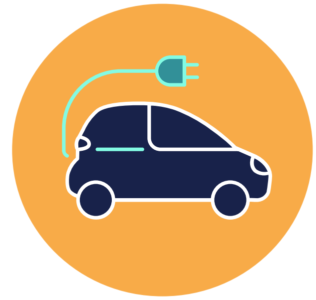
Electric Vehicles Are Driving Rates Down for All Customers

January 2024 | Sarah Shenstone-Harris, Paul Rhodes, Jason Frost, Ellen Carlson, Eric Borden, Courtney Lane, Melissa Whited



National Update

Electric vehicles (EVs) offer a key opportunity to reduce harmful emissions and save consumers money at the same time. EVs are responsible for far fewer greenhouse gases and local air pollutants than conventional vehicles and become cleaner as more renewable electricity is added to the grid. In addition, EVs are generally much cheaper to operate than conventional vehicles.

The number of EVs on the road are rapidly growing and increasing in share among light-duty vehicles. By the end of 2022, more than 3.2 million EVs had been sold in the US alone. Federal, state, municipal and industry action to incentivize and increase the adoption of EVs promise to accelerate this transition. The new electricity load and flexible demand represented by these vehicles has major implications for our future energy system and could increase total electricity use by 25 percent. By charging during hours of the day when there is least demand on the grid, however, the electric vehicle transition could reduce electric rates for everyone.

Evaluating the impact of electric vehicles on the road today can help us understand their effect on the grid and how they might shape the power system in the future. Accordingly, this analysis examines costs and revenues associated with EVs between 2011 and 2021 across the United States. **We observe that over the last 11 years, EV drivers across the United States have contributed approximately $3.12 billion more than their associated costs, driving rates down for all customers. When we also include utility expenditures for EV programs, EV owners have contributed approximately $2.44 billion more in revenues than in costs.**

How Are EVs Affecting Electricity Rates?

Recent growth in EV adoption has raised the question of how EVs affect the electricity rates paid by all households, including those that do not own EVs. This is an important equity question that should be analyzed when determining the role that electric utilities should play in supporting the transition to EVs.

Answering this question requires comparing electric utility revenues from EV charging with utility costs associated with serving EV load. If the utility revenues from EVs exceed the utility system costs, then EV adoption can reduce electricity rates for all customers. Conversely, if the costs are greater than the revenues, non-EV owners could end up paying more for their electricity. This effect holds true even for utilities without revenue decoupling. Additional revenue will be accounted for in subsequent rate cases, and even during the time between rate cases, the revenue from EVs may be used to offset higher costs in other areas, delaying the need for a rate increase for utilities without decoupling.

Multiple prospective studies have forecasted that utility revenues will exceed costs with future electrification. However, to address this question using real-world data, Synapse evaluated the utility system revenues and costs associated with EVs purchased within the last decade across the United States. Specifically, this analysis tracks revenues and costs associated with over 2 million battery electric and plug-in hybrid EVs sold between 2011 and 2021.

We analyzed the electricity rates that EV owners pay compared to the marginal cost of providing that electricity (generation, transmission, and distribution costs) plus the expenditures associated with utility EV programs. We gathered cost and rate data from across the country to inform this analysis, including from RTOs, the Federal Energy Regulatory Commission, filed tariffs, and published marginal cost values. While managed charging and time-of-use ("TOU") tariffs are becoming the norm across the country, we assume for the purposes of this analysis that most EVs are charging according to a non-managed shape, based on load curves developed by the U.S. Department of Energy. We also use a database of EV program expenditures, assuming that these investments will be paid off over 10 years. For California, where over 40 percent of the country's EVs are located, we used hourly marginal costs based on the California Public Utilities Commission ("CPUC")'s Avoided Cost Calculator and load curves from the CPUC's Load Research Reports.

Tracking EV Adoption Across the 50 States

In 2011, which was the first year of our analysis, just 16,000 EVs were on the road nationwide. By 2021, the number of EVs has surpassed 2 million – over a 100-fold increase from 2011. Figure 1 shows cumulative EV sales by region in the United States.

