

Plug-in Hybrid Electric Vehicles and Positive Load Growth

Why a PHEV “smart charging” strategy should be on the agenda for your next meeting with your utility’s CEO

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Summary

Plug-in Hybrid Electric Vehicle (PHEV) load growth may be coming sooner than you think, driven by factors beyond the utility's control. This development poses significant challenges for peak capacity and distribution planning, but also provides significant opportunities for environmental benefits, increased energy security, rate reductions and earnings opportunities. Based on prior work with utilities in the Western US, this brief summarizes how Freeman, Sullivan & Co. (FSC) and Energy and Environmental Economics, Inc. (E3) can assist your utility in both developing a comprehensive PHEV strategy and gaining regulatory approval for a "smart charging" program. In brief, FSC and E3 can provide:

- 1) A robust PHEV adoption and charging forecast.**
- 2) An informed approach for motivating off-peak charging.**
- 3) A comprehensive PHEV strategy including program design, regulatory strategy, management and regulatory approval and ultimately, program funding.**

Among the reasons to view load growth due to the adoption of PHEVs as a beneficial fuel switching program are its net economic and environmental benefits for the utility, its ratepayers, and society. PHEV loads reduce fossil fuel use and greenhouse gas (GHG) emissions and are essential to meeting long term climate change goals. PHEV batteries can be charged using excess, off-peak wind generation, facilitating the integration of renewable resources. Furthermore, unlike any other initiative, a PHEV program can simultaneously reduce rates and increase utility earnings.

These benefits can only be realized with a properly designed PHEV smart charging program. Successful implementation of the program will require a coordinated effort at the utility management level. This effort must address potential external lobbying efforts against PHEVs from the petroleum and refining industry and others. The strategy must also overcome internal resistance to PHEVs from utility departments such as generation planning and procurement; distribution planning; energy efficiency; billing; and information technology. Individually, each of these departments is likely to see challenges that outweigh the benefits, without considering the broader picture. A high level regulatory strategy is also essential because without special treatment, otherwise beneficial PHEV load growth will actually increase the utility's burden in meeting GHG emissions, Renewable Portfolio Standards (RPS), and energy efficiency goals.

PHEVs could lead to rapid load growth sooner than you think

Ten years after the introduction of the Prius to the US in 2000, Hybrid Electric Vehicles (HEV) are on track to make up approximately 4 percent of the total light-duty vehicle fleet in California. If PHEV adoption were to follow a path similar to the Prius, PHEVs introduced in 2010 would lead to electric demand totaling less than 1 percent of California's system load in 2020.

However, this should not lead utility resource planners to be sanguine about the potential impacts of PHEVs on their systems. PHEVs represent a fundamentally different proposition to consumers than the HEV. PHEVs provide convenient, at-home charging, reduce fuel costs and satisfy individual desires to express environmental, social and technological values both real and symbolic. The encouragement offered by federal and state government incentives increases the potential for unexpectedly rapid adoption of PHEVs. Furthermore, uncontrolled charging will

