVs fully qualify as long range EVs.

IV. Electric Vehicle Charging Infrastructure Overview

At present, there are three different classes of electric vehicle charging infrastructure L1, L2, and direct current Fast Charging. As depicted in Figure 1 and detailed below, each of these has their own benefits and limitations associated with its installation, maintenance and operations costs, convenience, rate of charge, electric utility impacts, ease of use, etc.

Figure 1: The Electric Vehicle Charging Pyramid

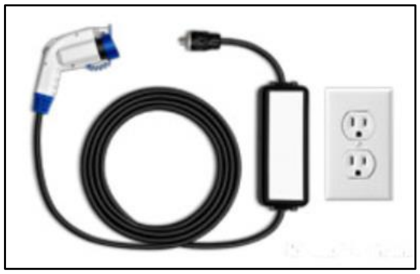


It is important to note that the chargers themselves do not provide the electricity nor in the case of L1 and L2, convert the host supplied electricity from alternating current to direct current which is what supplies the EV battery with energy, rather they are safety devices between the electrical supply from the host and the EV. The charger's first function is safety, by ensuring that the device they are plugged into is an electric car capable and willing to accept a charge. In industry parlance, EV chargers are known as electric vehicle supply equipment (EVSE).

a. Level One

L1 charging is plugging into a regular 110V outlet. L1 is typically used in single and multi-family dwellings and less commonly in the workplace and the public space. The charge rate is between 1.4kW and 1.9kW resulting in charge rates of 5-10 miles/hour. L1 benefits include the simplicity of plugging into an existing 110v outlet, no electrician required; negligible impacts to the greater grid and the lowest installation cost. Potential negatives include the slow charge rate, though this may also be in advantage in avoiding an expensive retrofit to install a L2 charger. Note: specific charge rates will depend on the EV model and the existing state of charge.

All EVs come with a L1 charger capable of plugging into a standard 110v outlet.



Mitsubishi Stock Charger and 110V Outlet

b. Level Two

L2 supplies 240V which is similar to what an electric oven uses. L2 enables a range of charging speeds up to 19.2 kW (~80 miles/ hour) though most PHEVs accept only up to 3.3kW (~12 miles/ hour) and dedicated battery electric EVs up to 6.6kW (~24 miles/ hour). As the case with L1, specific charge rates will depend on the EV model and the existing state of charge.

Within the L2 class there are two types of L2, which are typically referred to as "networked" and "non-networked chargers. Networked chargers have the ability to support the grid via ancillary services and demand response programs plus host-user control and billing capability.

Note, with technological advances, non-networked chargers can be converted to limited smart chargers. For example, eMotorWerks has recently developed a product, the "Juice-Plug" that sits between the J1772 connector of the existing charger and the EV and utilizing existing WiFi is able to remotely control charging to support the grid.

L2 is typically used in single and multi-family dwellings plus workplace and the public space. L2 benefits include the faster charge rate, permission and billing services (for the charging station host) and noted ability to support the grid. Negatives include the potential for detrimental grid impacts and for networked chargers, a much higher purchase price (4 to 6x) that of non-networked chargers plus ongoing annual network fees.

From left to right, ChargePoint Networked charger, Clipper Creek non- networked charger a and eMotorWerks JuicePlug

c. Direct Current Fast Charging

As detailed below, at present, there are three direct current Fast Charging (DCFC) standards, each with their own connector hardware/ orientation. DCFC stations are essentially equivalent to gasoline stations with the purpose to enable long distance/ regional EV driving for the long range and commuter dedicated battery electrics plus to provide charging for those without residential or workplace charging. These stations are significantly more expensive in comparison to L1 and L2 installation and depending on the additional electrical infrastructure required cost over $100,000 per charger install.

These chargers are typically installed along highways, destination locations such as malls and motel/hotels and car dealerships (both as a place to charge and for EV customer education). Given the power requirements, these are not for the single family dwelling though they might serve a large multi-family dwelling and are likewise rarely used for workplace charging. Figure 2 notes the DCFC density in the PAEC region.

Tesla SuperChargers: Tesla Motors has built (and is expanding) an exclusive nationwide network of superchargers under their own standard both within and connecting most major cities in the country. These DCFC are rated at 120kW and depending on battery state of charge will add ~170 miles in approximately30 minutes.

