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SOME CONTROVERSIES IN THE APPLICATION OF MARGINAL COST PRICING TO ACCELERATE ELECTRIFICATION: A CASE STUDY IN RATE-MAKING IN CALIFORNIA

Ahmad Faruqui

The state of California would have the world's fourth-largest economy if it were a stand-alone country.[1] What happens in California is often emulated by other states in the US, and often, though not always, sets the stage for what happens around the world. That is not just true in the world of technology, data centres, and AI, but also in the world of energy policy.

California, by being at the cutting edge of such technology developments and industries, is often in the eye of the storm. It has set some aggressive goals for electrification, to mitigate carbon emissions and enhance public health. The same is true in much of the US and in most nations electrification is a high priority.

Within the US, where energy policies differ significantly between states, it is a high priority in several states on the west and east coasts. Unfortunately, in California and in other states such as New York and others in New England, electricity rates are not only high but are also on the rise. That poses a significant barrier to the electrification of key end uses, such as heating, ventilating and air conditioning, water heating, cooking, and clothes drying within the home, and of vehicles.

In a meeting with regulatory staff at the California Public Utilities Commission in 2019, I was invited to engage in a brainstorming session to identify policies that the state could take to promote the electrification of homes. without any consideration of their political feasibility. Three listed policies stood out:

1. Lower the price of electricity, perhaps by providing a tax credit.
2. Raise the price of natural gas, perhaps by putting a tax on it.
3. Ban the use of natural gas in new homes and the sale of natural gas equipment a few years out, and in a decade or so, just shut off the supply of natural gas to all homes.

The listing stimulated a thoughtful discussion of the pros and cons, but the consensus was that none of these measures could be undertaken by the regulatory agency. They would have to be approved by the legislature and approved by the Governor.

The barriers to electrification

Two key electrification technologies, heat pumps and electric vehicles (EVs), tend to be more expensive to purchase and install than their fossil fuel counterparts. And if electric rates are high, electrification technologies will also be more expensive to operate. In those circumstances, electrification is not cost-effective. Additional barriers exist in the supply chain, such as a lack of products, a lack of contractors, and a lack of customer awareness.

[1] https://www.gov.ca.gov/2025/04/23/california-is-now-the-4th-largest-economy-in-the-world/.

While rebates and tax credits can help lower the purchase and installation costs of electrification technologies, they do little to offset the disadvantage to operating costs arising from high electricity rates. By and large, electricity rates are based on average or embedded costs. These tend to be much higher than the marginal costs of electricity, which are mostly based on renewable forms of energy such as solar and wind.

Raise the fixed charge and lower the energy charge to promote electrification

Some economists have suggested that a way forward is to price electricity at marginal cost and to recover the revenue deficiency through a fixed charge. But given the substantially discrepancy between marginal and average costs, the fixed charge would be prohibitively high. For example, in California, it could be as high as $74.02 per month for Pacific Gas & Electric Company (PG&E), which serves 5 million customers in northern California. This would be politically untenable. It would also represent a monumental rise from the current fixed charge, which is 0 dollars per month.

Thus, a variant was proposed which would vary the fixed charge with income, with lower income customers getting a lower fixed charge and higher income customers getting a higher fixed charge.[2] This was termed the Income Graduated Fixed Charge (IGFC).

After much debate and discussion, the California Public Utilities Commission approved a less dramatic version of this rate. The number of income tiers is set to three, with the lowest income tier paying $6 per month and the highest income tier paying $24.15 per month, with the average fixed charge at ~$18. Energy prices will be lowered by 5-7 cents/kWh across the three investor-owned utilities. That represents a reduction of 15 per cent for PG&E's customers, whose average rate is around 40 cents/kWh.

The energy prices would still be much higher than the marginal cost of electricity, and fail to lower the operating costs of electric equipment. There is no empirical evidence that the IGFC would accelerate electrification.

Most customers would simply view this as a shell game between fixed and variable charges. In fact, the average customer would not see any change in their bill. Compounding the problem, low-use customers, who use energy efficiently or live in smaller homes or in milder climates, would be penalized with higher bills. Why would they want to further raise their bills by electrifying their homes and their vehicles?