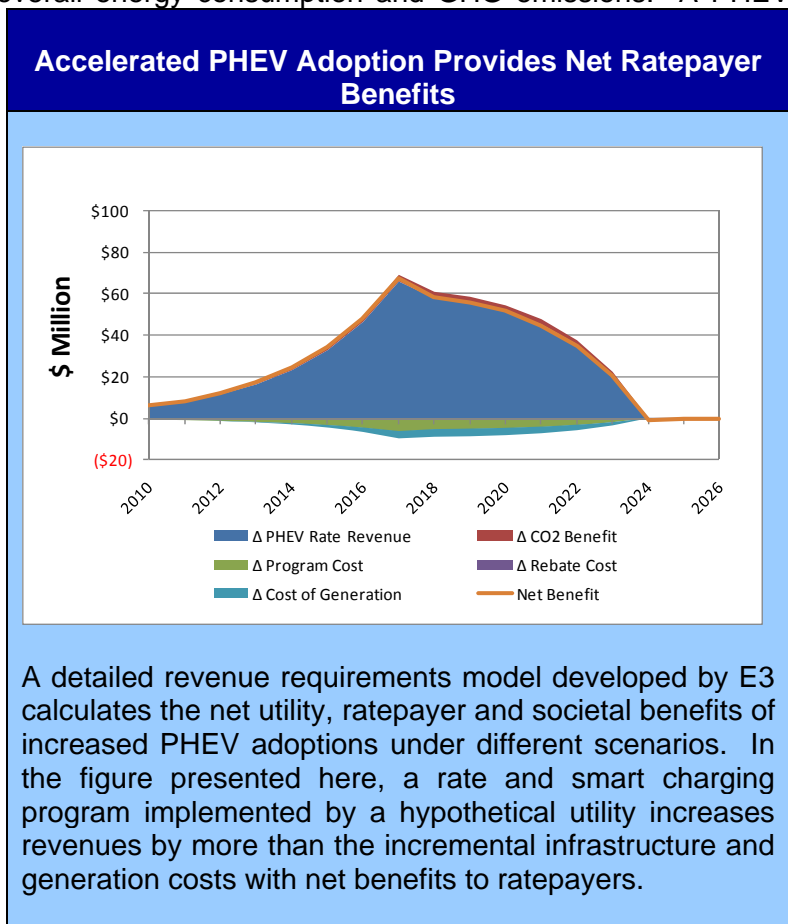
coincide with utility peak load, leading to a significant absolute MW, if not percentage, increase in peak load. At the adoption rates described above, E3’s analysis for California in 2020 shows a peak PHEV peak load of 235 MW. This increase will require 2 to 3 new peaking plants to serve an end-use that does not currently exist. As described further below, PHEV adoption will be concentrated in specific geographic areas, causing further challenges for the distribution system.

Utilities should view PHEV load growth as a positive

While it is important to appreciate PHEV load growth as a desirable development, increased PHEV charging loads present a challenge on numerous fronts from the narrow perspective of the utility. By increasing electric loads, PHEVs can be seen as placing additional strain on utility systems in an era where new generation facilities are harder to site. The increase in PHEVs may also be seen as undoing much of the work in the last decade to reduce load growth through energy efficiency. GHG and RPS policies place an additional burden on utilities: by adding load, PHEVs will increase GHG emissions in the electric sector (despite reducing *total* GHG emissions when the transportation sector is factored in), as well as increase the amount of renewable power that must be purchased by the utility to meet RPS targets.

Viewing the impacts to society as a whole changes the picture dramatically. From this perspective, PHEVs should be viewed not as leading to unwanted load growth, but as a positive fuel switching program. PHEVs are the first transitional step towards electrifying the transportation sector and reducing overall energy consumption and GHG emissions. A PHEV, with a battery and an electric drive train, is inherently more fuel-efficient than internal combustion engine vehicles (ICEVs) and can reduce total energy consumption by up to 65 percent. PHEVs also emit 55 percent less CO₂ as compared to an ICEV, assuming a generation mix similar to that for California.

