SCE Electric Vehicle (EV) Virtual Power Plant Analysis Shows $5,600 10-Year Savings Per EV Customer

Analysis of 5,000 Southern California Edison customer's hourly loads and commuting behavior suggests that residential peak period loads can be completely offset with an EV market share of only 10 %

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Abstract

This paper presents results of the first study to provide a customer-detailed empirical estimate of the financial benefits of a utility EV battery peak clipping /load shifting virtual power plant (VPP). An analysis of 5,000 individual SCE customers, including hourly loads and commuting detail, indicates that the entire residential sector peak can be offset with full nighttime EV battery recharging with only a 10 percent EV market share.

Estimated financial benefits of this EV VPP are annual cost savings of $560 per EV customer even after accounting for the cost of overnight EV recharging.

Expected rapid growth of the EV market along with the significant benefits shown here of even limited EV market saturation highlight the urgency of developing appropriate utility programs, EV technologies and a supportive regulatory framework.

Summary

Industry experts agree that recent technology cost reductions will significantly increase the percentage of electric vehicles (EVs) in the coming decade. Deloitte forecasts a tipping point in 2022 where the cost of ownership of an EV will reach parity with the cost of an internal combustion engine vehicle .[1] LMC Automotive[2], a consulting firm that provides market forecasts, estimates that EVs will make up 30 percent of the new car market sales by 2030.

Clearly a significant technological transformation is taking place. Utility pilot programs show that potential recharging kW spikes at the end of daily commutes can be distributed with managed charging to shift recharging demands across nighttime hours.

This study analyzed data on 5,000 individual SCE utility customers including each customer's hourly loads, commuting data, and battery reserves after afternoon commuting to simulate the ability of a VPP to clip the residential sector peak while constraining EV overnight recharging to avoid an overnight peak.

Study results show that, at a market share of just 10 percent, combining EV battery electricity supply to the grid in peak period hours along with managed overnight charging can provide an EV virtual power plant (VPP) that completely shaves residential peak demands. Savings are estimated at $560 per EV customer, even after accounting for the cost of recharging the EV battery.

Expected rapid growth of the EV market along with the significant benefits shown here of even limited EV market saturation highlight the urgency of developing appropriate utility programs, EV technologies and supportive regulations to take advantage of this new VPP resource.

Data and Analysis Approach

A sample of 5,000 individual Southern California Edison (SCE) residential owner-occupied single family dwelling unit customers was drawn from the Los Angeles Metropolitan area MAISY Utility Customer 8760 Hourly Load Database (http://www.maisy.com/maisydatabases.htm)[3]. Individual customer data items include customer hourly loads, commuting data and household data. Random weeks in January and August were chosen to generate representative daily load shapes.

For this analysis, the SC&E EV time-of-use rate period differentials are applied to estimate cost savings.

Utility cost savings for each kWh shifted from on-peak to off-peak is approximated as the differential in those two rates. Shifting one kWh from the 4-9pm on-peak time period to off peak hours saves $0.25 in the summer and $0.23 in the winter[4]. Weekend savings were not considered because weekday commuting savings are significantly greater than potential weekend savings and because MAISY data provides actual commuting data for weekdays but not for weekends. Consequently, financial benefits estimates can be considered lower-bound estimates.

Program parameters assume that utility load management will access reserves remaining in the EV battery after the afternoon commute, reserving at least 20 percent of the full battery charge (approximately 60 miles of driving distance) for contingent travel. The analysis assumes a level 2 home charging station with a charging demand requirement of 10 kW with a full charge requiring 9 hours providing a 300 mile range.

Households with more than $125,000 in income and with total daily automobile commutes of less than 120 miles were selected to represent future EV owners. EV ownership was randomly assigned to households in this subset who used private automobiles to commute.

Analysis Results

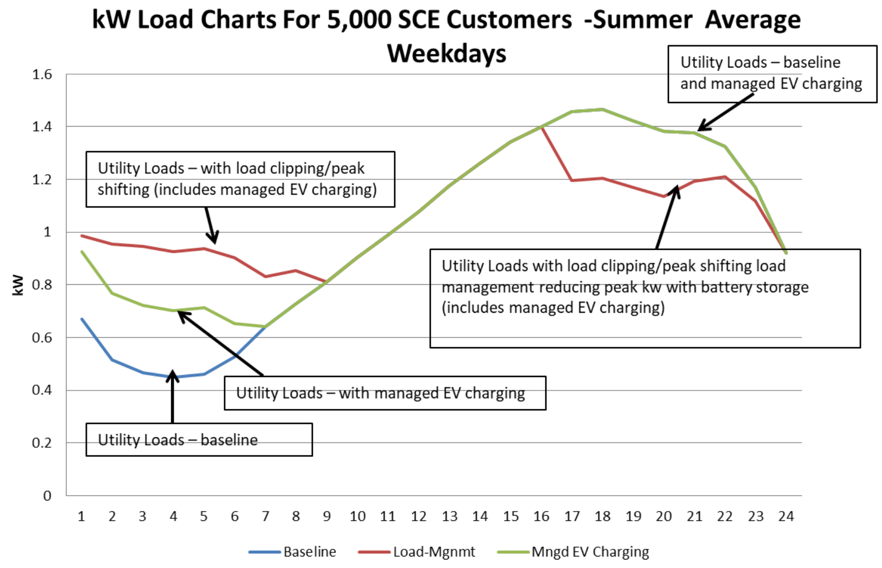
A 10 percent EV market share was identified as a reasonably near term forecast that completely clips current residential peaks shifting loads to off-peak hours. Analysis results are shown in the table and charts below.

