Electricity Bills and Climate Change: Should Energy Hogs Pay More?

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Based on a stream of research with outstanding colleagues

- Severin Borenstein and James Bushnell, “Do Two Electricity Pricing Wrongs Make a Right? Cost Recovery, Externalities, and Efficiency”, American Economic Journal: Economic Policy, 2022, 14(4), pp. 80-110

- Severin Borenstein and James Bushnell, “Headwinds and Tailwinds: Implications of Inefficient Retail Energy Pricing for Energy Substitution”, NBER Environmental and Energy Policy and the Economy, 2022, 3, pp. 37-70

- Severin Borenstein, Meredith Fowlie and James Sallee, “Designing Electricity Rates for An Equitable Energy Transition”, Energy Institute at Haas Working Paper #314, February 2021

- Severin Borenstein, Meredith Fowlie and James Sallee, “Paying for Electricity in California: How Residential Rate Design Impacts Equity and Electrification”, Energy Institute at Haas Working Paper #330, September 2022

- Severin Borenstein, “Energy Hogs and Energy Angels: What Does Residential Electricity Usage Really Tell Us About Profligate Consumption?”, Energy Institute at Haas Working Paper #341

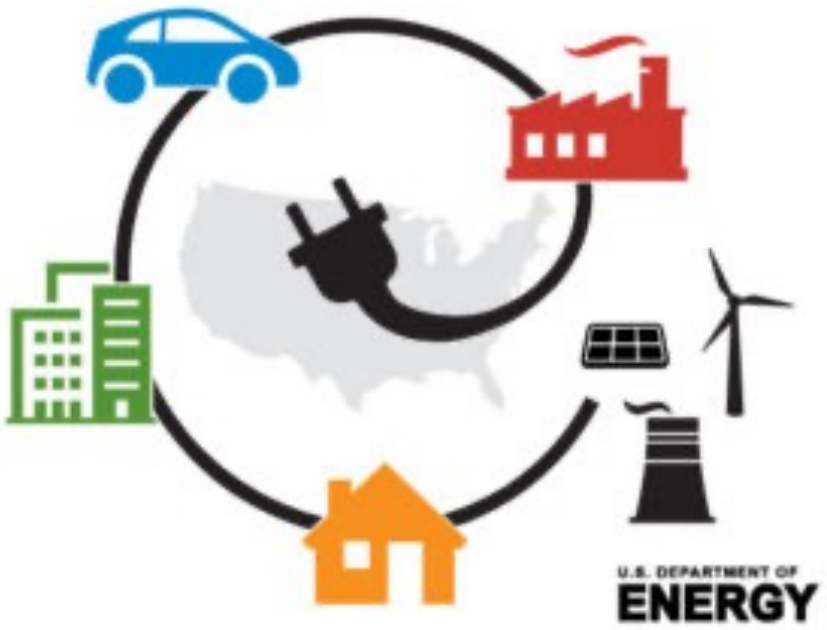
Background: the role of electricity in the energy transition

Two-step plan for deep decarbonization:

1. Generate clean electricity
2. Electrify everything

Electricity rate structures are crucial here:

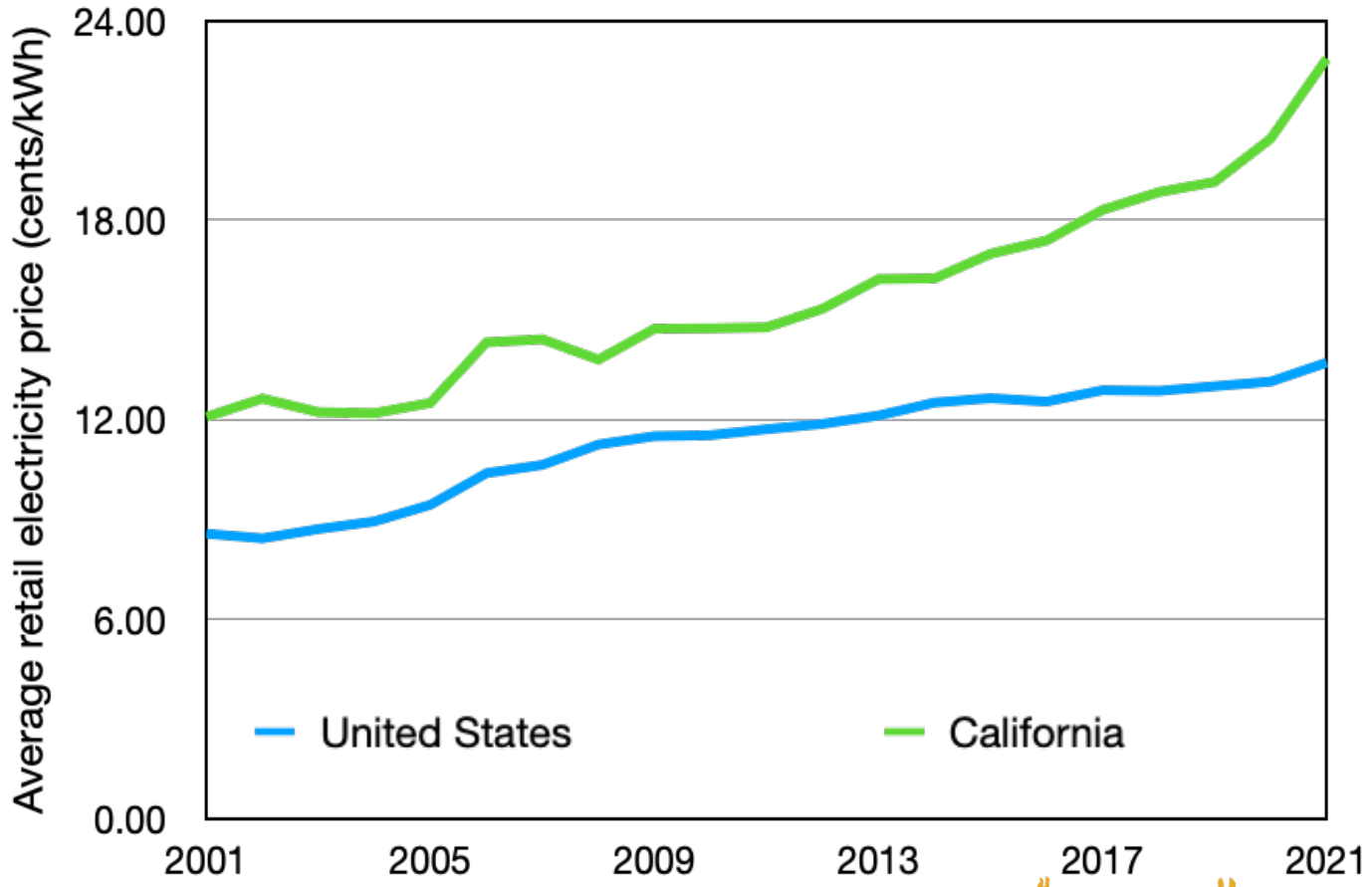
- People won't electrify vehicles and homes if electricity is too expensive
- High prices are a barrier to consumer acceptance of electric vehicles/appliances



