**BEFORE THE PUBLIC SERVICE COMMISSION**

**OF THE STATE OF MISSOURI**

In the Matter of a Working )

Case Regarding Electric ) **Case No. EW-2016-0123**

Vehicle Charging Facilities )

**Missouri Public Service Commission Docket on Vehicle Electrification**

**Literature Review, submitted by Natural Resources Defense Council (NRDC)**

1. [*Engaging Utilities and Regulators on Transportation Electrification*](https://www.ethree.com/documents/E3-NRDC_EVs_Paper_Final_20150129.pdf)

Ryan, Nancy E., and Luke Lavin. "Engaging Utilities and Regulators on Transportation Electrification." Energy+Environmental Economics. March 1, 2015.

PEVs are widely recognized for their environmental benefits and are expected to play a significant role in achieving carbon emissions reductions consistent with national climate goals. However, PEVs also offer specific benefits to utilities, utility customers, and PEV owners that can only materialize with utility and regulatory engagement on PEV policy. Due to spare capacity on the distribution system during off-peak hours, greater utilization of system assets from increased PEV loads can spread out fixed cost recovery over a larger amount of electricity sold and in turn, lower rates for all customers. Because PEV charging has the potential to drive distribution system upgrades that could increase costs for all customers, utilities should ensure that charging is done at off-peak times to avoid additional infrastructure investment and that the additional revenues collected from charging exceed the additional cost of satisfying the new load. Since PEV loads are incredibly flexible over the course of the day, time-variant rates such as time-of-use or real-time pricing can send price signals to encourage charging during off-peak hours, delivering net benefits to PEV owners and all utility customers. In the longer-term, dynamic rates can also assist in the reliable integration of non-dispatchable renewables and prevent periods of over-generation and curtailment. In sum, E3 encourages state utility regulators to continue to develop the regulatory certainty required for utilities to make investments in transportation electrification infrastructure and approve time-variant electricity rates that benefit utilities, customers, and PEV owners alike.

1. [*Overcoming Barriers to the Deployment of Plug-in Electric Vehicles*](http://www.nap.edu/catalog/21725/overcoming-barriers-to-deployment-of-plug-in-electric-vehicles)

Kassakian, John G., David Bodde, and Jeff Doyle. "Overcoming Barriers to Deployment of Plug-in Electric Vehicles." The National Academies Press. 2015.

In 2014, PEV sales comprised just 0.76 percent of total light-duty vehicle sales, underscoring several obstacles that electric vehicles face in the path to greater market adoption. The first set of obstacles is tied to lack of customer information on PEV functionality, fuel (electricity) costs, and incentives for PEV ownership. Because increased PEV penetration depends significantly on customers’ perceptions of the vehicles’ value, government entities at all levels should ensure that information on PEV-related costs, benefits, incentives, and developments is communicated effectively to customers. Another set of obstacles concerns the current lack of charging infrastructure needed to support the adoption of PEVs, particularly at homes and workplaces. To overcome this problem, the NRC recommends that local governments simplify permitting processes for charging installation and develop building codes that support future installations, particularly at multi-unit dwellings where barriers to installation are highest. Additionally, because NRC finds that PEV charging can benefit all utility customers through increased fixed asset utilization, which in turn can lower rates for all customers, the Council recommends that state energy regulators support utility installation of charging infrastructure in areas where these customer benefits materialize. This recommendation is further supported by the finding that utilities are the only private entity, aside from automakers, with a compelling business case to invest in public charging infrastructure. The final bucket of obstacles relates to PEVs’ impact on the reliability and adequacy electric distribution systems. Although NRC finds that the effect PEV charging on these systems will likely be insignificant, it recommends that utilities adopt time-of-use or real-time rates to encourage charging events during low-demand, low-cost periods.

1. [*Impacts Assessment of Plug-in Hybrid Vehicles on Electric Utilities and Regional U.S. Power Grids (Parts I and II)*](https://www.ferc.gov/about/com-mem/5-24-07-technical-analy-wellinghoff.pdf)

Kintner-Meyer, Michael, Kevin Schneider, and Robert Pratt. "Impacts Assessment of Plug-In Hybrid Vehicles on Electric Utilities and Regional U.S. Power Grids." Federal Energy Regulatory Commission. January 21, 2007.