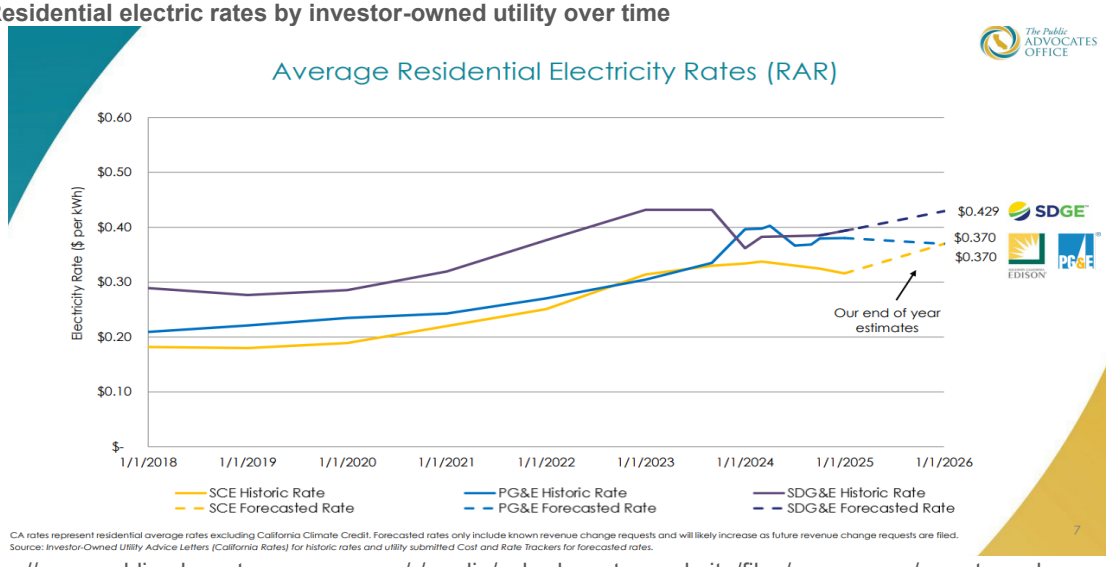
Unsurprisingly, this change in rate design has run into significant public opposition, having generated more negative press coverage, including editorials, letters to the editor, and op-eds, than any other energy issue in the past few years.[3]

Pricing electrification at marginal cost: a case study[4]

A much better approach would be to price electricity associated with fossil fuel technologies at average cost and electricity associated with electrification technologies at marginal cost. The drop in operating costs would be substantial.

The trend in electric rates for California's three largest utilities, including PG&E, is shown below.