The Context

- Residential electricity prices in California are high, rising, and increasingly out of line with the rest of the country.
- High rates disproportionately hit disadvantaged households
- California may foreshadow trends that will impact many jurisdictions with rising fixed costs of climate change impact on electricity systems and increased climate mitigation efforts

Average Residential Electricity Prices



Source: US Energy Information Administration

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Economic Context

- Electric utility service – transmission and distribution – is a natural monopoly. Charging efficient marginal cost prices would not cover all of the costs of the utility.
- California's regulated utilities rely on volumetric pricing to collect residential revenues. So do most US utilities, though they have a small fixed charge.
- Virtually all fixed costs and priorities funded via rate payers – which are not incremental costs – are recovered via high volumetric rates.
- We label the gap between marginal (volumetric) price and social marginal cost as an **"electricity tax"** on each kilowatt-hour of electricity.
- The cost recovery burden (the electricity tax) falls on households as a function of their level of electricity consumption.

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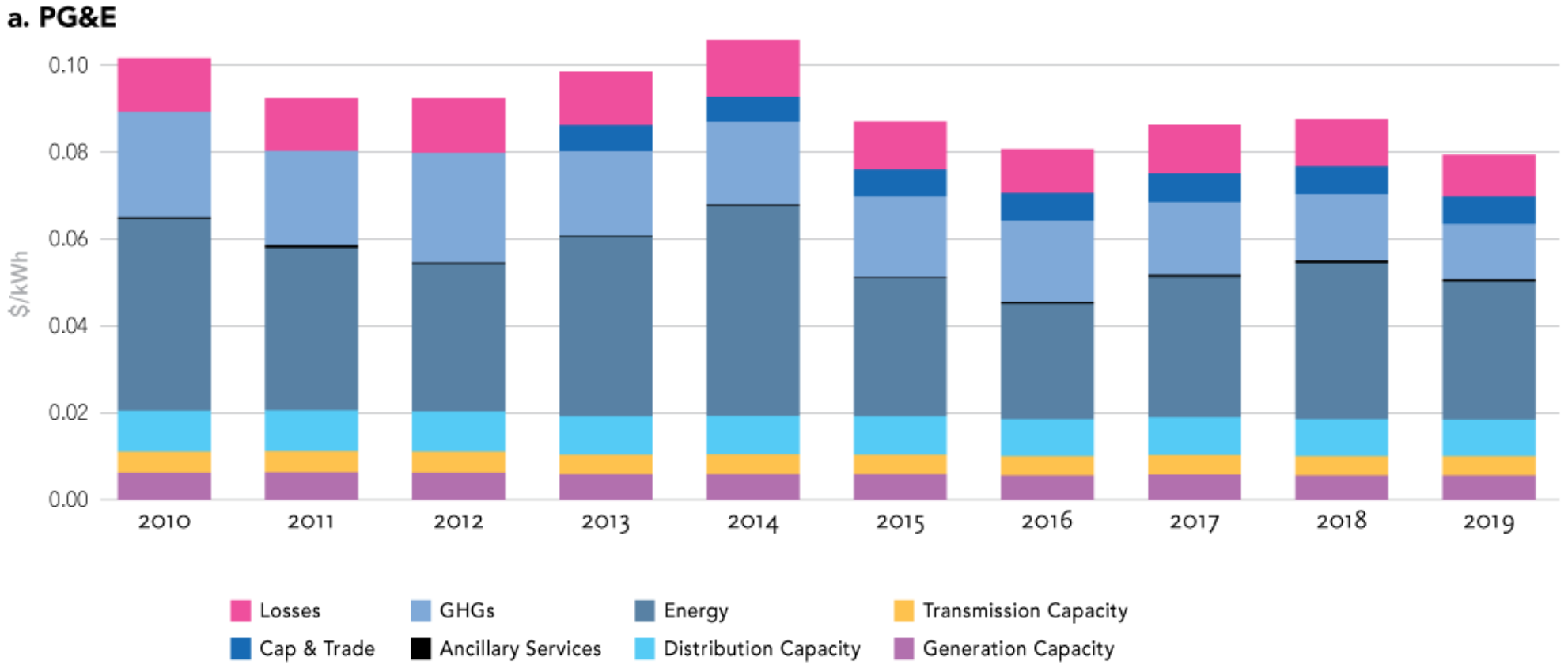
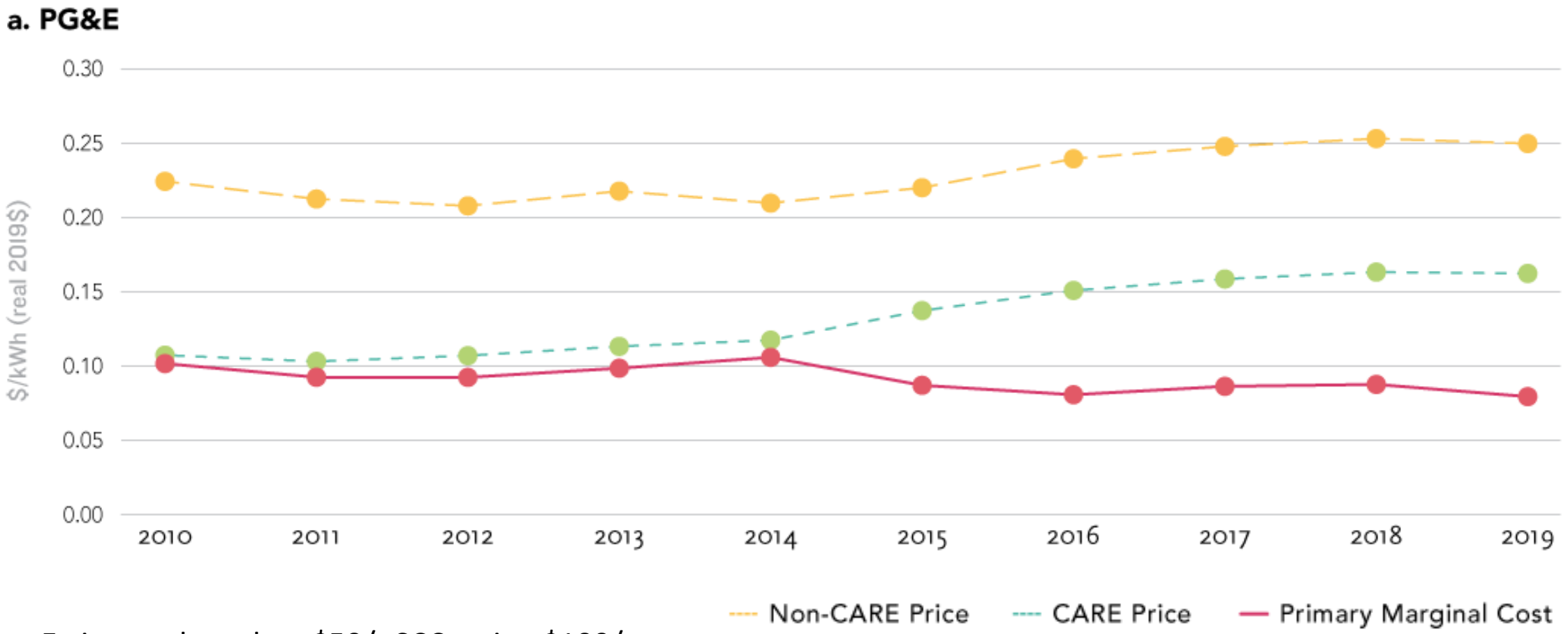
California's Three Largest Investor-Owned Utilities