Tesla Connector

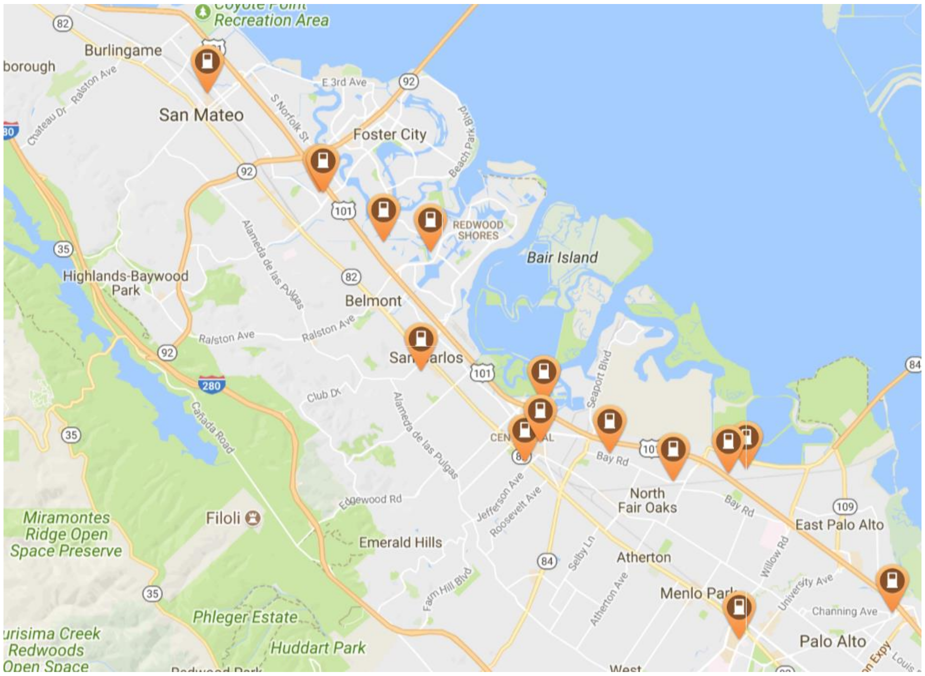
CHAdeMO: The CHAdeMO standard was developed and is used by Toyota, Nissan and Mitsubishi. Most stations have charge rates between 40 – 60 kW which is fast enough to charge a commuter EV Nissan LEAF to 80 percent in approximately 30 minutes. In addition, there are a few 100kW stations being rolled out though at present there are no EVs (with the exception of Teslas) capable of accepting such a charge rate. Finally, the CHAdeMO standard is being amended to increase the maximum charge rate to 150kW.

CHAdeMO Connector

Combined Charging System (CCS): The CCS standard was developed and is used by all of the American and German OEMs plus Hyundai and is derived from the Society of Automotive Engineers (SAE) J1772 L2 connector. Most CCS stations have 50kW charge rates which is fast enough to charge a commuter EV Volkswagen e-Golf to 80 percent in less than 30 minutes. In addition, in preparation for long range, high charging rate EVs, the first 150kW CCS station was recently installed in Fremont, California. Finally, in Europe, a consortium of German and American OEMs are planning to install 400, 350kW charging stations based on the CCS standard.

CCS Connector

Figure 2: DCFC Density in the PAEC Region



d. DCFC Benefits-cost analysis

While fast chargers are critical for the long term viability of EVs, for this report, the cost benefit ratio of fast chargers to that of the actual EV user was not calculated due a number of factors. First, the typical EV drivers do not own or pay for the fast charger installation (sometimes they do not even pay for the electricity received from the station). Second, the economics of most DCFC installations, has been distorted for differing reasons as noted below:

i. Car Dealerships

Fast chargers have been installed at most car dealerships in California to both demonstrate DCFC use to potential customers and to support the greater EV driving community.

ii. Consent Decrees and Conditional Use Permits

Fast chargers have and are being installed in California (and across the United States) as a result of a number of consent decrees. For example, as part of NRG's settlement with California over electricity price-fixing, NRG is required to install at least 200 DCFC in California. Similarly, Volkswagen, as part of their diesel settlement, are to spend $1.3 billion in California on EV infrastructure with a large spend on fast chargers. Finally, some cities have required DCFC installations as a component of a conditional use permits.

iii. California Energy Commission and Local Grants

Fast chargers have been and are being installed via California Energy Commission (CEC) and local grants. For example, the I5 DCFC EV corridor was primarily funded by the CEC and likewise, a number of Californian Air Quality Management Districts have offered grants to install fast chargers. In the PAEC region, the Bay Area Air Quality Management District (BAAQMD) is currently offering up to $18,000 to install a DCFC and in prior years, the District has offered up to $40,000 per installation.

iv. DCFC at Gasoline Stations

While this has not happened in California yet, the oil company British Petroleum BP is considering deploying DCFC at their European gas stations as a new business opportunity. Further, the oil company Shell is already deploying DCFC at their gasoline stations in the Netherlands

Given the above distorted economics for DCFC and the changing landscape of EV adoption due to the introduction of long range EVs, STA's recommendation to a municipality would be to encourage DCFC installations by third parties be funding from a grant, via a consent decree or evolving business model and not to self-fund DCFC installations.