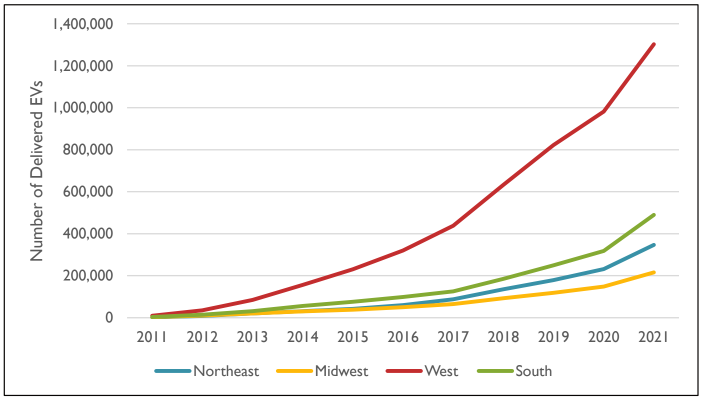


Figure 1. Cumulative EV sales in the United States, 2011-2021, by region

The Western region, anchored by California which counted over 1 million EVs in 2021, far outpaces the other regions of the US. Nevertheless, EV adoption rates are accelerating nationwide, with BloombergNEF predicting that EV sales will represent more than half of all car sales by 2030.

EV Charging Patterns and Time-of-Use Charging

EVs pull their energy from the electricity grid, but the time of day that the charging occurs defines the cost and carbon content of its power and the impacts on the grid overall. If vehicles charge when demand is already high and electricity is the most expensive, EV could exacerbate grid impacts and costs. If they can take advantage of low overnight demand or plentiful solar power in the afternoon, however, they can improve the economic and environmental performance of the power system overall.

For this analysis, we assume the majority of EVs are charged at home and mostly in the early evening at the end of the workday. This hourly use pattern was developed by the U.S. Department of Energy ("DOE") and corresponds with real-world data, representing charging patterns of EVs not taking service on time-of-use rates (which represents the vast majority of EVs on the road).

Time-of-use tariffs affect the costs that consumers pay depending on when they use electricity and can incentivize consumers to use electricity when it is least expensive for everyone (i.e. when there is less overall demand on the grid). We can already see the impact this has on EV charging based on data reported by California's largest investor-owned utilities. Figure 2, below, shows the average daily charging curve for EVs on time-of-use (TOU) tariffs in California alongside DOE's national average charging curves for EV owners not on TOU rates. The grey bars represent the number of states whose electric grid peaks in each corresponding hour, when electricity is most expensive.

As Figure 2 shows, the price signals provided by the time-of-use tariff, combined with EV technology that allows for managed charging, shifts typical EV charging from times of peak use to overnight periods, when demand is typically low. These shifts reduce costs to EV owners and operators for charging their vehicles, while also more efficiently using electricity infrastructure and reducing costs for everyone.

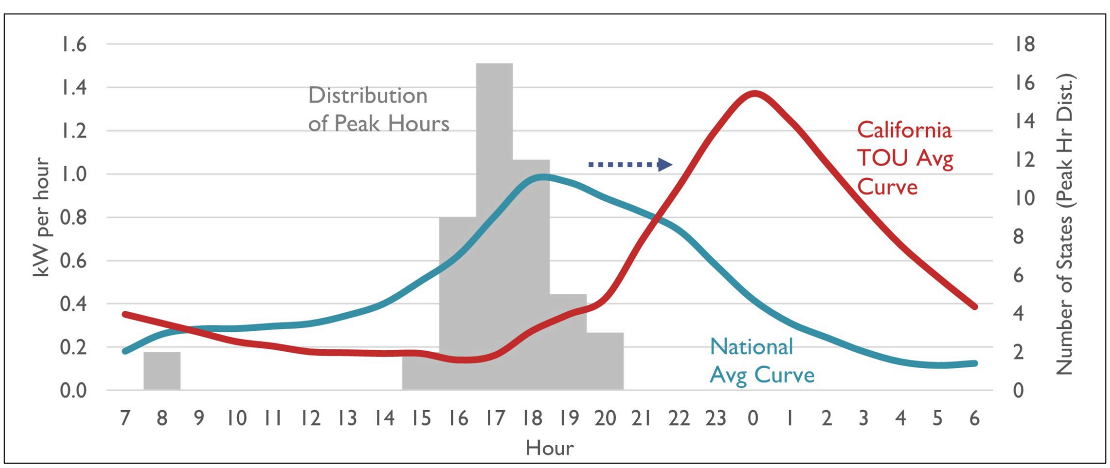


Figure 2. Typical EV charging curve versus the California TOU average EV charging curve, with the distribution of all states' average system peak hour.