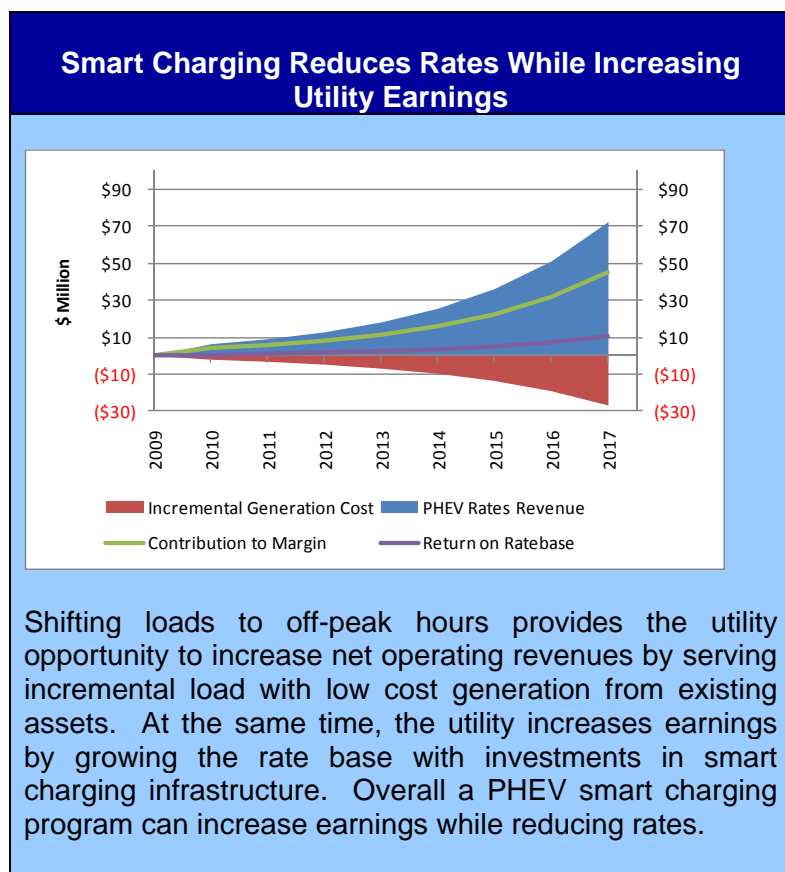
These benefits of PHEVs should lead utilities and regulators to promote, not fear, their adoption. This will require a coordinated regulatory effort that goes beyond the challenges PHEVs pose to the utility sector and demonstrates the benefits to society as a whole. In this vein, a study produced by E3 shows that electrification of the transportation and other sectors with low-carbon generation will be the key to achieving long-term GHG emissions reduction goals. In California, meeting 2050 GHG reduction goals will require nearly eliminating gasoline consumption.



To accomplish this, ICEVs must be replaced by 40 million EVs and PHEVs, representing 90 percent of all new light-duty vehicles. Even with aggressive energy efficiency and conservation, electricity demand in the state could double as a result of the electrification of the transportation and other sectors needed to meet 2050 GHG targets.

PHEVs Provide Utility and Ratepayer Benefits

If PHEV load can be shifted to off-peak hours with a utility smart charging strategy, additional benefits can be achieved. PHEVs can assist in the integration of wind generation, currently the cheapest source of renewable energy. PHEVs can provide beneficial loads during off-peak periods when ISOs and utilities are increasingly facing problems of excess generation.



Improved financial performance is the final benefit that might be the most important from the perspective of the CFO and shareholders. Unlike efficiency, PHEVs can provide net energy savings and GHG emission reductions while simultaneously reducing rates and increasing utility earnings. Increasing electricity sales during off-peak hours provides increased revenues using existing assets, decreasing the proportional allocation of fixed costs in utility rates. At the same time, investments in smart charging infrastructure expand the rate base and increase earnings. Implementing the smart charging strategy that will be essential to achieving these benefits entails some challenges, as discussed in the next section.

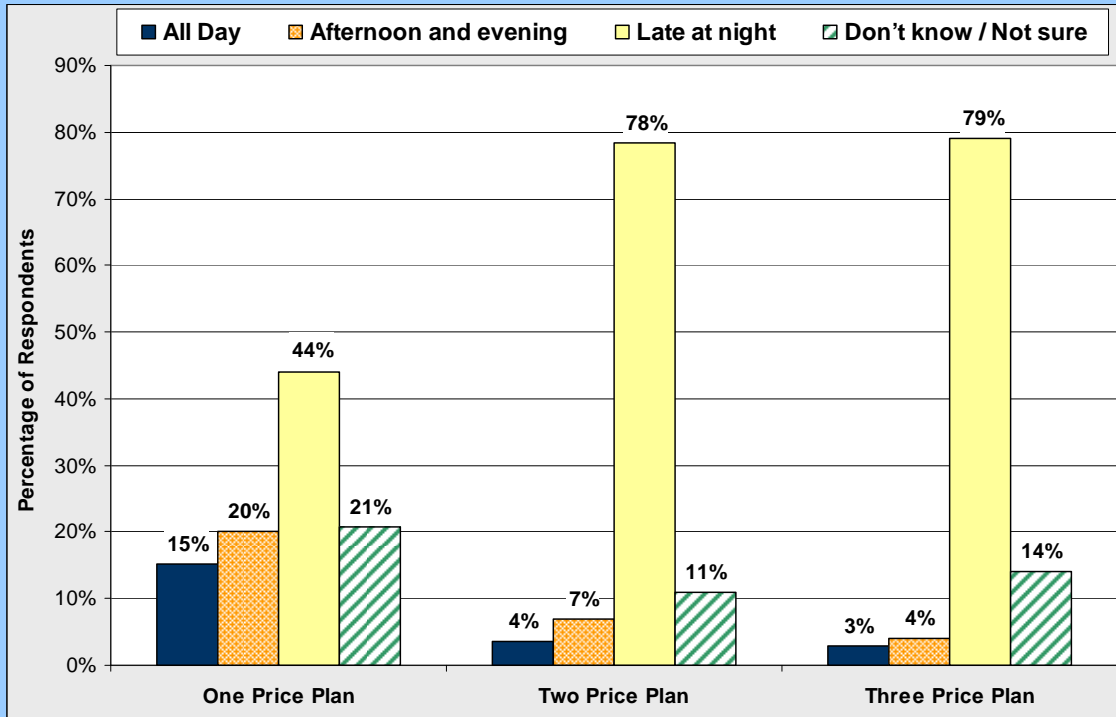
A Smart Charging Strategy Will Be Essential