Figure 1: Residential electric rates by investor-owned utility over time

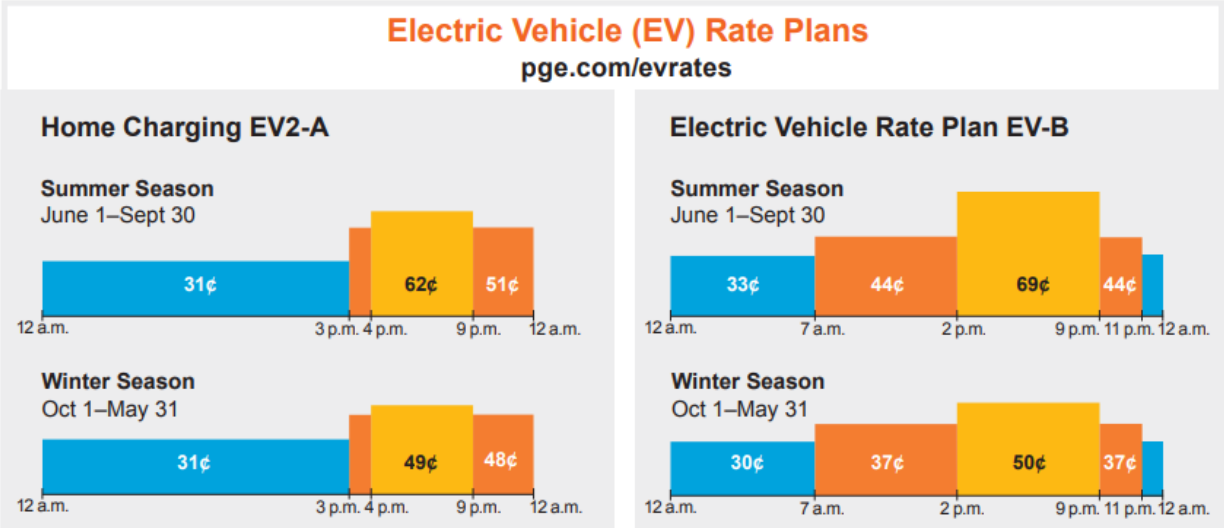


Source: https://www.publicadvocates.cpuc.ca.gov/-/media/cal-advocates-website/files/press-room/reports-and-analyses/250218-public-advocates-office-q4-2024-rates-report.pdf
Source: PGE.Com

[2] https://www.next10.org/publications/electricity-rates.
[3] https://www.energycentral.com/energy-biz/post/seven-reasons-why-other-states-should-not-emulate-california-s-income-pqBXoGG39eIQaG6.
[4] https://energyregulationquarterly.ca/articles/accelerating-electrification-by-lowering-its-operating-costs-through-technology-specific-marginal-cost-pricing#sthash.NUGpS9wE.dpbs.

One of the popular rates being used by PG&E's EV customers is EV2-A. The rate features three pricing periods. During the summer, the off-peak rate is 31 cents/kWh.[5] If EV load is priced at the marginal cost of electricity, the price may drop to 10 cents/kWh.

Figure 2: PG&E's EV2-A rate for EV customers



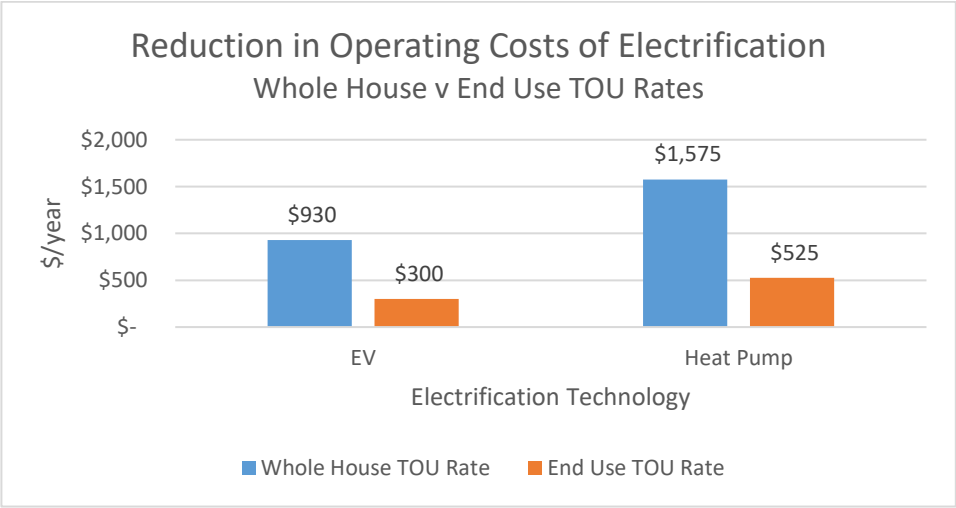
Source: https://www.pge.com/tariffs/assets/pdf/tariffbook/ELEC_SCHEDS_EV2%20(Sch).pdf

A typical household whose EV load is 3,000 kWh/year would see its annual EV driving costs drop substantially from $930 to $300. This would substantially enhance the appeal of EVs to drivers who are in the market for a new car, and would probably accelerate the rate at which EVs are taken up.

In the areas that lie east or south of San Francisco, or in the Central Valley, summers are hot, and winters are cold. A heat pump for heating, ventilating, and air conditioning (HVAC) may consume 3,500 kWh/year. In the summer, a heat pump in the cooling and ventilation mode is likely to run for several hours a day, spanning the off-peak, mid-peak and peak periods. It is likely to run most intensely in the late afternoon and early evening periods. In the winter, in the heating and ventilation mode, it is likely to run mostly in the mid-peak and off-peak periods.

If the year-round peak period price averages 55 cents/kWh, the mid-peak averages 49 cents/kWh and the off-peak price averages 31 cents/kWh, then a weighted average price of 45 cents/kWh may be used to get a (very) rough estimate of the annual operating cost of a heat pump.