Annual social marginal cost estimates ($/kWh)



Notes: Marginal cost components are weighted by IOU load. See text for details on the construction of cost components. Additional details on data sources and methodology behind author calculations can be found in the Appendix.

Residential prices versus social marginal cost ($/kWh)



Estimates based on $50/t SCC; using $100/t raises the red line by about 2 cents in 2019

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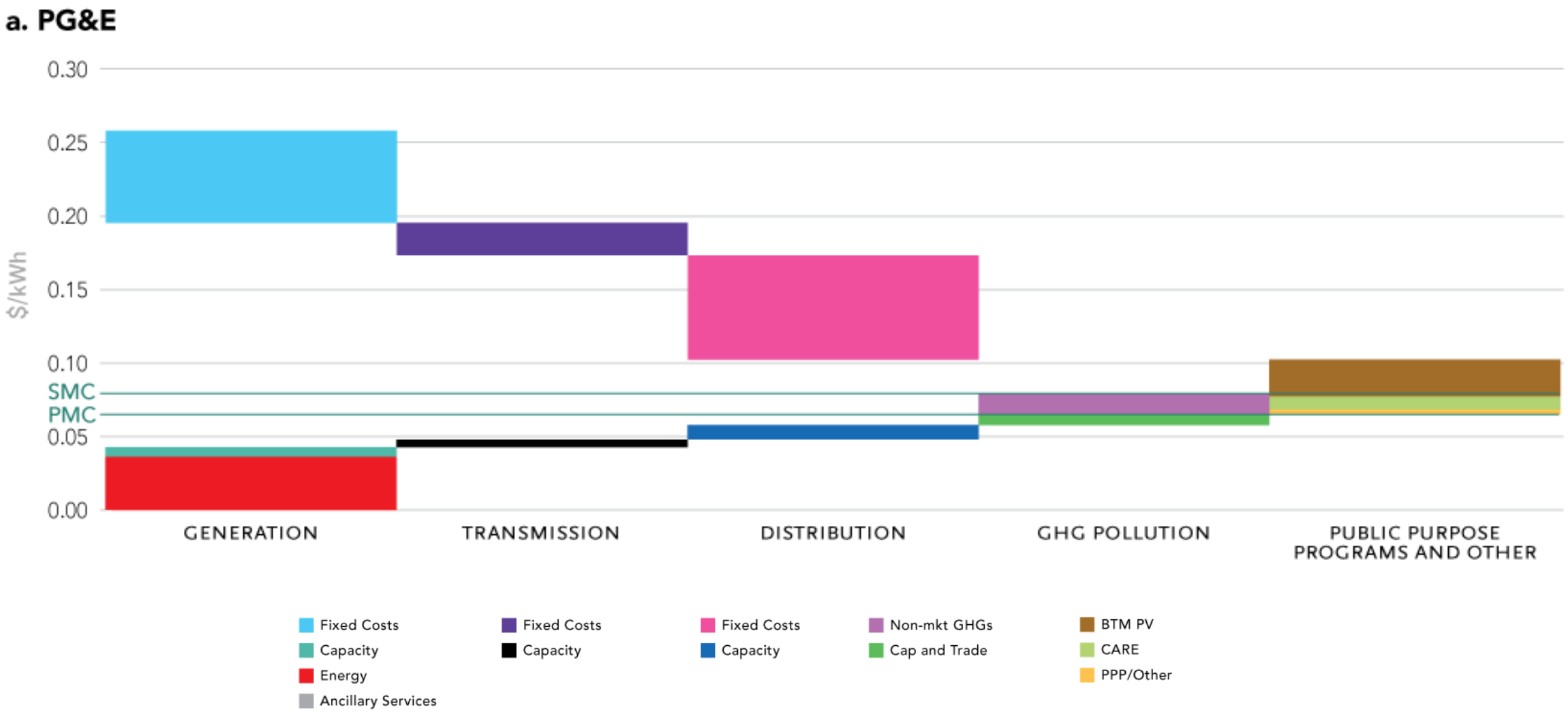
2019 residential price decomposition ($/kWh)