Part I

One potential concern regarding the electrification of the US light-duty vehicle fleet lies in ensuring that generation, transmission, and distribution systems can adequately supply this incremental power for vehicles while meeting reliability standards and containing costs. But because these systems are built to meet peak demand, they often have spare capacity to generate and transfer additional electricity. Based on NERC load data from 2002, 73% of the entire US light-duty vehicle fleet could be electrified as PHEVs without upgrading or adding any additional infrastructure. As a result of greater PHEV use, total greenhouse gas emissions would be reduced by 27% and reduce national oil consumption by 6.5 million barrels per day. A necessary component of this scenario is the introduction of time-variant rates that send a price signal to encourage charging during off-peak times and avoid the creation of higher peaks.

Part II

The second part of the report assesses the economic impacts of light-duty vehicle electrification from the perspective of the utility and utility regulator, using Cincinnati Gas & Electric and San Diego Gas & Electric as test cases for vertically integrated and “wires only” utilities, respectively. As a result of increased electrification, average variable costs associated with delivering electricity may increase due to higher-cost generation coming online to satisfy load, but average fixed costs ($/kWh) may decrease as cost recovery is spread out over more kilowatt-hours sold. In the case of both utilities, transportation electrification leads to an overall net decline in utility operating costs as per-unit fixed transmission and distribution costs decrease. Whether or not these savings are returned to utility customers in the form of reduced rates or pocketed by shareholders (or some combination of both) is up to the discretion of the utility regulator. In sum, greater electric vehicle penetration can help flatten load curves, improve the efficiency and utilization of fixed assets, and achieve cost savings for utilities and their customers.

1. [*California Transportation Electrification Assessment Phase 2:Grid Impacts*](http://www.caletc.com/wp-content/uploads/2014/10/CalETC_TEA_Phase_2_Final_10-23-14.pdf)

"California Transportation Electrification Assessment Phase 2: Grid Impacts." Energy+ Environmental Economics. October 23, 2014.

This report analyzes electric utility costs and impacts associated with widespread vehicle electrification among California’s three investor owned utilities and Sacramento Municipal Utility District. First, the incremental bills PEV owners would pay to charge their vehicles more than offsets the additional cost of delivering the incremental electricity, leading to savings that can be delivered to customers in the form of lower electricity rates. These utility costs are also significantly reduced when customers are on time-of-use rates that facilitate off-peak charging, as they help avoid generation, transmission, and distribution upgrades. Moreover, as more intermittent renewables are integrated onto the electric system, PEVs ability to charge dynamically can prevent periods of over-generation and smooth out large load ramps in the morning or evening. Finally, with regard to multi-family, public, and workplace charging, further study is required to assess the “make-ready” costs necessary to support high PEV adoption scenarios. However, distribution cost upgrades associated with electrification should remain modest. Using the Total Resource Cost test and taking into account the elements above, PEV adoption delivers a net economic benefit of $5000 per vehicle over the life of the PEV.

1. [*Policy Priorities for Advancing the U.S. Electric Vehicle Market*](http://carnegieendowment.org/files/electric_vehicles.pdf)

"Policy Priorities for Advancing the U.S. Electric Vehicle Market." Carnegie Endowment for International Peace. September 2012.

Plug-in electric vehicles (PEVs) provide a range of public benefits including but not limited to: reduced local air pollution and greenhouse gas emissions, increased energy security, and provision of electricity storage services for grid reliability purposes. Several challenges remain in the path towards widespread PEV adoption, not least of which is charging station availability. However, policymakers have the ability to tap a variety of levers to facilitate PEV use and its consequent public benefits. Potential policy avenues include: permitting utilities to rate-base charging infrastructure that is in the interest of PEV drivers and utility customers, including the deployment of DC fast charging stations, and revising electricity rates to reflect time-varying grid conditions and to incentivize charging during off-peak hours. These preliminary policies will encourage PEV adoption in a manner that benefits utility customers while avoiding costly generation and distribution upgrades.