EV-specific or general TOU rates are less well subscribed outside of California. However, TOU rates, especially rates designed specifically for EVs, are beneficial for both utilities and customers. Since they can shift the majority of charging away from peak periods, they can help reduce the costs of upgrading the grid while also increasing utility revenues, thereby helping to put downward pressure on rates for all. These types of rates will become especially important as the number of EVs on the roads across the country will increase in the coming years.

How does EV charging impact overall electricity rates?

By comparing the revenues generated by EV charging to the utility's marginal cost to serve these EVs, we can construct a picture of whether EVs are creating more revenues than costs (driving costs for everyone down) or creating more costs than revenues (driving costs for everyone up).

The results of our analysis indicate that, across all regions in the United States, **EVs have increased utility revenues more than they have increased utility costs, leading to downward pressure on electric rates for EV-owners and non-EV owners alike.** Between 2011 and 2021, we estimate that EV drivers across the country have contributed $3.12 billion *more* in revenues than associated costs, cumulatively over the study period (in 2021 dollars). Figure 3 shows the extent to which revenues from EVs outweigh the generation, transmission, and distribution costs for the period 2011-2021.

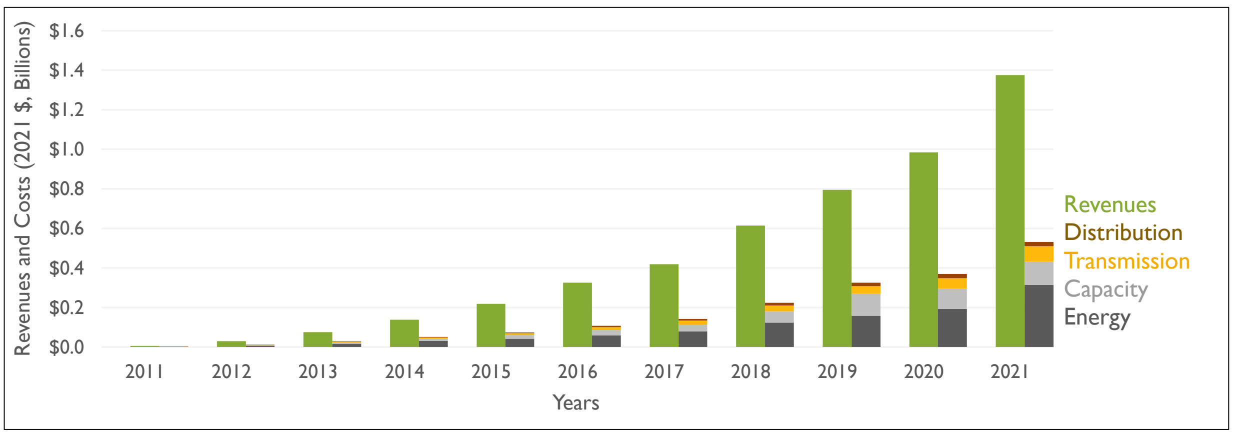


Figure 3. Total costs versus total revenues of EV charging across the United States per year from 2011-2021.

When also considering utility expenditures on EV programs, revenues from EVs outweigh costs by $2.44 billion, cumulatively over the study period (in 2021 dollars) (Figure 4).