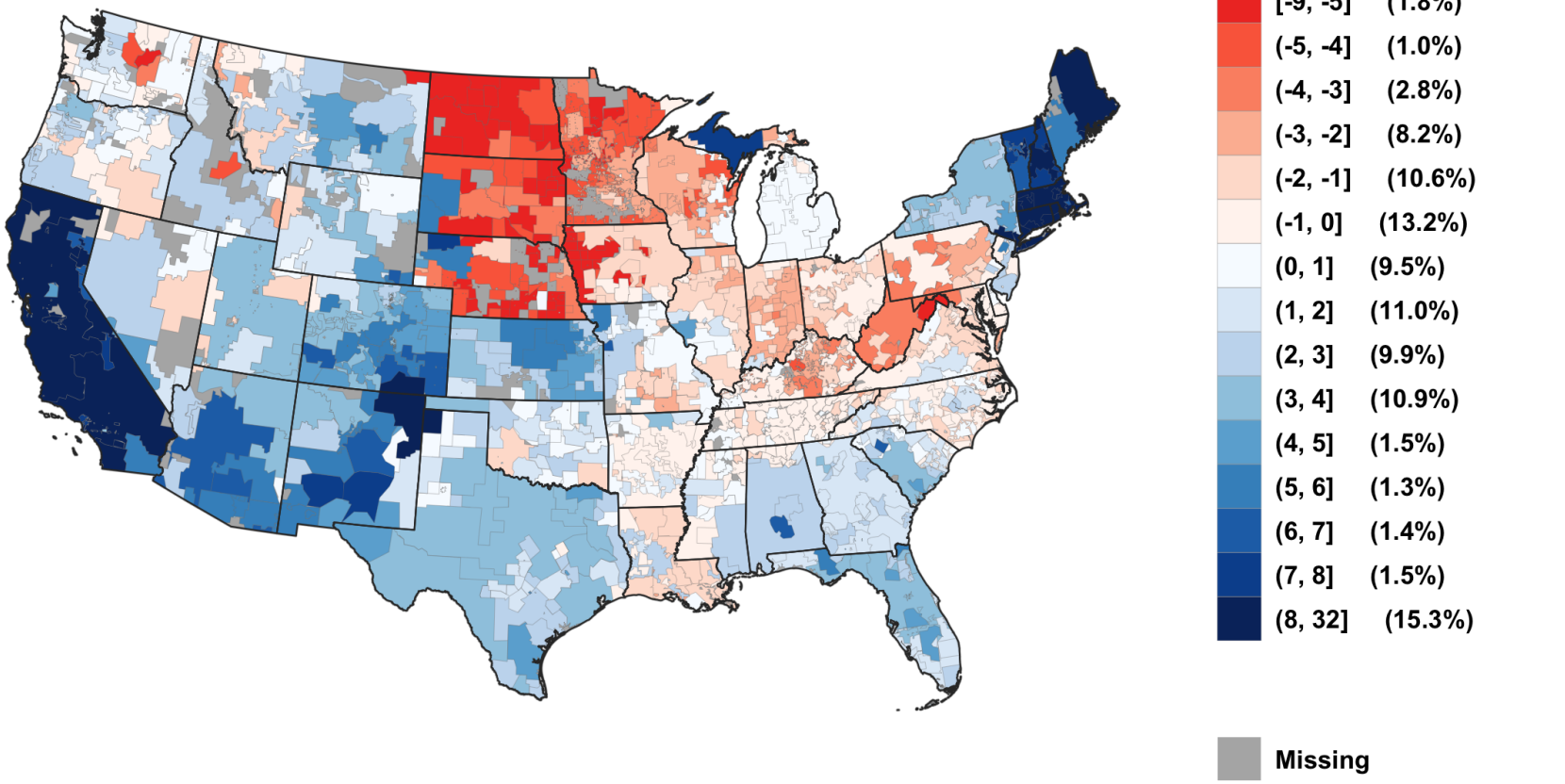
Notes: Primary marginal cost estimates are weighted by IOU load. Average 2019 residential prices (CARE and non-CARE) are constructed using advice letters and rate schedules PG&E sources: 5366-E-A/B; 5444-E; 5573-E; 5644-E. SCE sources: 67666-E: 67668-E. SDGE: 31811-E; 31501-E. Details on the methodology behind author calculations can be found in the Appendix.

What is driving the gap between price and SMC?

- Legacy infrastructure costs
- Legacy energy contracts that are now above market
- Vegetation management
- Distribution system maintenance and upgrades
- Grid hardening/wildfire risk mitigation
- Wildfire victim compensation (due to “inverse condemnation”)
- Subsidies for new technology R&D
- Energy efficiency programs, EV charging stations
- Subsidies for low-income customers
- Net energy metering for rooftop solar (due to P>>SMC)
- …and prices are set to rise further relative to SMC

Is California different now? In the future?

- The "electricity tax" is lower, even negative, in some parts of the country
- Based on $50/ton SCC, SMC rises at higher values of SCC
- Source: Borenstein and Bushnell (2022)



Aside on the economically efficient price

- One component of social marginal cost is the "social cost of carbon", the negative impact of emitting GHGs
  - Recently updated from around $50 to nearly $200
- But the efficient price of electricity depends in part on how substitutes – gasoline and natural gas – are priced
- If substitutes are underpriced, underpricing electricity is needed to attain efficient substitution among energy sources
- If raising the SCC is not accompanied by increases in cost of gasoline and natural gas, then may have little effect on economically efficient price of electricity

How is this cost burden shared across households?

- We want to understand how the cost burden of the “electricity tax” is allocated across `advantaged' and `disadvantaged' households. We use income, a very imperfect measure, as our metric.
- We analyzed 2019 individual household billing data