Controlled or “Smart” charging of PHEV batteries, will be critical to maximizing utility rate and earnings benefits. Several studies have documented that with uncontrolled charging, PHEV loads will increase rapidly after commuters arrive home between 4:00-6:00pm. Peak charging loads will occur between 6:00 and 9:00pm, coincident with peak load for many utilities. This increase in peak demand would require investment in new generation and transmission and distribution (T&D) capacity. With the marginal cost for new capacity generally higher than the average cost of a utility’s existing portfolio, this investment would almost certainly place upward pressure on rates.

In contrast, smart charging can shift PHEV load to super off-peak hours, when generation costs are lower and there is plenty of excess capacity. Yet utilities should not underestimate the

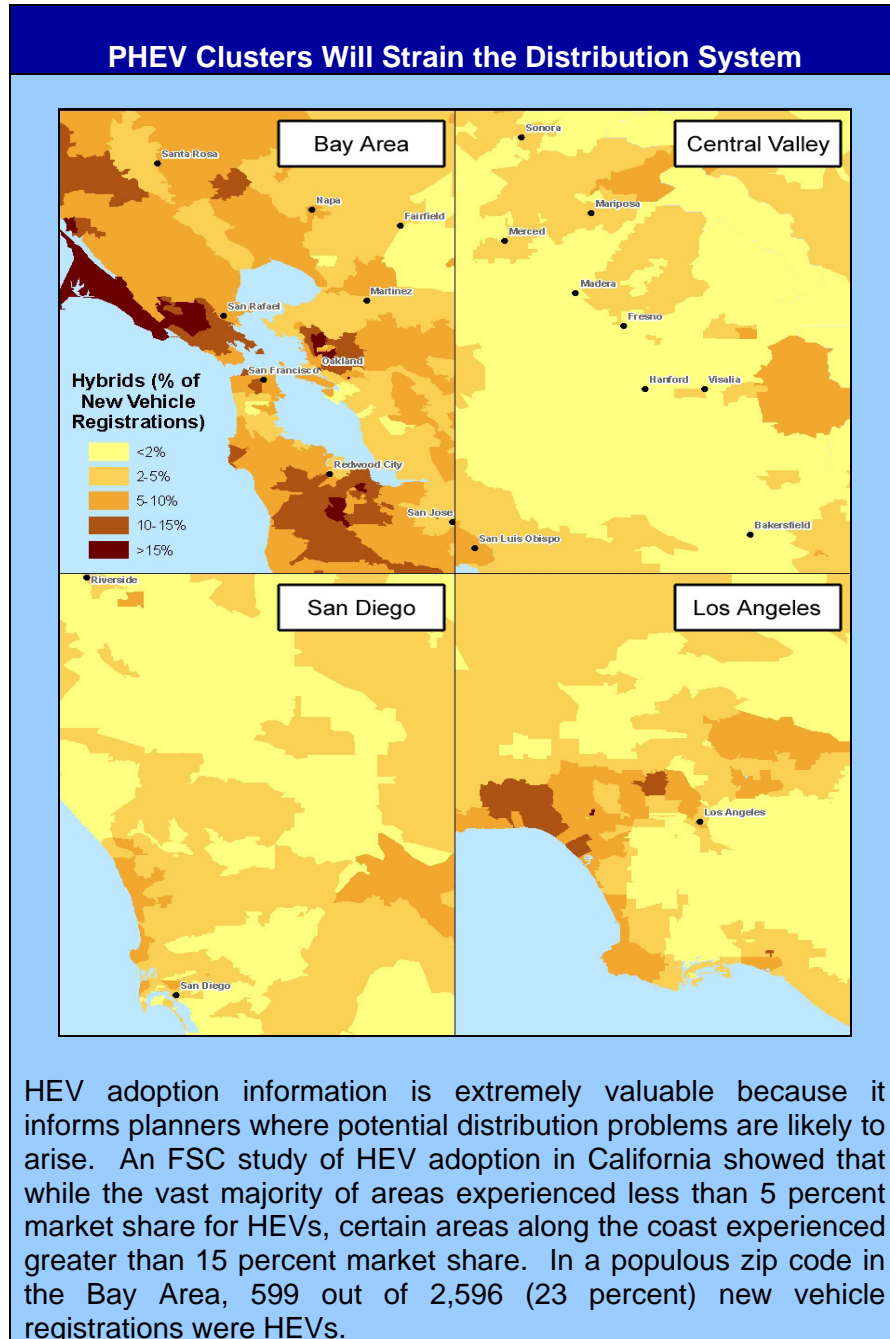
challenges of implementing smart charging, the excitement surrounding advanced meters and smart grid notwithstanding. Ideally, vehicle charging infrastructure will include dedicated meters for PHEV charging and enable two-way communication of rates and loads. The changes required to customer billing and IT systems alone to implement this system can be significant, as FSC and E3 have seen with several utilities.