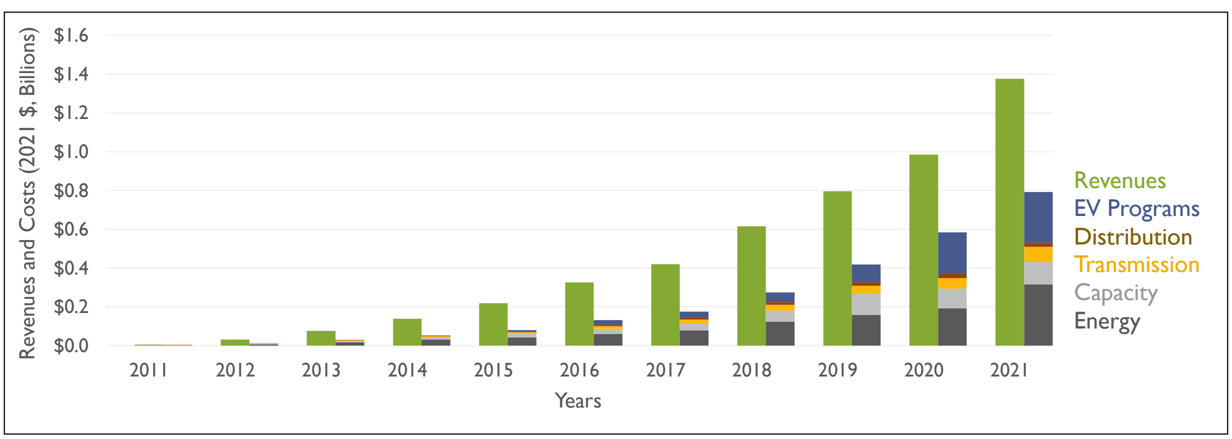


Figure 4. Total costs, plus EV program expenditures, versus total revenues of EV charging across the United States per year from 2011-2021.

Figure 5 shows revenues versus costs by US region. The Western region—anchored by California, which has the most EVs by far of any state—drives over two thirds of revenues and costs. Revenues outpace costs in every region.

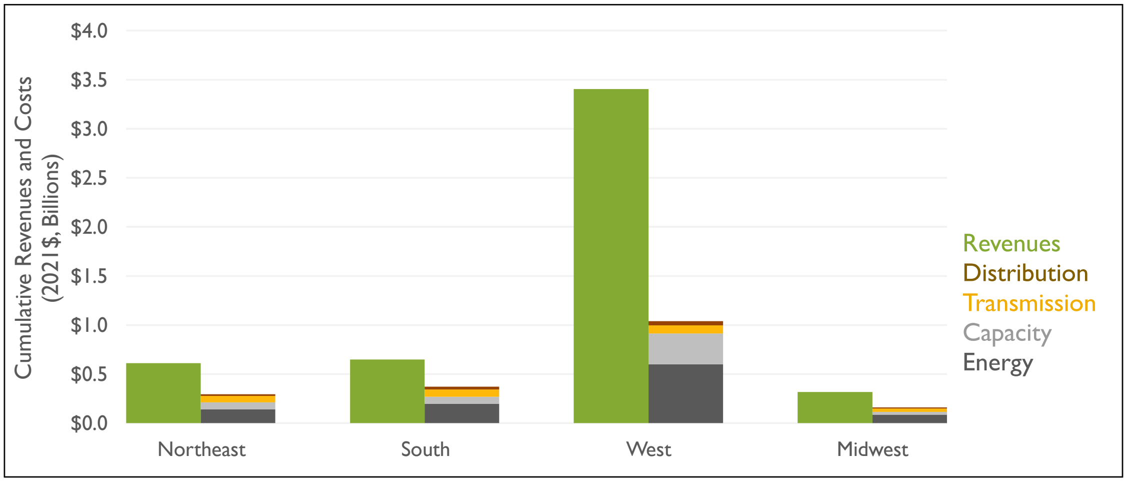


Figure 5. Cumulative total costs versus total revenues of EV charging across the United States from 2011-2021.

Once again, when also accounting for EV program spending, revenues exceed costs in every region (Figure 6).

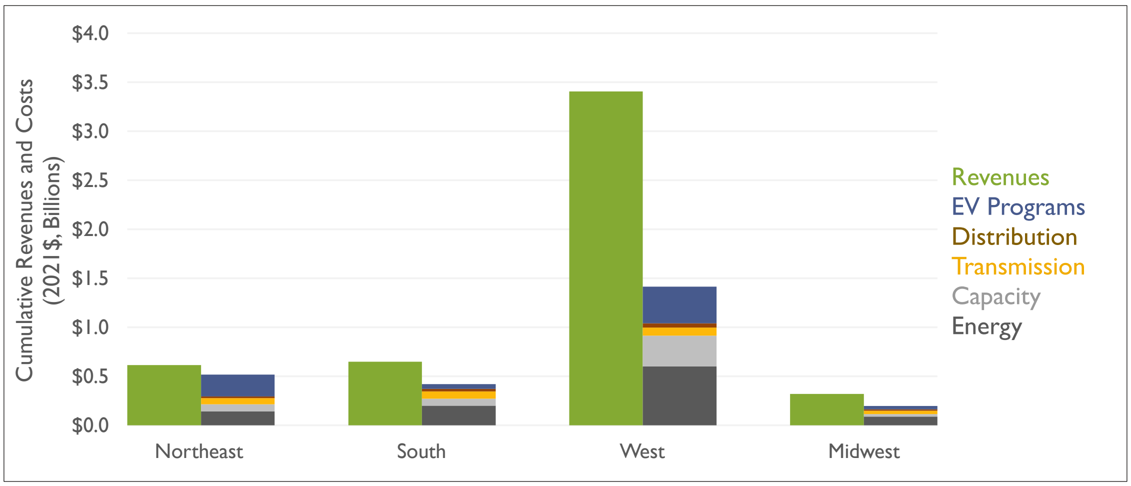


Figure 6. Cumulative total costs, plus EV program expenditures, versus total revenues of EV charging across the United States from 2011-2021.