V. EVCI Building Types and EVCI Cost Benefit

As discussed above, L1 and L2 EVCI is typically installed in four different building types, single family dwellings, multi-family dwellings, the workplace and the public space such as shopping destinations including private and public garages.

This report completes a benefits-cost analysis for single family dwellings and multi-family dwellings. As detailed below, both workplace and public charging were determined to be unsuitable for calculating a true benefits-cost analysis. First, in evaluating workplace and public charging, it should be understood that public charging is typically a blend of workplace charging and public (destination) charging in that the employees of the destination location (shopping malls, movie theatres, amusement parks, etc.) likewise typically have access to the chargers. Given this blend, workplace and public charging, from a benefits-cost analysis and purposes of this discussion, are considered to be essentially the same.

Second, similar to DCFC, this infrastructure is not owned by the actual EV drivers using the chargers. While they may pay for the electricity used in charging their EV and even additional cost component to address station maintenance, it is highly unlikely that the users are addressing the installation and charger acquisition costs. Further, there is a reasonable chance that the actual station owner, (municipality, employer or other third party) did not fully pay the full cost of the installation and charger acquisition; there have been and continue to be a number of grants and other programs available to offset a portion of these costs.

Third, workplace charging is typically considered an employment perk and some companies in the Bay Area have essentially guaranteed free EV charging for every employee that drives an EV to work. These companies consider providing charging as another incentive to attract new and retain existing employees. As such, these practices significantly skew the data in attempting to complete a benefits-cost analysis of installing EVCI in workplaces. This economic distortion can be rather large with some companies installing expensive networked chargers versus others simply providing a few 110V outlets.

However, workplace (and destination) charging provides a critical role accelerating EV adoption. Not only does workplace charging provide the fuel for the commute (or more) but also acts as an advertisement/ educational tool for EVs. By physically seeing EV infrastructure, the non-EV driving public's concern over the (perceived) limited range of an electric vehicle is reduced.

For local governments considering installing EVCI in their public garages, given the changing landscape of EV adoption due to the introduction of long range EVs, STA recommends installing L1 and L2 charging infrastructure via one or more of the following low cost options:

- Where the installation is paid for by a third party (such as under PG&E's Charge Network Program)
- Via a grant (BAAQMD's Charge Grant Program)
- By expanding charging availability by converting an existing L2s to L1s (one to three ratio)
- Allowing use of existing L1 outlets
- Tapping into lighting fixtures to facilitate L1 charging

Finally, in considering an expensive networked charger over a non-networked or simple 110V outlet, due to the billing capabilities of the networked charger, it should be noted that AB 2414 states that providing free electricity to state employees is not considered a gift of public funds and it may be more cost effective to give away the electricity than to expend dollars to catch dimes.

VI. EVCI Cost Benefit Methodology & Assumptions

To complete the EVCI benefits-cost analysis, as detailed below, STA first determined the cost to install the EVCI by either integrating the EVCI at the time of construction or adding the EVCI to existing building types (retrofitting).

a. Single Family Dwellings

To determine the installation cost for new and retrofits associated with single family dwellings, STA used PlugShare.com to both identify and survey approximately 50 single family dwellings with some form of EVCI in the Southern San Mateo County. PlugShare.com maps noting the locations of the single-family dwellings is included in Appendix A. The survey included in Appendix B, asked if the EVCI had been installed at the time of the home's construction or as a renovation. The survey further asked for the installation cost, the charger cost plus the number of hours spent by the home owner in getting bids, permits, evaluating chargers etc. Further to evaluate and test above costs, STA surveyed 5 home builder / electricians with over 160 years of experience that have both done work in the nearby city of Palo Alto and the greater PAEC region. Surveying builders/ electricians working in Palo Alto was important as Palo Alto has had an ordinance since 2013 requiring that new homes include Level 2 EVCI. Given this ordinance, it was inferred that these builders would have an understanding of the additional EVCI cost at the time of new construction and with Palo Alto being geographically next door to the PAEC region the data would also take into account building costs in the Bay Area.

b. Multi-family Dwellings

To determine the installation cost for retrofits associated with multi-family dwellings, STA used PlugShare.com to both identify and survey multi-family family dwellings with some form of EVCI in Southern San Mateo County. Given that there was only one unit found via PlugShare.com, STA surveyed the same builders surveyed for the single family dwellings.

c. EVCI Cost Estimates

Table 3 notes EVCI installation costs for integrating the EVSE installation into new construction. This data only includes cost estimates from the builders as the PlugShare.com users EVCI installations were retrofits. The column labeled "Accuracy" is an indication of how confident the builders/ electricians were in the cost estimate provided.

