RESEARCH HIGHLIGHTS

Low Energy: Estimating Electric Vehicle Electricity Use

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How much are electric vehicles actually being used?

Context

As policymakers invest more in electric vehicles as one tool to reduce carbon emissions, it's important to understand how much consumers are using them. If EVs are being driven as much as conventional cars, it speaks to their potential as a near-perfect substitute for traditional vehicles, with high potential for emissions reductions. But if EVs are being driven substantially less than conventional cars, this raises questions about the potential for EV technology to decarbonize transportation by replacing the gasoline-powered fleet.

To date, policymakers have had to rely on small, unrepresentative samples or survey data to gauge EV use, as well as to study the impact of EVs on the energy system and environment. Evidence is mounting that these sources provide an inaccurate picture of behavior. An alternative is to calculate electric vehicle miles traveled using data on the electricity used to power EVs. While charging at networks operated either by commercial charging businesses or vehicle manufactures such as Tesla is directly metered, the California Air Resources Board estimates that upwards of 85 percent of EV charging occurs at home. Thus, the vast majority of electricity used by EVs is difficult for policymakers to parse out.

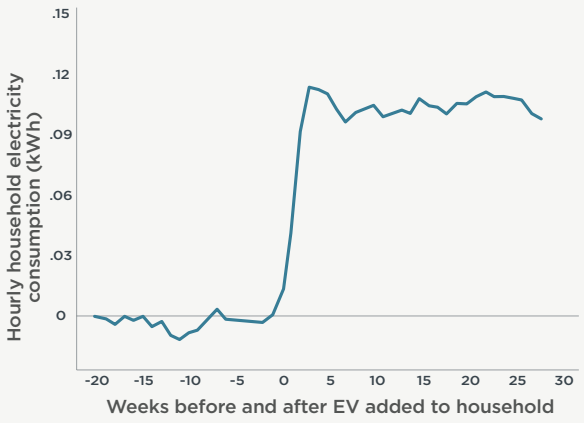
Methods

To quantify EV usage, the researchers estimate the impact of EV adoption on residential energy consumption, convert this into a measure of total EV electricity use by accounting for away-from-home charging, and then convert total EV electricity use into electric vehicle miles traveled using data on EV fuel economy. Their study is based in California, which is home to about half of the EVs in the United States. They combine nearly 12 billion hours of electricity meter measurements—roughly 10 percent of residential electricity meters in California's largest utility territory, Pacific Gas & Electric—with address-level EV registration records from 2014 to 2017. This produces the first at-scale estimates of residential EV charging load.

Key Findings

- The arrival of an EV increases household electricity consumption by 2.9 kilowatt-hours per day—less than half the amount assumed by state regulators. It is clear that the adoption of an EV caused the observed change in electricity use because the household electricity use prior to buying an EV is flat, the jump in consumption is immediate, and the increased use remains stable over time. Moreover, the consumption pattern across hours of day is inconsistent with other potential uses of electricity at home: energy use increases in the evening hours, but not during the day.

Figure 1 · Impacts of EV adoption on household electricity use

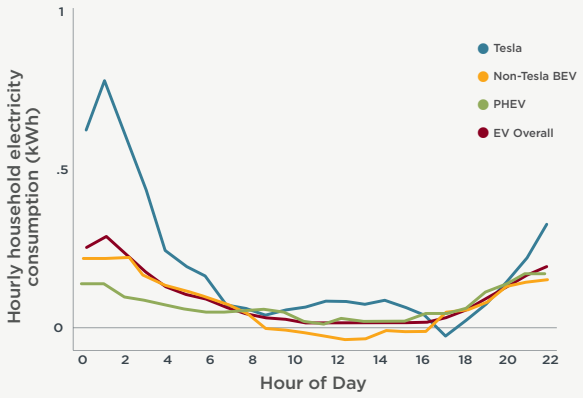


- The majority of EV electricity use occurs in the evening hours, between 10pm-6am, as households charge their EVs when they come home and leave them plugged in overnight. This is the worst timing for the environment, at least in the context of California. Solar energy makes up a significant share of generation during the day when the sun is shining, leaving only a small fraction of electricity to be generated by gas-fired plants. At night, dirtier gas-fired power must pick up the slack from the missing solar. This means every unit of energy used during that period produces more marginal emissions relative to charging during the day.

- Teslas consume almost double the amount of electricity per hour than the non-Tesla EVs studied. This is likely due to a combination of factors, including Tesla's higher battery capacity.

- Having adjusted for the share of out-of-home charging, the electricity consumed translates to about 5,300 electric vehicle miles traveled per year, roughly half as large as EV driving estimates used by regulators and also half as large as vehicle miles traveled in gasoline-powered cars.

Figure 2 · Impacts of EV adoption on hourly electricity use



CLOSING TAKE-AWAY

EVs are driven substantially less than conventional cars. The question is "why?" Current EV owners may simply drive less, and be unrepresentative of drivers overall. Alternatively, EVs may not be as easily substituted for gasoline vehicles as previously thought. Since EVs are being used far less than what regulators are estimating, optimal policy may change. This discrepancy may affect decisions about electricity distribution infrastructure investments, as well as estimates of EVs' contributions to pollution reduction and carbon emissions abatement.

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