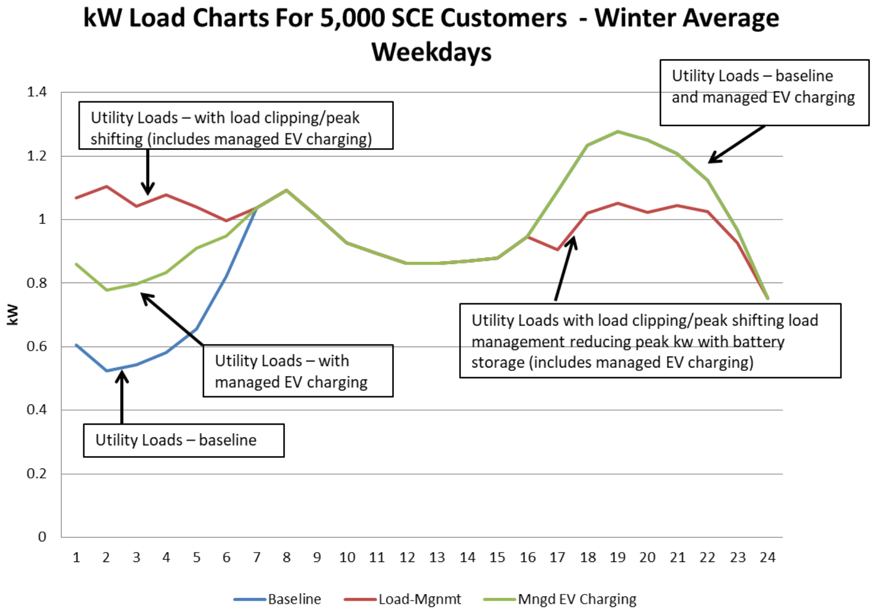
Estimated Average Annual EV Owner Savings With a Peak Clipping/Load Shifting Strategy

Hour	17	18	19	20	Totals
Summer					
savings by hour	$ 81	$ 81	$ 78	$ 76	$ 317
Winter					
savings by hour	$ 53	$ 61	$ 64	$ 65	$ 243
Annual					
savings by hour	$ 134	$ 142	$ 143	$ 141	**$ 560**

These results show that each EV generates $560 of actual net annual cost of service savings to SCE.[5] That is,, extracting EV battery electricity after the nighttime commute to reduce customer loads and recharging batteries overnight at prevailing rates saves $560 per EV customer annually, even after the cost of recharging for the daily commute. Over a 10 year period, savings amount to $5,600 per EV.

Graphically the hourly load impacts of this program are shown below for this sample of SCE customers for both summer and winter seasons.





Several items to note:

- Baseline and managed EV charging reflect the same peak period hourly loads because the managed loads scenario assumes that all after-commute charging is delayed until night time hours
- Only the load clipping/peak shifting EV VPP management strategy reduces peak period hourly loads
- Managed EV charging and load clipping/peak shifting VPP load management increase early morning hourly loads; however those loads are no more than pre-peak period loads
- Each EV customer's battery reserve was used to completely offset their electricity use in peak hours

Analysis Caveats and Applications to Other Utility Services Areas

The analysis and results presented here provide a quantitative example of potential benefits that can be achieved with a utility EV virtual power production strategy in the SCE utility service area. More detailed and accurate savings calculations can be achieved with analysis extensions described in the next section. For example, the 100 percent participation in the EV VPP program assumed in this analysis can be extended to account for EV non-participants and individual customer op-outs. Battery reserve usage was limited to completely offset each EV customer's hourly electricity use. However, nearly all EV customers had sufficient battery reserves to pull more power making EV customers net power producers in peak hours.

With respect to applying these results to other utility service areas, diversity in utility customer hourly loads, commuting behavior, avoided peak costs and cost of overnight charging determine EV VPP savings unique for each utility. While these results suggest a significant potential for utility EV VPP SCE programs, more detailed analysis is required to assess results for each individual utility service area.