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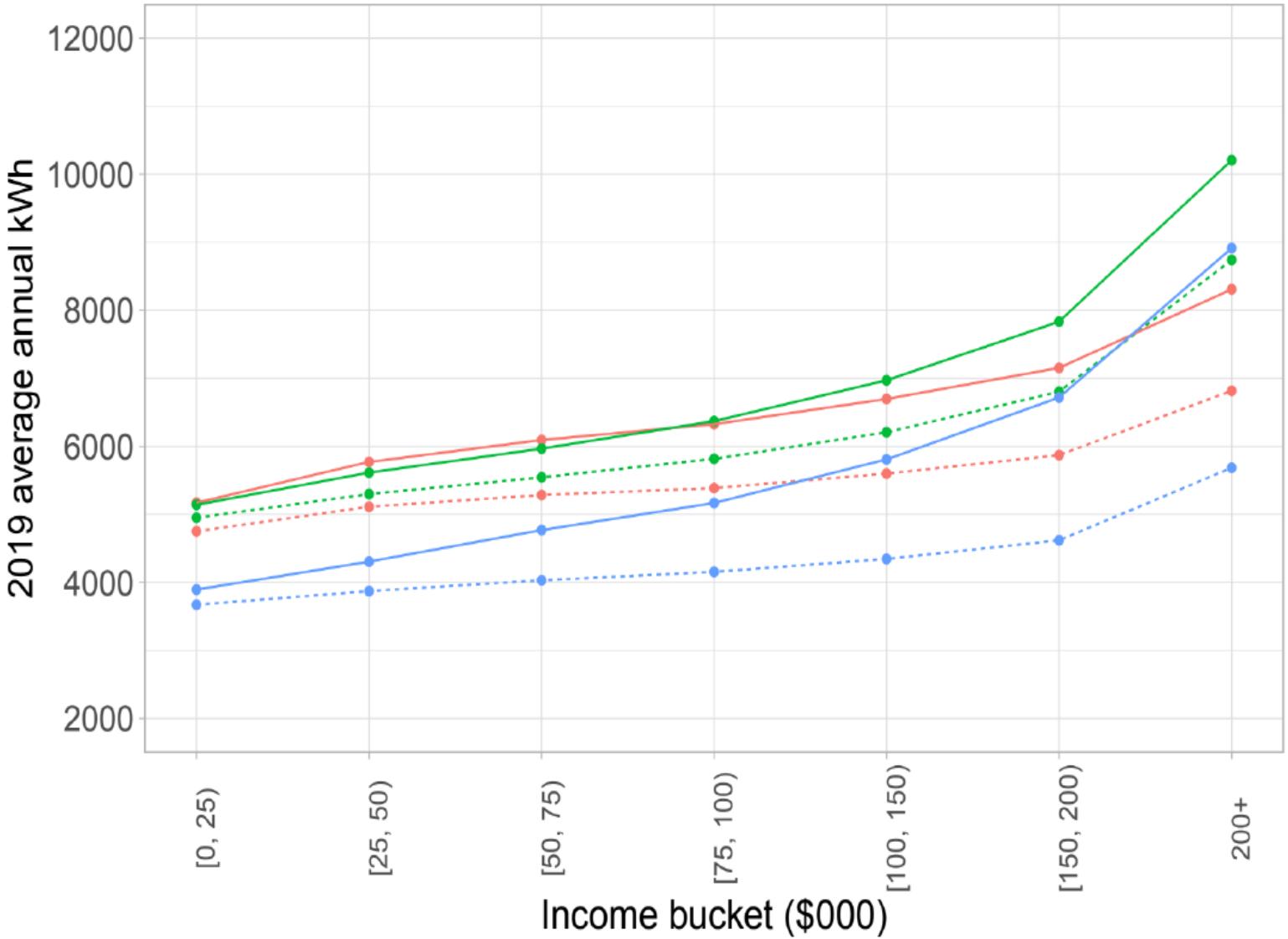
Gross and Net Consumption by Income Bracket



- Richer households consume more, but rooftop solar substantially reduces the correlation
- Flat volumetric pricing recovers more cost from users with higher consumption.

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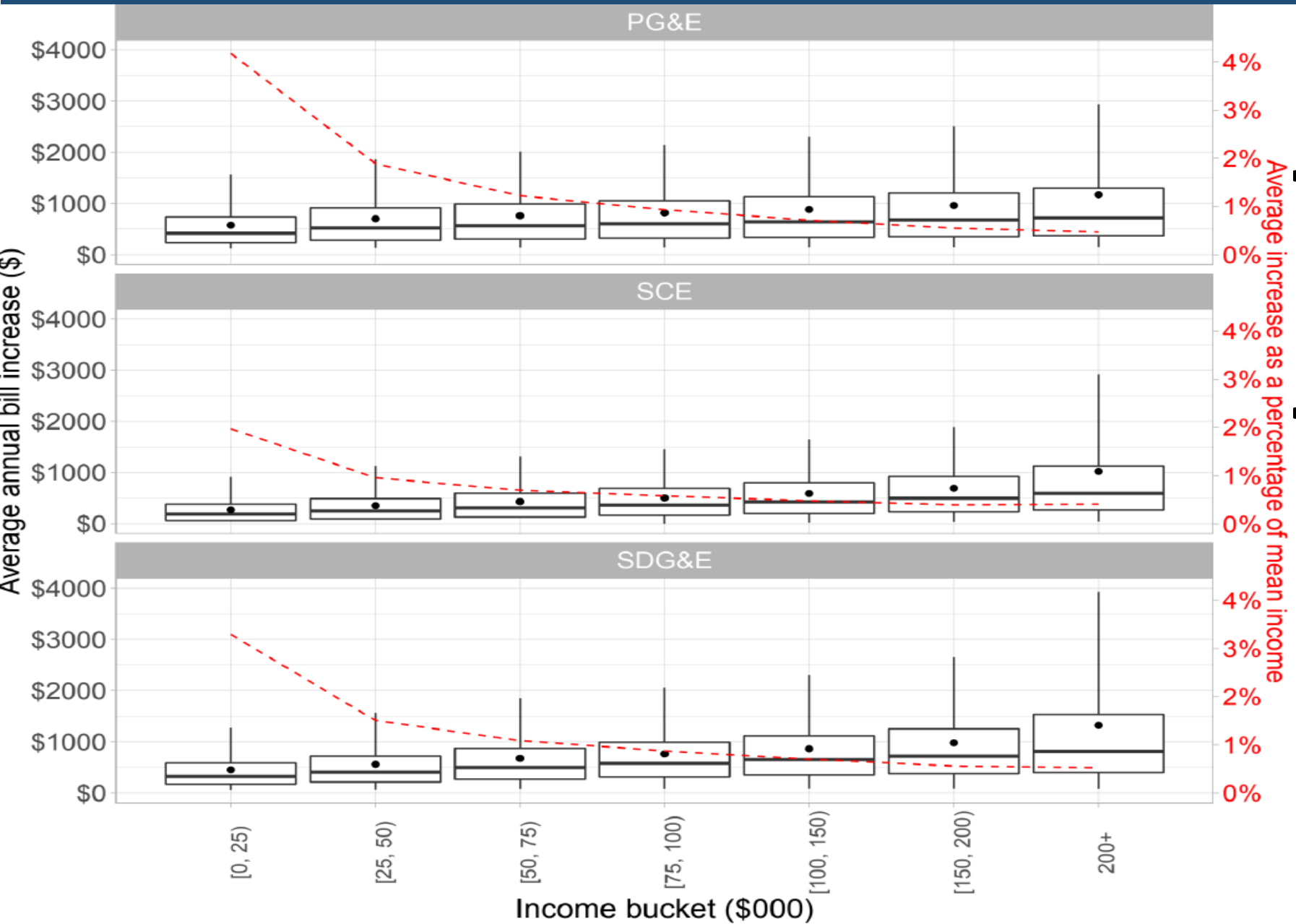
Annual Residual Cost Burden by Income Category (2019)



- Richer households pay more “electricity tax” per year.
- But poorer households pay a much higher *share* of income. The tax is very regressive.

