Distribution Grid Electrification Model

Fact Sheet

Our mission is to advocate for the lowest possible bills for customers of California's regulated utilities consistent with safety, reliability, and the state's climate goals.

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The Public Advocates Office at the California Public Utilities Commission has undertaken a study of the costs of upgrading the distribution grids of the three largest investor-owned electric utilities (IOUs) to meet California's transportation electrification goals. Our results indicate that the total cost of upgrading the IOUs' distribution grids by 2035 will be approximately $26 billion.[1] This is about half of the cost identified by a similar recent study, the *Electrification Impacts Study Part 1* (EIS),[2] conducted by Kevala, a consultant engaged by the California Public Utilities Commission.

California's goal that all new light-duty vehicles sold be electric by 2035 drives the need to plan for distribution system upgrades and their attendant costs in a manner that is thoughtful, careful, and comprehensive. Building electrification and medium-duty and heavy-duty fleet electrification amplify this need. The need for careful distribution system planning is the basis for our Distribution Grid Electrification Model (DGEM). In addition to providing climate and other environmental benefits, electrification could put downward pressure on electric rates by increasing electricity sales. As the cost of providing electric service – including the costs to upgrade the system – are recovered across more units of electricity sold, electrification may cause downward pressure on electricity rates across California. However, this scenario is contingent upon myriad factors, including planning and forecasting to avoid overbuilding grid infrastructure and whether ratepayers pay for costs beyond their traditional responsibilities.

We look forward to the continuing public discourse on how to best plan for and implement the state's transportation electrification goal. In particular, we view all feedback on the DGEM as a crucial part in ensuring that our study helps to advance the state's goals.

Background

As purchases of electric vehicles (EV) in California increase, electricity distribution grids will need to be upgraded to support additional EV charging infrastructure. Forecasting the costs of these upgrades is critical to understanding the drivers of potential future cost impacts to electric ratepayers and the magnitude of these costs. Infrastructure needs and cost forecasts should also inform grid planning and help to assess the necessary timing of building new distribution grid assets. Finally, quantifying the total cost of upgrades allows us to better understand the potential benefits of incentives designed to encourage EV owners to charge at off-peak times when electricity prices should reflect lower system costs.

[1] This figure and all other cost figures in this report are in constant, present-day dollars.

[2] The EIS was issued as an attachment to *Administrative Law Judges' Ruling Setting a Workshop, Admitting Into the Record Part 1 of the Electrification Impacts Study and Research Plan, and Seeking Comments,* May 9, 2023; issued in Rulemaking (R). 21-06-017. Available at: https://docs.cpuc.ca.gov/SearchRes.aspx?DocFormat=ALL&DocID=508423139.

Our study

The focus of our study is to estimate the cost of upgrading California's three large electric IOUs' distribution grids to meet California's electrification goals. Our methodology involves using the registered address of every vehicle in California to estimate where EV uptake is likely to occur through 2035. We used these locations to model where additional charging load on the three IOUs' distribution grids is likely to appear. We then used this additional load data, combined with forecasted non-EV load growth, as the basis for determining where grid capacity will be exceeded and the cost to upgrade the distribution systems to provide sufficient capacity. We used the estimated cost to upgrade the IOUs' distribution grids to determine the rate impacts on ratepayers.

Based on our analysis and modeling, we estimate that through 2035, the costs to upgrade electric distribution grids will be approximately $26 billion. Using this cost estimate, we find that electrification applies an *overall downward pressure* on rates across all three of the large electric utilities, as shown in Figure 1. This is because, all other costs being equal, upward pressure on rates due to increased infrastructure costs due to electrification is more than offset by downward pressure on rates due to the increased consumption of electricity resulting from electrification. All ratepayers, even those who cannot (or choose not to) electrify, could financially benefit from electrification.