Extending the Analysis

The analytic approach outlined in this paper can easily be extended to provide a more comprehensive utility service area program analysis. Full year MAISY utility customer hourly loads, household and commuting data for a sample of all customers in a utility service area, actual utility service area cost of service, more detailed EV ownership and program design and participation models can be used to develop reliable utility-specific analysis and strategies. Geographic detail can identify substations and feeders most likely to benefit from an actively managed VPP strategy. Scenario analysis can provide business case results to reflect alternative EV characteristics and saturation and program assumptions.

Addendum

This white paper has received considerable attention since its release two day ago along with a variety of comments and questions and a gentle push-back on the economics of an EV VPP. This addendum responds to the most frequent of these comments.

1. Battery cycle/economics issues. Battery charging cycles primarily determine the lifetime of EV batteries (BTW, charging from 60-70% is just 10% of a battery charging cycle). The current 1,500 Tesla charging cycles reflect about 450,000 miles of driving (Tesla estimates 300,000 – 500,000 miles). The average $560 per year utility savings determined by the study translates to an average of 43 kWh/week EV battery discharge to the grid. At 15,000 miles driven per year with the 43 kWh grid discharge each week, the VPP program reflects 52% of total charging cycles and an expected battery lifetime of 19.6 years so battery degradation is not likely to pose a problem for most EV owners, though different driving and discharge parameters obviously change the estimated lifetime.

For example, if the EV owner has a much longer commute and a much greater peak kWh use so that the battery degrades enough to require replacement. Elon Musk has quoted a battery module (not the pack) replacement cost of $5,000 - $7,000. If the replacement module characteristics are the same as the original, the implied cost of electricity generated from the new battery are $0.055/kwh. Since the average cost savings of switching from peak to off-peak periods is about $0.24, the net benefit is $0.185 for each kWh shifted. Thus, the net annual cost savings per EV customer is $431 or $4,310 over 10 years after taking account of charging cycle cost impacts.

It should be noted that charging cycle constraints are constantly increasing and battery costs are declining so actual business case calculations for future years will be even more attractive.

Finally, EV batteries that have degraded enough to be replaced can still have significant value as in-home battery resources used in utility load management programs.

2. **Institutional Inertia.** Most regulators and EV manufacturers have not fully recognized the magnitude of benefits associated with this EV VPP strategy. Part of the paper's objective was a call to these parties to recognize the urgency of developing a framework to promote these benefits. That includes manufacturers changing their warrantee requirements.

4. **Controls and electronics** requirements are not likely to be an obstacle though they will incur some costs. A number of companies already offer EV discharge/storage services via customer aggregation services.

5. **Caveats.** Finally, as mentioned in the Caveats section of the paper: "The analysis and results presented here provide a quantitative example of potential benefits that can be achieved with a utility EV virtual power production strategy in the SCE utility service area. More detailed and accurate savings calculations can be achieved with analysis extensions described in the next section. "

References

1 (https://www2.deloitte.com/content/dam/Deloitte/uk/Documents/manufacturing/deloitte-uk-battery-electric-vehicles.pdf) .

2. (https://www.greencarreports.com/news/1122249_forecast-in-2030-gasoline-will-still-power-7-out-of-10-new-u-s-vehicles)

3 MAISY Utility Customer Hourly Load Databases (http://www.maisy.com/maisydatabases.htm) have been applied to address solar, battery, CHP, cool storage, microgrids, wind, programmable communicating thermostats and a variety of additional smart technologies, load management and demand response programs.

4 (https://www.sce.com/residential/rates/Time-Of-Use-Residential-Rate-Plans).

5. Costs savings reported in this paper are actual net cost savings – that is savings in utility cost of service that could actually be received by customers in their electric bills. Studies of managed EV strategies calculate "cost savings" as the difference peak period charging costs and overnight charging costs. Customer electric bills will still increase with managed savings as a result of overnight charging costs – though not as much as if charging occurred in peak periods.

About the Study Author. Dr. Jerry Jackson, president of the consulting firm Jackson Associates (JA) and leader of the Smart Grid Research Consortium has advised utilities and technology companies on market analysis, sales and market strategy for a variety of new energy technologies including electric vehicles, solar, thermal energy storage, fuel cells CHP, wind, flywheels, demand response, energy efficiency and various smart grid technologies. He has also held academic positions at Texas A&M University, Georgia Tech Research Institute and the University of Central Florida. See the JA client list at http://www.maisy.com/clients.htm .

About MAISY Utility Customer Databases. MAISY Utility Customer Databases used in this study contain dwelling unit, household, equipment, and energy use including hourly loads for more than 7 million individual US residential and commercial utility customers. More information is available at http://www.maisy.com/maisydatabases.htm