As can be seen in Figure 7, the number of EVs is strongly correlated with the cumulative net rate impact (revenues minus costs).

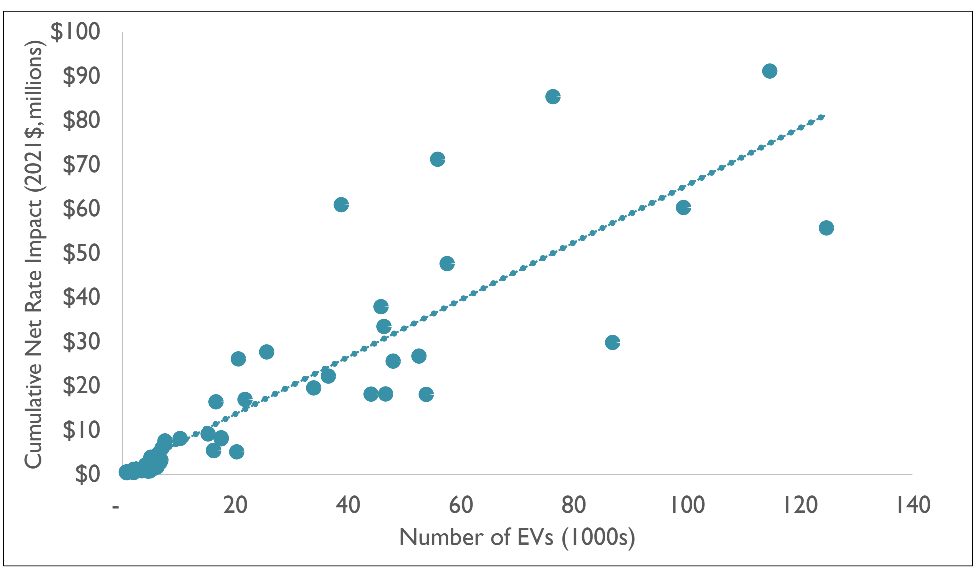


Figure 7. Correlation between the number of EVs and the cumulative net rate impact, with each dot representing a state.[23]

In other words, as the number of EVs increases, the total net rate impact also increases. This is the case in every state across the country (Figure 8).