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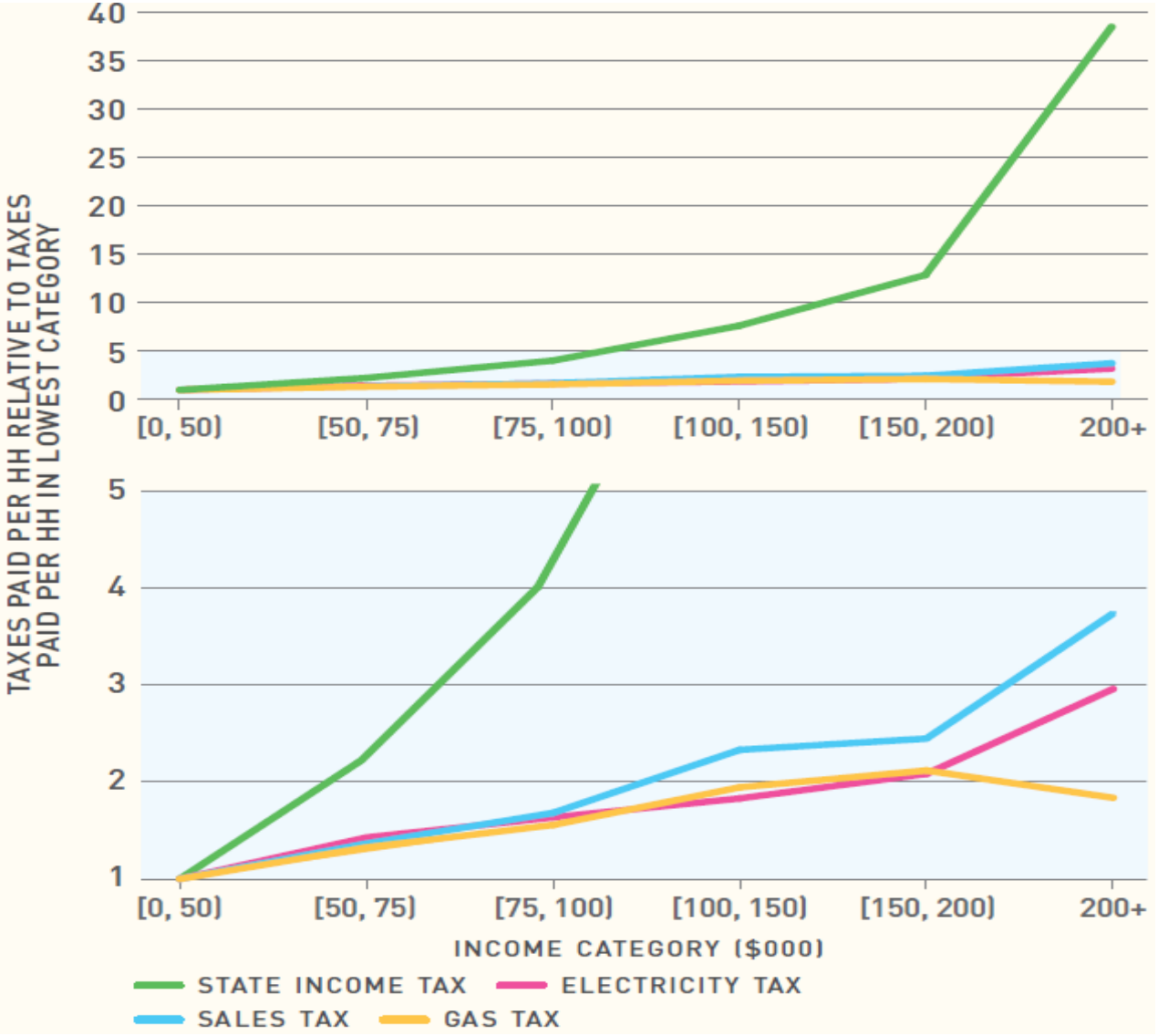
Progressivity of Alternative Tax Sources



- Based on the Consumer Expenditure Survey for gasoline, sales, and income taxes, the "electricity" tax is more regressive than California's sales tax, and dramatically more regressive than the income tax.

- Paying for select costs—like wildfire mitigation, low-income subsidies, and energy efficiency programs—with state funds would reduce prices and improve equity.

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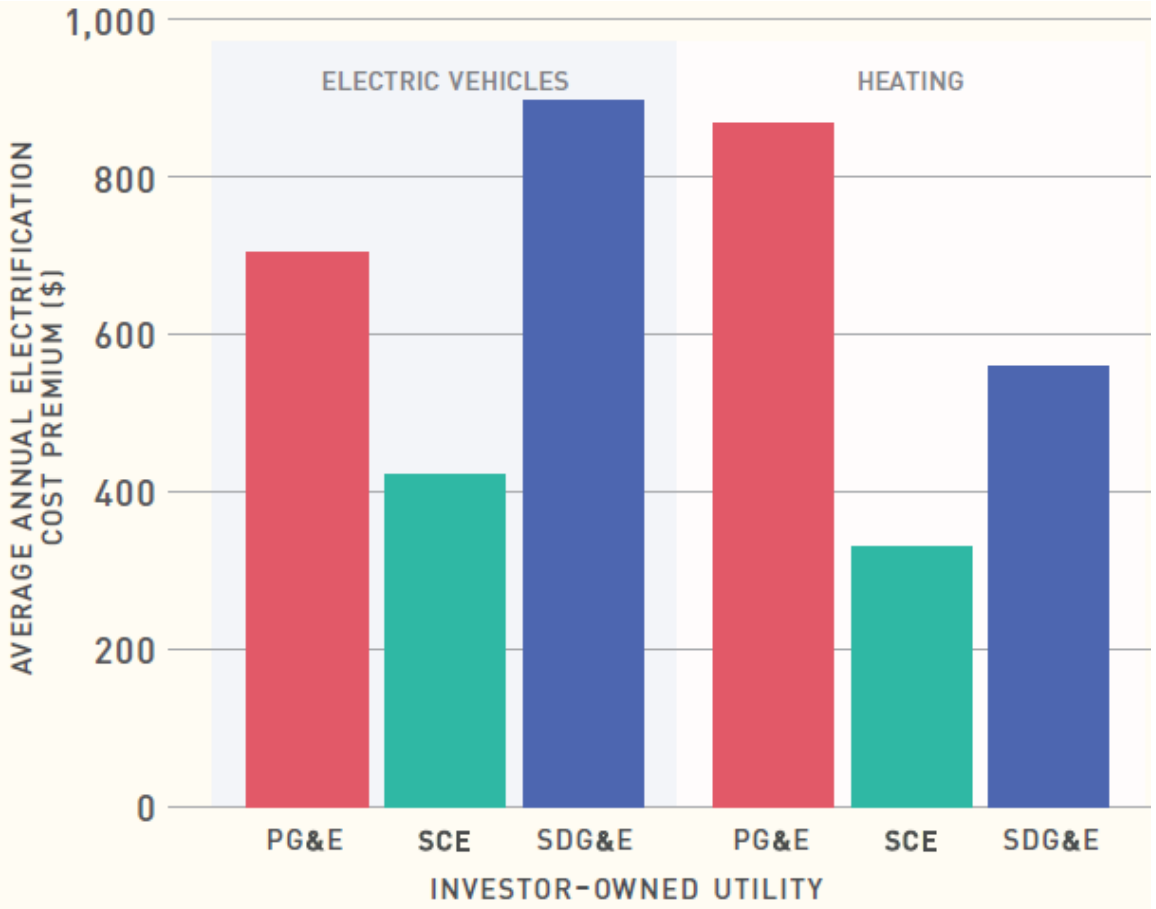
Electrification Cost Premium for EVs and Heating