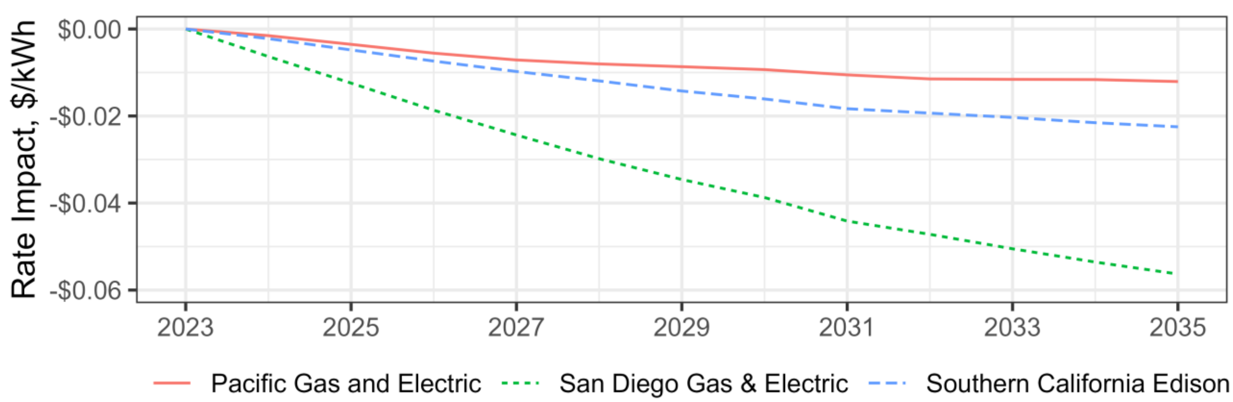

Figure 1. Projected rate impacts of electrification. (kWh = kilowatt-hour.)

Our estimate of the costs to upgrade the electric distribution grids has increased since our preliminary results in May 2023, which showed a range of $15 to $20 billion. Our preliminary results were based on the EIS's assumption that two miles of feeder, on average, would have to be upgraded for each feeder overload. Since then, we have analyzed additional data from the three utilities that led us to conclude that, on average, six miles of feeder will have to be upgraded to overcome each overload. This change has a significant impact on the total estimated cost.

Differences between the DGEM and the EIS

The EIS preliminarily estimates the total upgrade costs to be incurred through 2035 by the three utilities is $51 billion. There are two main reasons for the difference between our estimate ($26 billion) and the EIS's estimate. First, as described above, our estimate of average feeder length that is upgraded per overload is three times the EIS's estimate. If we were to use an average length of two miles of feeder to align with the EIS, our cost estimate would decrease, to $16 billion.

Second, the EIS assumes a larger growth in peak load. Our peak load forecast is drawn from and aligns with the California Energy Commission's Integrated Energy Policy Report (IEPR), whereas the EIS's peak load is the result of its unique model and assumptions. Figure 2 compares the 2021 and 2022 IEPR forecasts to the DGEM's forecast and the EIS's forecast of peak load growth.