Table 3: EVCI, Installation, New Construction

NEW CONSTRUCTION	Average, $	Accuracy
Single Family Dwelling, 110V, L1	$ 264	High
Single Family Dwelling, 240V, L2	$ 450	High
Multi-Family Dwelling, 110V, L1	$ 500	Medium
Multi-Family Dwelling, 240V, L2	$ 800	Medium

Table 4 notes EVCI installation costs for a retrofit. This data includes cost estimates from the builders and PlugShare.com users. In providing cost estimate data on retrofitting, all the builders caveated their cost estimates with language like "it depends" and "each EVSE installation is different." Furthermore, cumulatively, they had completed a few extremely inexpensive installations, for example where there was ample room in the home's electrical panel and the charger was installed less than two feet from said panel. They also had completed a few extremely expensive installations; where the panel had to be upgraded along with the drop line to the home and long conduit runs behind drywall. To address this cost range, both "Low" and "High" costs are noted along with an overall degree of confidence (High, Medium, Low) as provided by the builder.

Table 4: EVCI, Installation, Retrofit

RETROFITTING	Low, $	High, $	Accuracy
Single Family Dwelling, 110V, L1	$ 388	$ 2,250	Medium
Single Family Dwelling, 240V, L2	$ 650	$ 5,125	Medium
Multi-Family Dwelling, 110V, L1	$ 2,475	$ 7,750	Low
Multi-Family Dwelling, 240V, L2	$ 2,950	$ 9,000	Low

d. EV Cost Savings

To determine the EV cost savings over a conventional internal combustion engine based vehicle, a 2017 *Nissan Leaf* (commuter electric vehicle) was compared to a 2017 *Nissan Versa Note* due to the similarities with their size and body configuration.

Nissan Leaf

Nissan Versa Note

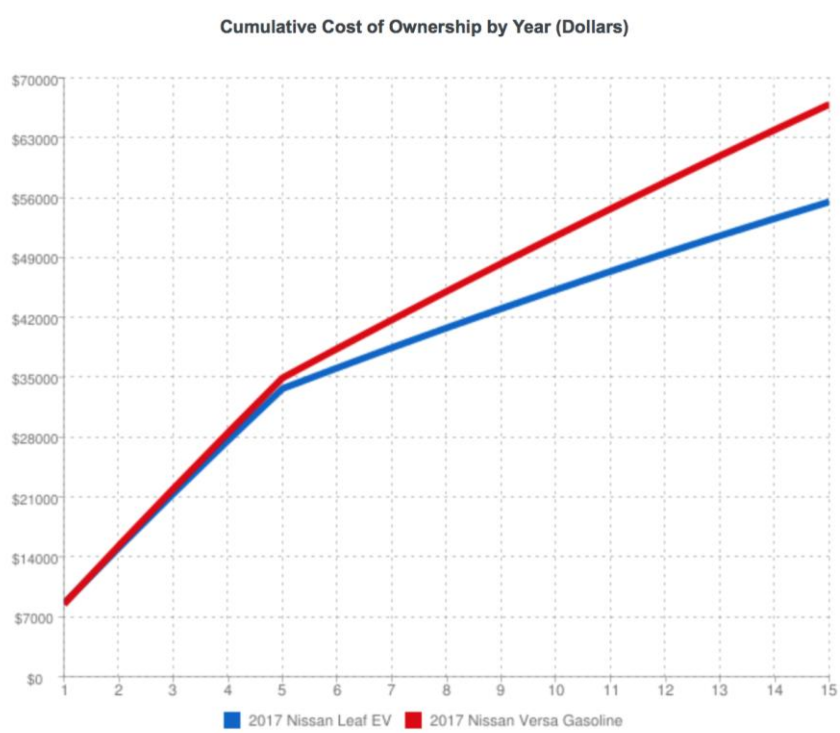
Two total cost of ownership models were run, the Department of Energy's (DOE) Alternative Fuels Data Center, Vehicle Cost Calculator which compares the two vehicles based on fifteen years of ownership and one developed by STA which compares the cost of ownership over a standard three year lease.

In both cases, the following cost reductions were applied to the Leaf's MSRP base price/ lease rate:

- $7500 Federal Electric Vehicle Tax Rebate (Note: in the Leasing Model, the tax credit is already accounted for in the Nissan provided leasing rate)
- $2500 California's Clean Vehicle Rebate Program
- $500 PG&E's Clean Fuel Rebate
- $1350 High Occupancy Vehicle benefit

As noted in Figure 3, the DOE Vehicle Cost Calculator estimated a total savings of approximately $10,500 over the fifteen years. Other inputs included an annual mileage of 12,000 and an average gasoline price of $3.50 /gallon. A full listing of the inputs and resulting output is included in Appendix C.