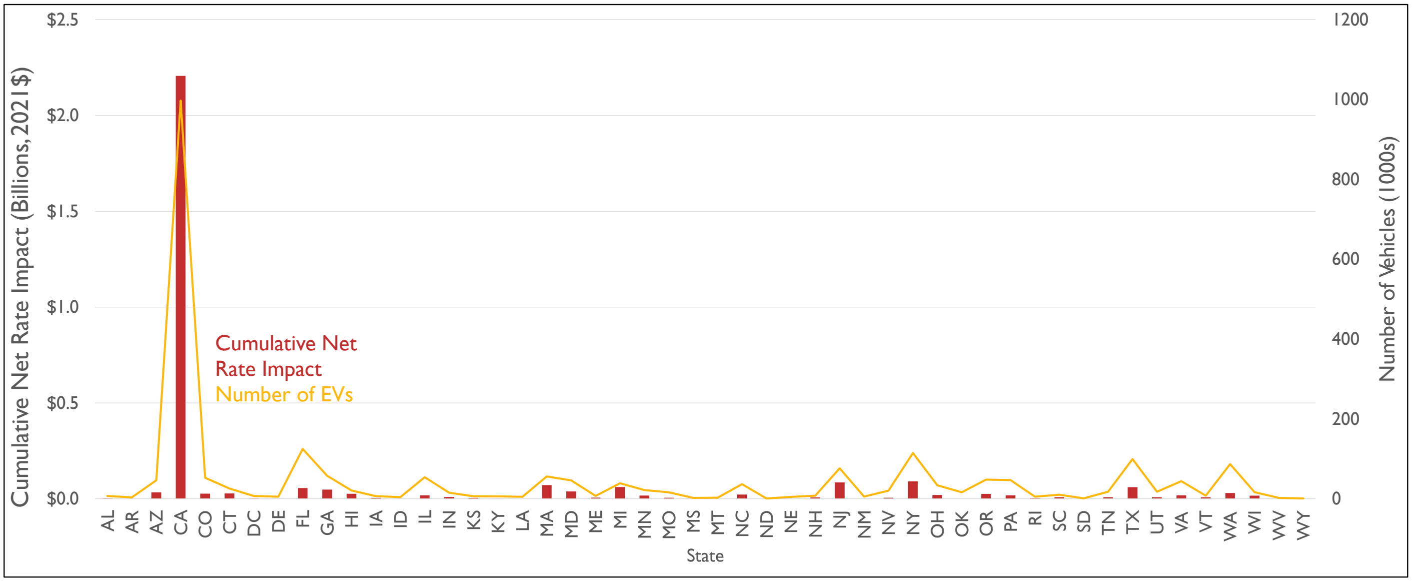


Figure 8. Cumulative Net Rate Impact (2011-2021) and the number of EVs by state.

A key reason why revenues from EVs outweigh the costs is that EV customers — particularly those on TOU rates — tend to charge during off-peak hours. By charging during off-peak hours, EVs impose minimal additional costs on the grid and help to utilize resources more efficiently. In fact, a report published in 2019 by Lawrence Berkeley National Laboratory, PG&E, and the Natural Resources Defense Council shows that shifting EV charging to off-peak times could allow the grid to accommodate all homes having EVs without upgrading most parts of the distribution system.[24]

Revenues from EVs Can Help Fund EV Charging Infrastructure

As electric vehicle adoption accelerates across the country, utilities are implementing programs to expand charging infrastructure and help accelerate electrification. These investments both support EVs that exists today and help reduce barriers to future EV adoption.

Utility investments in EV programs varies considerably by state, with some investing $1,000 per EV while others have not committed to any EV program spending. Our analysis shows however, that on a regional and national basis, revenues created by EV charging support both the costs to serve energy and public EV investments to date.

EVs Can Continue to Put Downward Pressure on Rates

EVs can provide substantial emissions reductions while also helping to reduce electricity rates for all customers by using the system more efficiently. Utilities can play an important role in ensuring that EVs benefit both EV drivers and non-EV drivers alike by encouraging EV customers to enroll in TOU rates and charge during off peak periods. In addition, utility investments that facilitate the deployment of charging infrastructure can accelerate the EV market, growing the potential benefits from widespread EV adoption.

If implemented carefully, utility-funded investments can deliver benefits to all utility customers in excess of their costs. Our analysis indicates that EV adoption in the US has already resulted in more electricity revenues than costs, and future growth in the EV market will lead to further increases in utility revenues. Implementing TOU rates and targeted investments in charging infrastructure can accelerate EV adoption, reducing utility bill costs and harmful emissions for EV and non-EV owners alike.

Endnotes

[1] Rocky Mountain Institute (2022). More EVs, Fewer Emissions. Available at: https://rmi.org/insight/more-evs-fewer-emissions.

[2] Taylor, T., Rosenburg, J. (2022). Total Cost of Ownership Analysis. Atlas Public Policy. Available at: https://atlaspolicy.com/wp-content/uploads/2022/01/Total-Cost-of-Ownership-Analysis.pdf

[3] Alliance for Automotive Innovation (2023). Advanced Technology Vehicle Sales Dashboard. Data compiled using information provided by S&P Global Mobility and Hedges & Co. Last updated 3/3/2023. Available at https://www.autosinnovate.org/resources/electric-vehicle-sales-dashboard.

[4] See California's requirement that all vehicles sold by 2035 will be plug-in electric vehicles and General Motors' announcement that they will only sell zero-emissions vehicles by 2035.

[5] National Renewable Energy Laboratory (2022). Electrification Futures Study: Scenarios of Electric Technology Adoption and Power Consumption for the United States. Available at: https://www.nrel.gov/docs/fy18osti/71500.pdf.