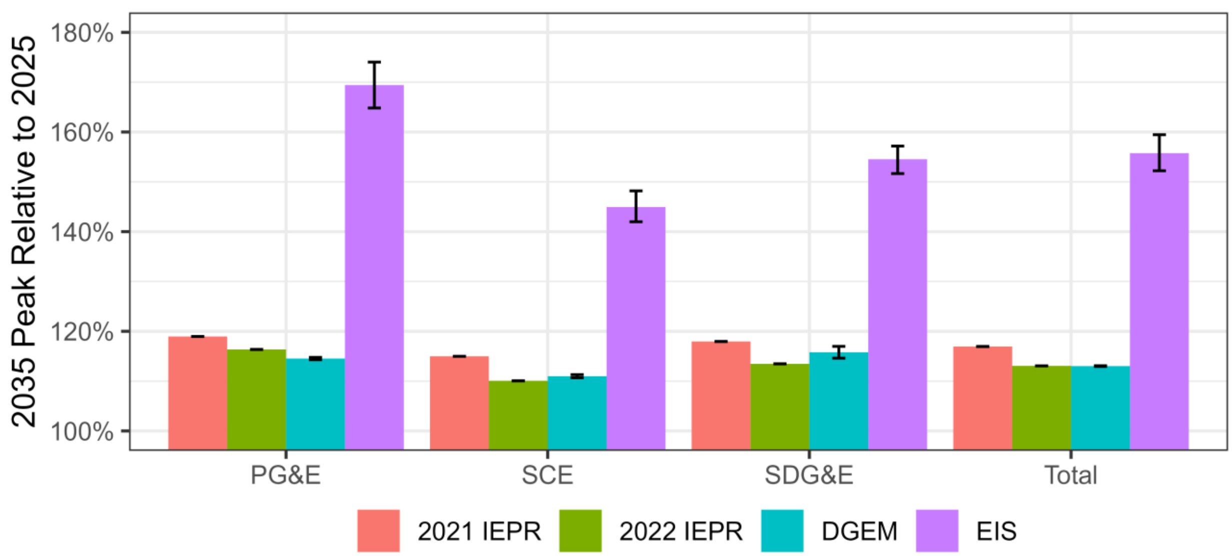

Figure 2. Comparison of peak load growth between two IEPRs, the EIS and the DGEM.

The EIS's higher estimated growth in peak load appears to be caused by the times at which the EIS predicts EVs will be charged relative to our load forecast source, the 2022 IEPR. Figure 3 shows that the EIS predicts a significant peak in EV charging at 9 p.m., driven by non-EV time-of-use rates which decrease at 9 p.m. Figure 3 also shows that the IEPR, which we use, forecasts that EV charging will occur much more evenly throughout the day. As peak load is a key driver of the need to upgrade distribution grids, the EIS's higher peak load growth forecast drives the EIS's higher estimated costs.

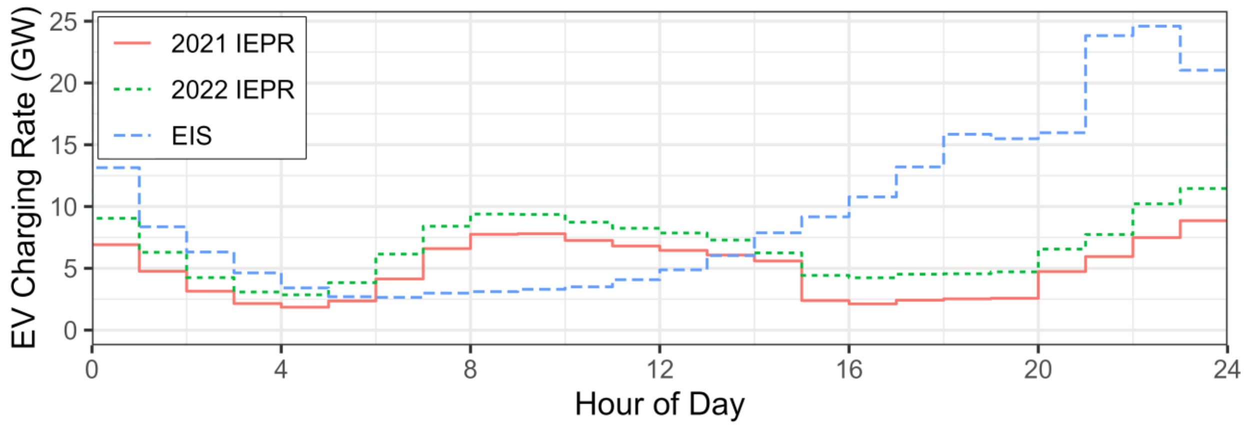

Figure 3. Hourly peak-day charging demand in 2035 from the 2021 and 2022 IEPRs and the EIS.

Our conclusions

We estimate that electrification will cost $26 billion in required upgrades to the utilities' distribution grids through 2035. However, this number has significant uncertainty, and the total cost could be as much as $18 billion lower or $31 billion higher. The main factors driving this range are the unit costs of new feeders and substations, particularly the former. In addition, we have found that the increase in electricity sales from electrification may outweigh the costs of distribution investments, causing a downward pressure[3] on residential electricity rates compared to present rates.