Figure 3: DOE 15-Year Total Cost of Ownership EV vs. ICE



As noted in Table 5 STA's cost of ownership estimated a total savings of approximately $9,700 over the three year lease. All the input parameters are noted in the Table. It is important to note that the STA model does not include insurance, taxes or title on either the electric or ICE vehicle.

Table 5: STA, 3-Year Lease, Total Cost of Ownership, EV Vs. Ice

Make, Year	Nissan, 2017	Nissan, 2017
Model	Versa-Note	Leaf
Lease, $/ month	$ 352	$ 229
Initial Payment	$ -	$ 1,999
3-Year Lease	***$ 12,672***	***$ 10,243***
Miles, over 3 years	36,000	36,000
Fuel $, gal or kWh	$ 3.50	$ 0.12
Electrical Generation:		PG&E, EV-B
Fuel, mpg City, 60%	31	n/a
Fuel, mpg Highway, 40%	39	n/a
Fuel, mile/kWh	n/a	4
Fuel, $	***$ 3,684***	***$ 1,080***
Oil , 4k miles, $35	***$ 315***	***$ -***
Maintenance	***$ 200***	***$ 200***
CA CVRP	-	***$ 2,500***
PG&E Incentive	-	***$ 500***
HOV	-	***$ 1,350***
Total 3-Year Cost:	***$ 16,871***	***$ 7,173***
Total 3-Year Savings:	***$ 9,698***	

Given that well over the majority of EV drivers lease over purchasing (75% in 2015), for purposes of the benefits-cost analysis the leasing savings of $9,700 or $3,200 per year is used in completing the benefits-cost analysis.

VII. Benefits-cost analysis

The benefits-cost analysis, was bifurcated into EVCI new construction and retrofitting, similar to the EVCI cost estimate above and is detailed in Tables 6 and 7 below.

Table 6: Results, EVCI New Construction

NEW CONSTRUCTION	Average, $	Accuracy	Payback, Months
Single Family Dwelling, 110V, L1	$ 264	High	1
Single Family Dwelling, 240V, L2	$ 450	High	2
Multi-Family Dwelling, 110V, L1	$ 500	Medium	2
Multi-Family Dwelling, 240V, L2	$ 800	Medium	3

Table 7: Results, EVCI, Retrofitting

RETROFITTING	Low, $	High, $	Accuracy	Payback-Low, Months	Payback-High, Months
Single Family Dwelling, 110v	$ 388	$ 2,250	Medium	1	8
Single Family Dwelling, 240V	$ 650	$ 5,125	Medium	2	19
Multi-Family Dwelling, 110V	$ 2,475	$ 7,750	Low	9	29
Multi-Family Dwelling, 240V	$ 2,950	$ 9,000	Low	11	33