Note: For electric vehicles and electric heat pump space heating in each utility territory, this graph shows the difference in average annual operating cost comparing current prices to price set equal to SMC. See text for details.

Higher volumetric prices hinder electrification, which is a major pathway for decarbonization.

On average, the “electricity tax” translates into a cost premium of roughly $700 *per year* in extra cost for charging an EV or installing an electric heat pump

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Solutions

- The current rate structure (high volumetric prices above SMC to recover costs) is bad for the climate and bad for equity.
- There are feasible rate reforms that are both good for the climate and good for progressivity.

- **Option 1:** move suitable costs onto the state budget.
- **Option 2:** an income-graduated fixed charge (IGFC).

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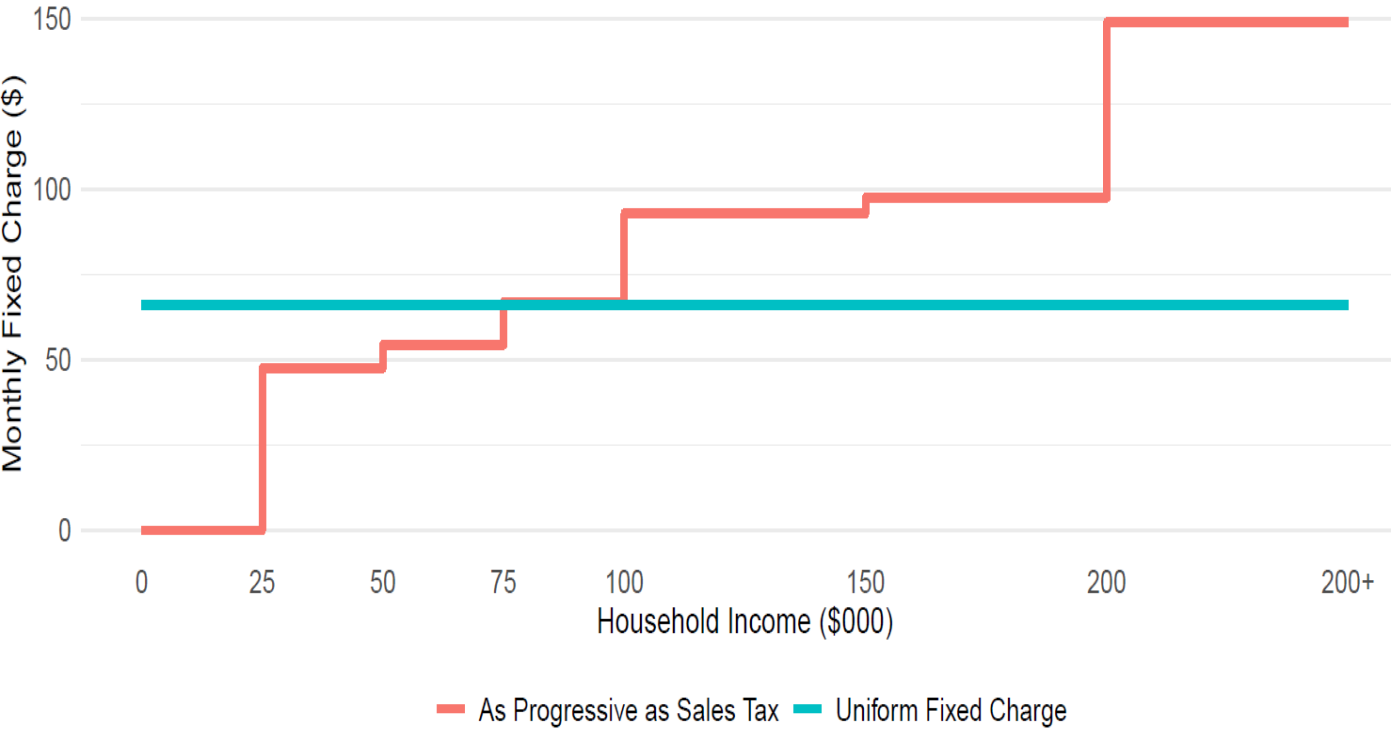
Income-graduated fixed charge

- A fixed charge can be made progressive if it scales with income
- This requires income verification
  - Utilities are not well situated to collect quality income data and do verification
  - Any income verification process will be costly, so worth doing this only if it is part of a pricing scheme with a significant fixed charge
  - Best scheme probably involves a trusted third-party to intermediate between state agencies (Franchise Tax Board) and utilities
- Only applies to residential customers. No real equivalent for commercial and industrial customers of vastly varying scale.

Example of Income-graduated Fixed Charge (PG&E)



Example of Income-Based Fixed Charge

In PG&E, a uniform monthly fixed charge would be $67 in 2019 (green line) to recover same revenue with P=SMC.

Red line shows an income-graduated fixed charge (IGFC) that matches progressivity of sales tax.