However, achieving this downward pressure on residential electricity rates is contingent upon five key model assumptions. Downward pressure on residential rates might not be achieved if:

1. EVs mostly charge in the evening, near peak hours (i.e., 6 p.m. to 10 p.m.), which would drive a higher peak load and, therefore, higher upgrade costs.
2. Electric rates rise to cover additional electrification programs, such as deploying EV chargers.[4]
3. New feeders and substations are more expensive than the DGEM estimates.
4. Expected load growth due to electrification does not occur.
5. Utilities build more infrastructure than is needed or build infrastructure in the wrong locations because upgrade costs will be higher.

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[3] Downward pressure on residential rates means that forecasted rates with electrification are lower than present rates, all other things being equal. Rates may still increase overall due to other factors such as wildfire mitigation or clean energy procurement.

[4] Ratepayers do not typically fund behind-the-meter infrastructure such as EV chargers because "the primary role of ratepayers [is] to fund utility-side infrastructure upgrades." See Decision (D.) 22-11-040, *Decision on Transportation Electrification Policy and Investment*, November 17, 2022 at 89-90, issued in R.18-12-006. Available at: https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M499/K005/499005805.PDF.

Good forecasting and planning are key parts of achieving this downward pressure on rates. Utility forecasts must be accurate and not lead to overbuilding of infrastructure. If overbuilding occurs, electrification could cause *upward pressure* on rates. Utility distribution planning processes, therefore, should be based upon realistic forecasts. Planning processes should be flexible and adaptable to provide for incremental infrastructure build and include offramps so that investment plans can be reshaped if it becomes clear that load will not appear when or where it was expected.

Even if electrification leads to downward pressure on rates, we cannot conclude that electric rates will fall. Other utility costs, such as wildfire mitigation or other climate change mitigations, could cause rates to rise in total. Moreover, effective policies, particularly around rate design, are needed to ensure that potential rate decreases are realized. For example, if EV owners are allowed to select a rate that does not recover the marginal cost to provide electricity, electricity rates for other customers could still rise.

The peak load on the distribution grid is a key driver of the upgrades needed, and the time at which EV owners charge is a key contributor to peak load. Approximately 70 percent of the costs identified in the EIS – $35 billion – vanish if EV charging is shifted away from hours of peak demand. Further work should be undertaken to understand in more detail the benefits and costs of mitigations, such as how to effectively incent EV owners to charge at times that could reduce the impact on the IOUs' distribution grids.

We have found that the present planned pace of primary distribution upgrades to the IOUs' distribution grids is approximately equal to what will be needed to meet the state's electrification goal. Prior research found that the pace of primary distribution upgrades needed in the future may far outpace historic upgrade rates for PG&E, and thus, upgrades may pose a bottleneck to electrification.[5] Our study does not corroborate this result.

Finally, our study was a data-intensive exercise, with much of the data coming from the three IOUs. While some datasets were excellent, some, particularly the cost data, lacked robustness. Additional types of data, such as the locations of vehicle fleets, were not available. Improvement in datasets would help achieve convergence in study results toward a consensus on the future cost of grid upgrades to meet electrification needs.

Further work and next steps

We welcome broad input and will engage with a wide range of stakeholders on the results of our study. Our results will also be available to Kevala as Kevala refines its analysis for the

[5] Salma Elmallah et al., *Can Distribution Grid Infrastructure Accommodate Residential Electrification and Electric Vehicle Adoption in Northern California?*, Environmental Research: Infrastructure and Sustainability, November 9, 2022 at 1. Available at: https://doi.org/10.1088/2634-4505/ac949c.

Electrification Impacts Study Part 2. No single study or pair of studies, particularly at this point in the electrification process, can definitively answer such a complex question as what the 2035 costs of distribution grid upgrades will be. This study aids the continuous discourse on electrification planning and the identification of associated costs and benefits rather than establishing a final cost projection.

Further work should deepen analysis of the impacts of electrification on the grid. Future studies should focus on improving estimates of EV charging profiles and charging locations, the cost of upgrades to overcome each grid overload, MD and HD deployment, and the potential impacts of managed charging. In addition, we did not analyze the impacts of electrification on total home energy costs, including reduced purchases of natural gas and gasoline. Total home energy cost would provide a fuller picture of how electric consumers' energy costs will change as electrification impacts transportation and other sectors.