VIII. Conclusions and Recommendations

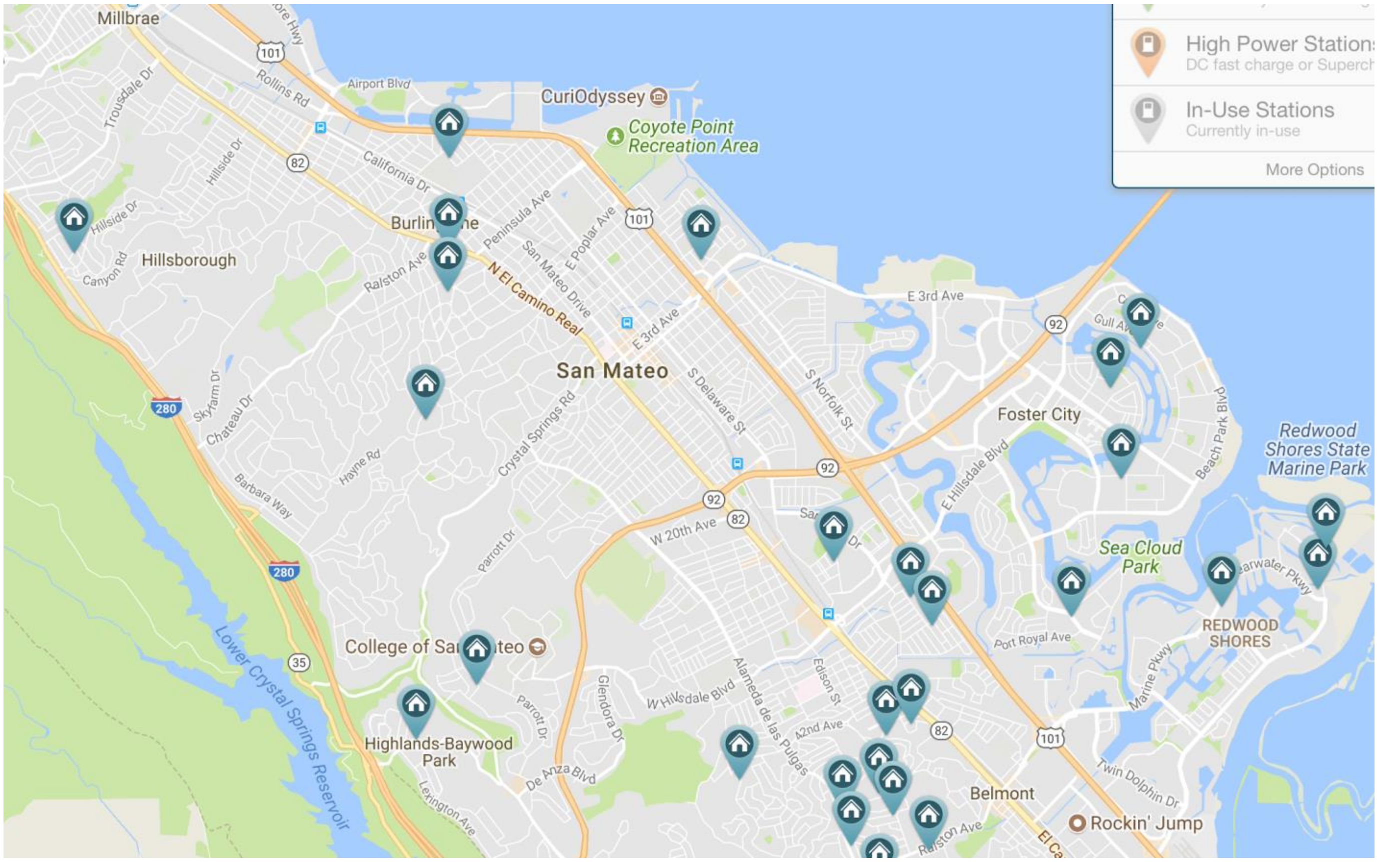
As evidenced in the benefits-cost analysis section, the payback for the installation of EVCI during new construction as compared to retrofitting is significantly shorter. To enable this savings for their citizens, municipalities should implement ordinances requiring EVCI installation at the time of new construction and major remodels.

Furthermore, should a municipality be considering an ordinance requiring EVCI installation at existing dwellings, the municipality should put a cap on expenditures per unit as there will be some dwellings (particularly in the multi-family dwelling stock) that may be extremely expensive to install