1. [*US Residential Charging Potential for Electric Vehicles*](http://www.cmu.edu/me/ddl/publications/2013-TRD-Traut-etal-Residential-EV-Charging.pdf)

Traut, Elizabeth J., Tsuwei Charlie Cherng, Chris Hendrickson, and Jeremy J. Michalek. "US Residential Charging Potential for Electric Vehicles." *Transportation Research Part D: Transport and Environment* 25 (2013): 139-45.

This study examines US charging infrastructure potential for PEVs based on results from the American Housing Survey and Residential Energy Consumption Survey. In a base case scenario, researchers estimate that 56% of US vehicles have a dedicated off-street parking space. Moreover, only 22% of vehicles have a dedicated off-street parking space proximate to electric outlets adequate for PEV charging. This lack of dedicated parking and, consequently, lack of investment in dedicated charging infrastructure significantly decreases the value proposition of PEV ownership for two reasons: not only does it prevent owners from capitalizing on a critical long-dwell charging opportunity, but it also prevents them from taking advantage of lower overnight electricity costs under a time-variant rate structure. Addressing this challenge, particularly for renters in multi-unit dwellings, is essential for achieving substantial PEV penetration.

1. [*Workplace Charging Challenge – Progress Update 2014: Employers Take Charge*](http://www.afdc.energy.gov/uploads/publication/wpc_2014_progress_report.pdf)

"Workplace Charging Challenge – Progress Update 2014: Employers Take Charge." U.S. Department of Energy. November 2014.

The Workplace Charging Challenge is a Department of Energy (DOE) initiative to increase PEV market adoption by raising awareness of the benefits of workplace charging and by making PEV ownership more convenient. Companies such as 3M, San Diego Gas & Electric, Google, and The Coca-Cola Company have participated and benefited from DOE technical assistance, from exchange of installation and operation best practices, and from recognition as businesses engaged in “sustainability efforts.” Results show that Workplace Charging Challenge employees are 20 times more likely to drive a PEV than employees at non-participating companies. Within participating firms, those that offered free electricity at their charging stations saw slightly higher PEV adoption than those that opted for fee-based charging. Moreover, 90 percent of partner companies reported that their charging stations were fully utilized at least five days a week.

1. [*Pathways to Deep Decarbonization in the United States*](http://unsdsn.org/wp-content/uploads/2014/09/US-Deep-Decarbonization-Report.pdf)

Williams, James H., Andrew D. Jones, and Haewon McJeon. "Pathways to Deep Decarbonization in the United States." Sustainable Development Solutions Network A Global Initiative for the United Nations. November 2014.

In order to curb rising global surface temperatures to no more than two degrees Celsius by 2050 and to avoid significant global environmental and economic damage, decarbonization of fuels and processes in American power, transportation, and industrial sectors will be critical. For transportation specifically, 80-95% of all vehicle miles traveled must come from vehicles that use primarily electricity, equivalent to deploying 300 million alternatively-fueled vehicles by 2050. In the High Renewables scenario for future light-duty vehicle stock, virtually all of the US fleet is expected to be comprised of PEVs.

1. [*Evaluation of State-Level U.S. Electric Vehicle Incentives*](http://www.theicct.org/sites/default/files/publications/ICCT_state-EV-incentives_20141030.pdf)

Jin, Lingzhi, Stephanie Searle, and Nic Lutsey. "Evaluation of State-Level U.S. Electric Vehicle Incentives." The International Council on Clean Transportation. Accessed October 2014.

Following the lead of federal incentives for electric vehicles, many states and local jurisdictions have adopted a wide range of policies to promote PEV growth. However, these policies and programs vary widely in terms of their per-vehicle customer benefits. This paper develops a methodology to quantify all benefits associated with PEV policies such as carpool lane access, free electricity at charging stations, charging infrastructure financing, purchase subsidies, free parking, emissions test exemptions, and license tax and fee reductions through 2013. First, the results reveal that PEV customer benefits from state-level policies are strongly and positively correlated with PEV sales. Second, from a benefit-cost ratio perspective, public charging infrastructure delivered the greatest net benefits to battery electric vehicle (BEV) owners out of all other incentives. Further research must be done to develop and refine methodologies that accurately reflect costs and benefits of PEV policies while incorporating other relevant macro-level trends.