Figure 3: Operating costs for EVs and heat pumps under marginal cost pricing



Source: Author's simulation

[5] It was 17 cents/kWh in 2019, just six years ago.

With the existing rate, that would amount to roughly $1,575 per year. If a marginal price of 15 cents/kWh is used, the cost would drop to $525, making it a substantially more attractive investment for customers, and probably accelerating the adoption rate. In both cases for EVs and heat pumps, operating costs fall by two-thirds, as brought out in Figure 3.

Some controversies in the application of marginal cost pricing focused on electrification

The notion that marginal cost pricing focused on key electrification technologies, such as heat pumps and EVs, can be used to decelerate climate change by reducing carbon emissions has generated several controversies. The 10 most frequently mentioned controversies are discussed below.

First, some parties dismiss climate change, saying it is a hoax,[6] and therefore there is no reason to focus on pricing strategies that might decelerate it or involve it in any energy policies at all. Adherents of this school of thought want to promote the continued use of fossil fuels not only for generating electricity but also for consuming energy. They want to continue supporting the use of natural gas for space heating and gasoline for driving cars.

This argument does not hold water in most professional circles. There is a large body of evidence in scientific literature that climate change is real and harmful to the health of the 8.2 billion people living on the planet. Thus, steps should be taken to mitigate it, and electrification is a good way of doing that.

Second, another school of thought accepts that climate change is a problem but argues that the best way to do that is to impose a carbon tax.[7] This would raise the price of natural gas and gasoline and discourage their continued use, and would indirectly encourage consumer adoption of electrification technologies. The notion of a carbon tax has been around in the economics literature for decades but, for a variety of reasons, such a tax has not been implemented.

Third, some parties assert that the simplest way towards complete electrification is to ban the burning of natural gas in homes and businesses for space and water heating and for cooking and clothes drying. The extreme proponents of this viewpoint want to impose the ban retroactively while the more moderate proponents want to impose it when equipment is being replaced in existing homes or about to be installed in new-builds.

The city of Berkeley sought to impose a ban on natural gas hookups in new construction, but ran into legal problems.[8] The state of California has banned the use of natural gas when replacing water heaters or space heaters in homes by 2030.[9] That will certainly trigger major concerns about energy affordability in a state where affordability is a very pressing problem. It may also run into serious legal challenges like those that arose in Berkeley when natural gas hookups were banned. In fact, they may be more serious because the statewide ban will also affect replacements, not just new construction.

Fourth, some parties assert electrification will move system load curves so that they reach a peak in the winter, as opposed to the summer, create winter peaks in areas where the system load curve peaked in the summer, since heat pumps will replace space heaters that run off natural gas or oil. That will strain the distribution grid, requiring expensive investments whose costs will outweigh the benefits of electrification. Others argue that many households living in areas with mild summers that did not previously have central air conditioning systems will now be given the opportunity to cool their homes in the summer with a heat pump. This will also strain the distribution grid.[10]

Studies should be undertaken to quantify the impact of electrification on the distribution grid in the summer and winter seasons. If the impacts are likely to be significant, they can be mitigated by introducing variations in the marginal cost calculations. As an example, some have suggested that marginal cost pricing should only be used in the winter season for heat pumps for those households who already have a central air conditioner in place.

Fifth, some have suggested that there should be locational variation in marginal cost pricing to account for variations in distribution costs across locations.[11] Others have argued that marginal cost pricing should vary by time of use, being higher in peak periods and lower in off-peak periods.[12] Some have gone a step further and argued that marginal cost-based pricing designs should have