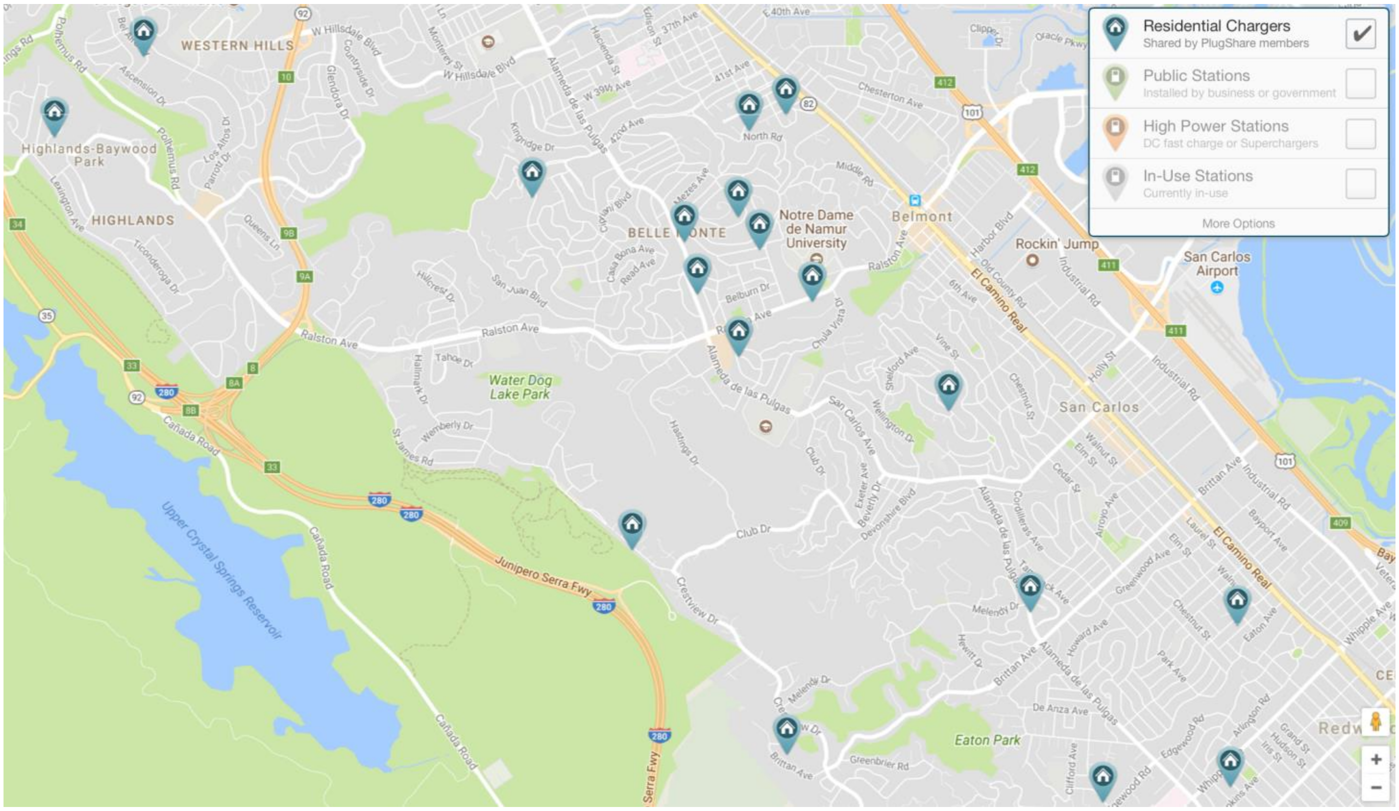
Finally, given the changing landscape of EV adoption due to the introduction of long range EVs, municipalities are encouraged to utilize existing funding programs when installing Level 1 and Level 2 charging infrastructure in the workplace/ public space and to assist and encourage third party providers in installing public DCFC.

Appendix A: PlugShare Residential Data, PAEC Region

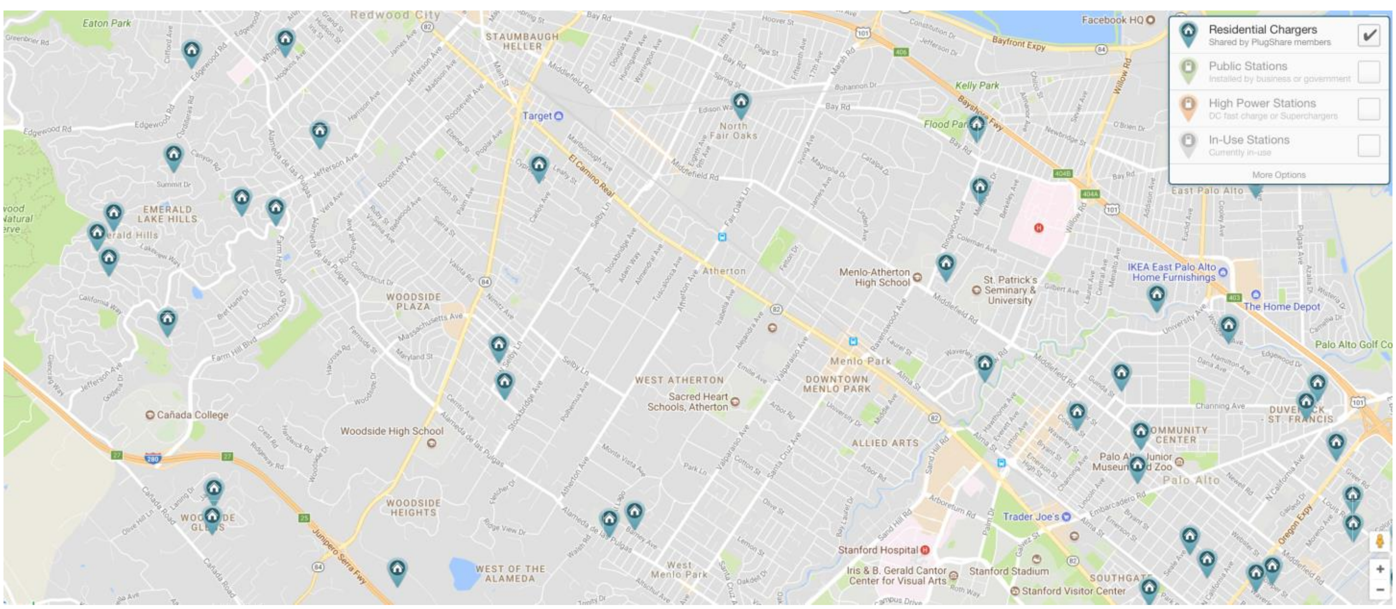
Plugshare Residential Data, PAEC Northern Region



Plugshare Residential Data, PAEC Central Region



Plugshare Residential Data, PAEC Southern Region



Appendix B: PlugShare Survey Script

Hi, I am a fellow PlugShare user in Palo Alto & have been asked to track some data down for the CA Energy Commission regarding home charging. Please consider answering these 3 questions, as incentive, I will donate $5 to Plug In America should you respond.