**TOU Rates Alone Can Encourage a Significant Shift to Off-Peak Charging:
Percentage of respondents who would charge their PHEV during different times**



A study performed by FSC shows that TOU rates alone can provide a strong incentive for customers to shift charging to off-peak hours. Under a single rate, only 44 percent of respondents said that they would usually charge their PEV late at night. Under the price plans with two or three TOU periods plans (without dedicated submeters for charging), the percentage of respondents that would usually charge their PEV late at night increases substantially to 78 and 79 percent respectively. Studies of driving patterns suggest that the disparity may be even greater. On the other hand, in hotter climates with air conditioning pushing household loads into the upper rate tiers, customers have been resistant to adopting TOU rates for their entire household. In such instances, submetering of PHEV charging may be needed to effectively promote off-peak charging. Enabling technologies and increasing customer experience with dynamic rates may increase customer response over time. Researching the types of rate plans that will minimize IT costs and provide sufficient incentive for customers to shift PEV charging off-peak is essential to maintaining system-wide stability.

Utilities face a number of technology options without the advantage of well-developed industry standards. Analysis performed by FSC and E3 can identify the most effective strategies and technologies to shift charging to off-peak periods in a cost effective manner.



Distribution Challenges will be Large

Smart charging will be doubly critical due to the challenges to distribution systems resulting from the tight concentration of PHEV adoption in certain areas. As seen in the sidebar to the left, high concentrations of PHEVs within certain geographic areas are to be expected based on HEV adoption patterns. Even with an overall PHEV adoption rate of less than 5 percent, concentrations above 15 percent will occur in selected zip codes.

Furthermore, studies have shown a strong customer preference for fast (Level II) charging. Fast charging of PHEVs will create loads of 3-5 kW, roughly equivalent to 20 large screen TVs or 12 refrigerators. For smaller households, this will represent a doubling of their peak load. Thus, 2 to 5 PHEVs charging on a single distribution line will quickly overload the final line transformer. Programs promoting PHEV adoption must address strong concerns voiced by utility distribution engineers

What You Need to Know to Develop a PHEV Strategy

1) What is the range of potential adoption scenarios for my service territory?