[6] https://www.sciencedirect.com/science/article/pii/S0272494423001779.
[7] https://www.nobelprize.org/uploads/2018/10/nordhaus-lecture.pdf.
[8] https://www.npr.org/2024/03/29/1241576489/berkeley-calif-repeals-its-first-in-the-nation-ban-on-natural-gas-in-new-homes.
[9] https://www.npr.org/2022/09/23/1124511549/california-plans-to-phase-out-new-gas-heaters-by-2030.
[10] See the comment by Philip Quadrini in https://energyregulationquarterly.ca/case-comments/comments-re-accelerating-electrification-by-lowering-its-operating-costs-through-technology-specific-marginal-cost-pricing-by-dr-ahmad-faruqui#sthash.IjgXrCnL.dpbs.
[11] See the comment by Carl Danner in https://energyregulationquarterly.ca/case-comments/comments-re-accelerating-electrification-by-lowering-its-operating-costs-through-technology-specific-marginal-cost-pricing-by-dr-ahmad-faruqui#sthash.IjgXrCnL.dpbs.
[12] This paper discusses various types of time-of-use rates: https://www.publicpower.org/periodical/article/what-weve-learned-half-century-time-varying-rates.

a much finer granularity and vary on an hourly or sub-hourly basis.[13] These are reasonable suggestions and should be considered in the formulation of marginal cost-based prices, but consumer understanding and acceptance should also be factored into the design of electricity rates.

Sixth, some have pointed out that new electrification technologies, by imposing additional load on distribution circuits, may require the installation of new distribution capacity. They have suggested that marginal cost pricing should include not only energy costs but also capacity costs. If that is the case, then capacity costs should be included in marginal cost-based rates. They could be rolled into energy charges, on a time-of-use basis, or as a demand charge.

Seventh, some have stated that marginal cost pricing targeted at key electrification technologies cannot be implemented without knowing end-use specific load shapes. That is correct. But they go on to argue that these cannot be inferred without end-use metering, which is expensive. However, advances in data science now allow end-use load profiles to be inferred, especially for large end uses, such as heat pumps and EVs. For EVs, utilities are already inferring their load shapes through telemetry. This is no longer an insurmountable problem and obviates the need for end-use metering.

Eighth, some argue that technology-specific pricing is discriminatory and violates long-standing regulatory practices. In my view, regulatory practices needs to change with the realisties of the situation If there are societal benefits to be gained from electrification, then pricing designs that promote it should be accepted by regulators.

Ninth, some have said a much simpler approach to electrification is to raise fixed charges and to reduce volumetric charges. An example of this is the Income Graduated Fixed Charge (IGFC) that was approved in California and whose implementation began on November 15, 2025, in southern California.

However, as discussed earlier, unless the volumetric charge is dropped down to marginal cost, it will not do much to spur electrification. And if it is indeed dropped down to marginal cost, the corresponding increase in fixed charges to ensure cost recovery will be so high as to be politically untenable.

Finally, some have raised a concern that marginal cost pricing directed at electrification will trigger a death spiral, since marginal costs are lower than average costs, which form the basis for utilities to recover their revenue. That should not be the case, since only incremental loads associated with electrification are being priced at marginal cost. If the latter is measured correctly, all the incremental costs associated with electrification will be recovered. And average cost pricing will still apply to infra-marginal loads, ensuring that utilities recover their revenues both for inframarginal loads and the marginal loads associated with electrification. The pricing design proposed in this paper is a two-part rate precisely to ensure that utilities recover all their revenues while also encouraging the installation of new electrification technologies.

Conclusions

In my opinion, the 10 controversies have not changed the fundamental merits of pricing electricity at marginal cost to accelerate electrification. But they have helped refine and further develop the concept.

The computation of marginal costs associated with key electrification technologies such as heat pumps and EVs should be refined to include variations arising from seasonality, location, and time. They should also consider distribution, transmission, and generation costs. And they may not be limited to an energy charge, but may include a capacity charge as well.

Of course, the resulting pricing designs should be vetted before being implemented through extensive customer interactions through interviews, focus groups, and conjoint analysis of customer surveys. The resulting designs should be tested in scientifically designed pilots before being offered in the field, initially on an opt-in basis and later on a default, opt-out basis.[14]

[13] This paper discusses hourly and sub-hourly pricing, often called real-time pricing: https://energyregulationquarterly.ca/articles/real-time-pricing-of-electricity-for-households-an-international-survey#sthash.BS2Yttv5.dpbs

[14] For a discussion on how to design and evaluate pilots, and then proceed to full-scale implementation, see: 'Bridging the chasm between pilots and full-scale deployment of time-of-use rates,' *The Electricity Journal*, Volume 33, Issue 10, December 2020, 106857.