1) Roughly, how much was it to install the charger (electrician, permitting) and how much was the charger?
2) How many hours did you spend in selecting an electrician, getting bids, reviewing the work, having the charger installed etc. - the "hassle" hours?
3) Do you know EV drivers who live in apartments or condos that have either braved the charger install process or are charging off 110v at their apartment/ condo. Would you be so kind to provide their contact info. (Likewise $5 bonus/ person to Plug In America too)

Thanks,
Sven,

Appendix C: DOE Vehicle Cost Calculator

Share

Vehicle Cost Calculator

This tool uses basic information about your driving habits to calculate total cost of ownership and emissions for makes and models of most vehicles, including alternative fuel and advanced technology vehicles. Also see the cost calculator widgets.

ASSUMPTIONS

Choose vehicles to compare

EDIT
Clear all

2018 | Make | Model | ADD >>

Create Custom Vehicle

		Vehicle	Price	Fuel Economy (City/Hwy)	Fuel Type
⊗		2017 Nissan Leaf Automatic (A1) EV	$ 18,830 Tax credit?	27/33 kWh/100m	Electric
⊗		2017 Nissan Versa 4cyl 1.6L Automatic 4-spd Gasoline	$ 15,480	26/35 mpg	Gasoline

Clear all

Fuel Prices

Gasoline

$ 3.50 /gal

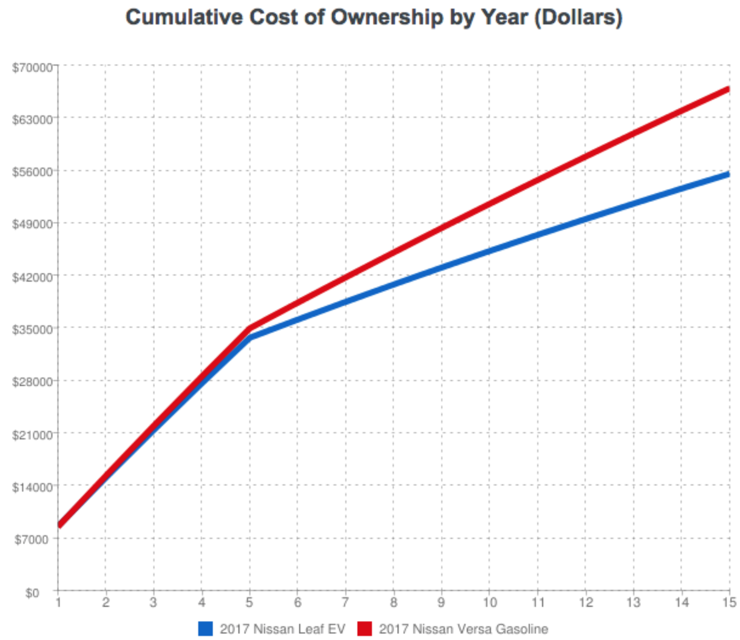
Tell us how you use your car

EDIT

GET RESULTS

Results

Vehicle	Annual Fuel Use	Annual Electricity Use	Annual Fuel/Elec Cost	Annual Operating Cost	Cost Per Mile	Annual Emissions (lbs CO2)
2017 Nissan Leaf EV	0 gal	3,541 kWh	$616	$2,721	$0.23	2,116
2017 Nissan Versa Gasoline	412 gal	0 kWh	$1,440	$3,698	$0.31	9,876
	Graph	Graph	Graph	Graph	Graph	Graph



This graph shows the cumulative cost of ownership by year for each vehicle, including fuel, tires, maintenance, registration, license, insurance, and loan payment. The tool assumes a five-year loan with a 10% down payment. Year one on the graph represents the 10 percent down payment plus the first year's total operating costs. For more information on this graph and other calculations, see the assumptions page.

Disclaimer:
The U.S. Department of Energy (DOE) and the National Renewable Energy Laboratory (NREL) do not endorse any companies or products described on the Vehicle Cost Calculator. Vehicle prices and specifications change frequently. Not all data have been verified by DOE or NREL, which manages the site. Consult a dealer or vehicle manufacturer before making purchasing decisions.