Bounding the magnitude and timing of increased PHEV charging load is essential to initiate the development of a PHEV smart charging strategy. However, publicly available PHEV adoption scenarios are based on broad assumptions, differ by orders of magnitude and are not well documented. Furthermore, adoption will vary significantly based on geographic and demographic factors specific to your service territory.

2) Where will PHEV clustering present a problem for my distribution system?

Even with relatively low overall adoption rates, clustering of PHEVs will present a problem in specific areas. Identifying those areas will enable you to develop a timely, targeted and cost-effective approach to addressing distribution system impacts.

3) What will uncontrolled vs. controlled charging profiles look like?

The comparison of uncontrolled vs. controlled charging scenarios is essential for a compelling demonstration of smart charging cost-effectiveness and justifying utility investments. Again, publicly available charging profiles are based on simplistic assumptions that are not transferable to different areas. Actual profiles in your service territory will depend to a great degree on charging technology, vehicle stock and driving patterns, which vary significantly between regions.

4) What strategies for motivating off-peak charging will be viable and effective for my utility?

As seen in California, the costs, benefits and effectiveness of different rate and smart charging strategies can vary significantly even within a single utility's service territory. The existing and anticipated capabilities of billing, IT and AMI systems will imply lower costs for sub-metering and controlled charging for some utilities as compared to others. Surveys have shown that rate design, technology and communication strategies all have profound impacts on customer charging behavior.

5) What are the impacts of a smart charging strategy on PHEV owners, ratepayers, utility shareholders and society as a whole?

Fortunately the PHEV smart charging program can provide benefits for all stakeholders. Nevertheless, demonstrating and quantifying those benefits will be essential to design rates, justify incentives and gain regulatory approval. Quantifying benefits in a transparent, open model helps to build consensus and gain stakeholder support, both internally and externally.

6) What are the environmental benefits of increased PHEV charging?

Reduced overall energy consumption and GHG emissions are among the largest benefits of a PHEV smart charging program. Once again, these benefits are utility specific, driven predominately by the regional generation portfolio and resource plans. For some utilities with base load coal generation, it is possible that off-peak charging will reduce costs, but increase GHG emissions.

7) How will PHEV load growth affect other strategic and policy goals?

Related to the environmental benefits is the question of how PHEV load growth will impact utility metrics under policy goals established for energy efficiency, renewable generation and GHG reduction. In jurisdictions with revenue decoupling, incremental PHEV loads will reduce rates, but will not increase utility earnings. Absent regulatory intervention, PHEVs and other forms of electrification will increase the utility's burden in meeting established policy targets and provide no benefits to shareholders.

FSC & E3 Are Uniquely Qualified to Gain Regulatory Approval and Funding for Your PHEV Smart Charging Program

FSC and E3 are uniquely qualified to help you develop a comprehensive PHEV program and then guide your PHEV program through the stakeholder and regulatory process critical to gaining approval and funding. Together, FSC and E3 have the market and regulatory expertise needed to provide critical insights on customer preferences and adoption and to make the regulatory case demonstrating the energy, environmental and ratepayer benefits of a smart charging program. An FSC/E3 analysis will provide:

1. A Robust PHEV Adoption and Charging Forecast

- a. A forecast of PHEV adoption backed by detailed automotive industry, customer survey and demographic data.
- b. The critical zip codes where concentration will be an issue for the distribution system.
- c. Hourly charging profiles based on vehicle types, driving patterns and charging habits.

2. An Informed Approach for Motivating Off-Peak Charging

- a. Estimate shift to Off-peak charging motivated by viable rate and metering options.
- b. An increased understanding of needed generation, distribution, metering, billing and IT investment under various scenarios.

3. A Comprehensive Strategy Covering Program Design, Regulatory Strategy, Management and Regulatory Approval and Ultimately, Program Funding.

- a. A revenue requirements model that quantifies rate and earnings impacts over time and that demonstrates the net benefits of PHEVs and smart charging to the utility, ratepayers and society.
- b. A comprehensive analysis that anticipates and addresses resistance from individual silos with the utility and regulatory agencies, including procurement, distribution planning, energy efficiency, billing and information technology.
- c. A justification and mechanism for making the changes in efficiency, RPS and GHG policies needed to promote positive PHEV load growth without penalizing the utility.