[6] For example, see: Public Advocates Office, Distribution Grid Electrification Model – Study and Report, 2023, available at https://www.publicadvocates.cpuc.ca.gov/-/media/cal-advocates-website/files/reports/230824-public-advocates-distribution-grid-electrification-model-study-and-report.pdf, and California Public Utilities Commission, Utility Cost and Affordability of the Grid of the Future: An Evaluation of Electric Costs, Rates, and Equity Issues Pursueant to P.U. Code Section 913.1, 2021. Available at: https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/office-of-governmental-affairs-division/reports/2021/senate-bill-695-report-2021-and-en-banc-whitepaper_final_04302021.pdf

[7] We analyzed revenues and costs from EVs in 49 states, excluding Alaska, as there was not sufficient data to conduct the analysis for that state.

[8] Atlas EV Hub. State EV Registration Data. Available at: https://www.atlasevhub.com/materials/state-ev-registration-data/.

[9] California's Avoided Cost Calculator (developed by E3) were used for distribution costs. We reduced these by 10 percent to mitigate double counting of distribution-related EV program costs.

[10] The load curve used for years 2011 through to 2020 are from United States Department of Energy, 2017, National Plug-In Electric Vehicle Infrastructure Analysis, Available at: https://www.nrel.gov/docs/fy17osti/69031.pdf. We developed a new average load curve for 2021, using data from DOE's EVI-Pro Lite tool. We took an average of the load curves from each state's largest city, weighted by number of registered EVs per state. Department of Energy, Alternative Fuels Data Center. Data retrieved July 2023. Electric Vehicle Infrastructure Projection Tool (EVI-Pro) Lite. Available at: https://afdc.energy.gov/evi-pro-lite.

[11] We assumed EVs were on non-TOU rates in California and TOU rates in Arizona (the majority of residential customers take service under TOU rates in Arizona). Data from 2021 Joint IOU Load Research and Charging Infrastructure Cost Report, filed on March 31, 2022. Public Utilities Commission of the State of California, Rulemaking 18-12-006. Available at: https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/transportation-electrification/10th-joint-iou-ev-load-report-mar-2022.pdf.

[12] Atlas EV Hub. Electric Utility Filings. Available at: https://www.atlasevhub.com/materials/electric-utility-filings/

[13] 2022 Avoided Cost Calculator for Distributed Energy Resources (DER). Available at https://www.ethree.com/public_proceedings/energy-efficiency-calculator/.

[14] 2021 Joint IOU Load Research and Charging Infrastructure Cost Report, filed on March 31, 2022. Public Utilities Commission of the State of California, Rulemaking 18-12-006. Available at: https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/transportation-electrification/10th-joint-iou-ev-load-report-mar-2022.pdf.

[15] Atlas EV Hub. State EV Registration Data. Available at: https://www.atlasevhub.com/materials/state-ev-registration-data/

[16] Regions based on US Census Regions. States in each region are as follows: Northeast: ME, NH, VT, MA, RI, CT, NY, PA, NJ; Midwest: OH, MI, IN, WI, IL, MN, IA, MO, ND, SD, NE, KS; South: MD, DE, DC, WV, VA, NC, SC, GA, FL, KY, TN, MS, AL, AR, LA, OK, TX; West: WA, OR, CA, NV, ID, MT, WY, CO, UT, AZ, NM. Pacific states (AK, HI) represent less than 1% of EVs in the U.S., and are included in the West category for readability and simplicity.

[17] Boudway, Ira. "More Than Half of US Car Sales Will Be Electric by 2030." September 20, 2022. Bloomberg. Available at: https://www.bloomberg.com/news/articles/2022-09-20/more-than-half-of-us-car-sales-will-be-electric-by-2030.

[18] National average load curves from the U.S. DOE, 2017, National Plug-In Electric Vehicle Infrastructure Analysis, Available at: https://www.nrel.gov/docs/fy17osti/69031.pdf, and the U.S. DOE's Alternative Fuels Data Center's Electric Vehicle Infrastructure Projection Tool (EVI-Pro) Lite tool, available at: https://afdc.energy.gov/evi-pro-lite.

[19] For instance, 17 states have a peak at 5pm and two states have a peak at 8am. California's average peak is 6pm. Peak load data from U.S. Energy Information Administration, form 930.

[20] This assumes that program costs are depreciated over 10 years.

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[22] The correlation coefficient is 0.99 for all 49 states included in this analysis. When California is removed, the coefficient is 0.86.

[23] California is not included in figure.

[24] Coignard et al., "Will Electric Vehicles Drive Distribution Grid Upgrades?: The Case of California". June 5, 2019. Institute for Electrical and Electronics Engineers. Available at https://ieeexplore.ieee.org/document/8732007.