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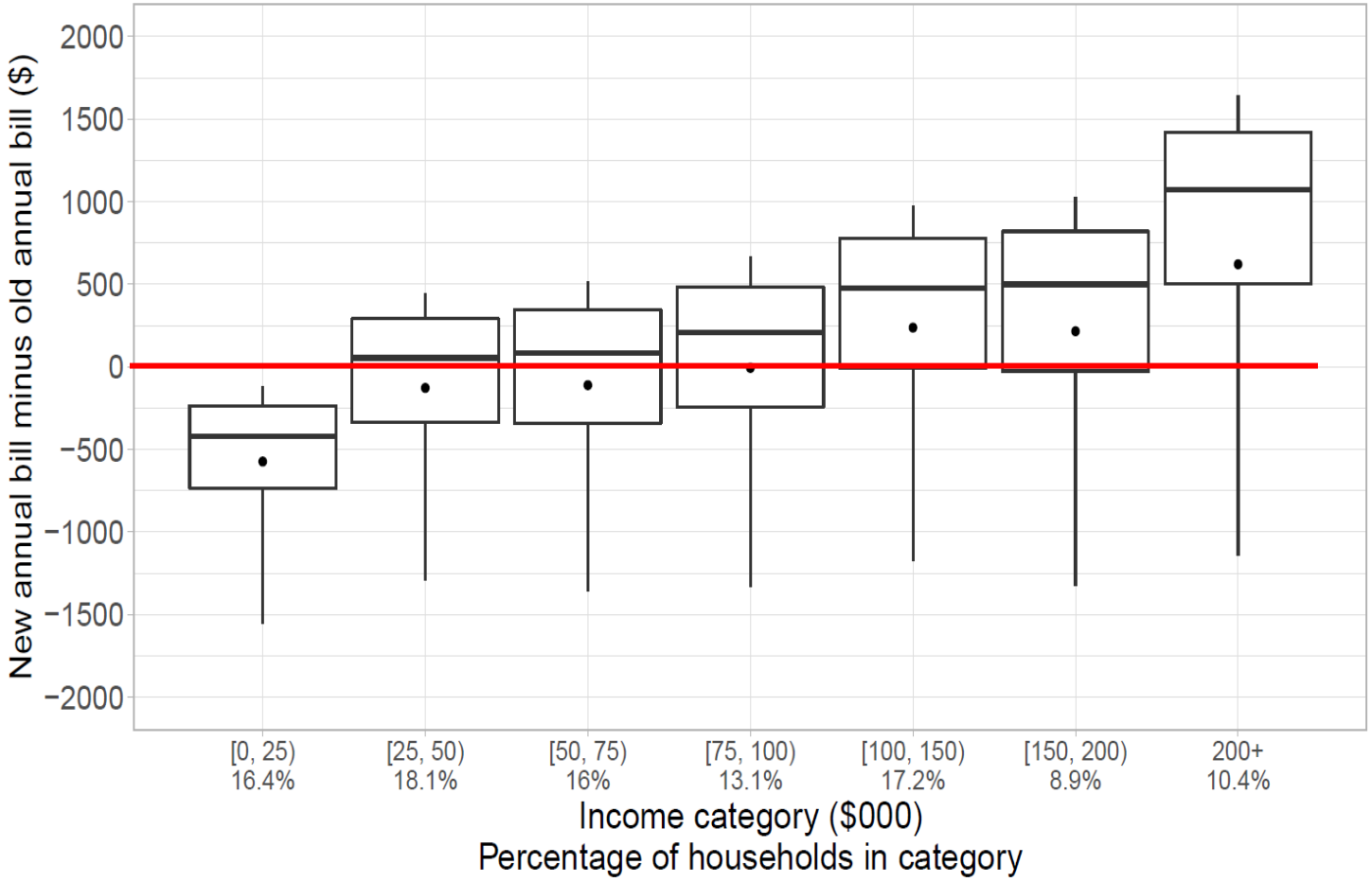
Effect on Monthly Bills (PG&E)

- Volumetric prices are much lower, so net impact on bill depends on both consumption and the IGFC.
- A negative number in figure indicates bill reduction under IGFC approach.
- Wealthiest households would see monthly bill increase by about $55 on average.
- Bill impacts will vary substantially depending on consumption.



Box and whisker plot shows the mean impact in a group (dot), the median impact (bar), the 25th to 75th percentile impact (box) and the 5th and 95th percentile (lines).

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But not everyone thinks lowering volumetric rates is a good idea

- One concern of opponents: this would encourage wasteful energy use
  - Though economists would generally not call it wasteful if customers are willing to pay the full social marginal cost (including pollution costs)
- Closely related concern: bills would fall for households that use more electricity, rise for those using less
  - "The big winners will be energy hogs in the Central Valley"
  - "The income-graduated fixed charge would raise bills to more efficient consumers"
  - "[The IGFC] will reward the energy hogs and penalize the energy misers"
- In fact, in CA and many other locations, increasing-block pricing explicitly penalizes high-usage households

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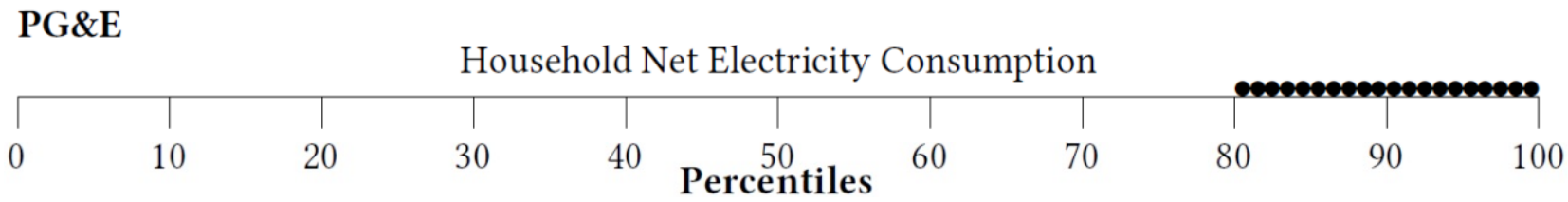
Is penalty pricing of electricity penalizing wasteful consumers?

- The narrative supporting all-volumetric revenue collection, and also increasing-block pricing, is that higher household electricity consumption indicates more wasteful usage
- But many other factors drive electricity consumption
- Unlike "wasteful" or "careful" consumption, many of the other factors that drive consumption can be observed
- What happens when we adjust for characteristics that most people would agree should not be penalized
  - such as *the number of people who live in the house*

Data for household electricity usage analysis

- Primarily focus on California's Residential Appliance Saturation Survey (RASS)
  - Covers slightly more than 30,000 residential customers of the three large investor-owned utilities: Pacific Gas & Electric, San Diego Gas & Electric, and Southern California Edison
- Includes electricity consumption and many characteristics of the households
- Start by looking at the highest 20 percentile annual consumers
  - who I will call the "energy hogs", at least for now

Location of Energy Hogs in Overall Distribution of Electricity Consumption



100

Define “energy hogs” as the households that fall in the top 20% of annual net electricity consumption

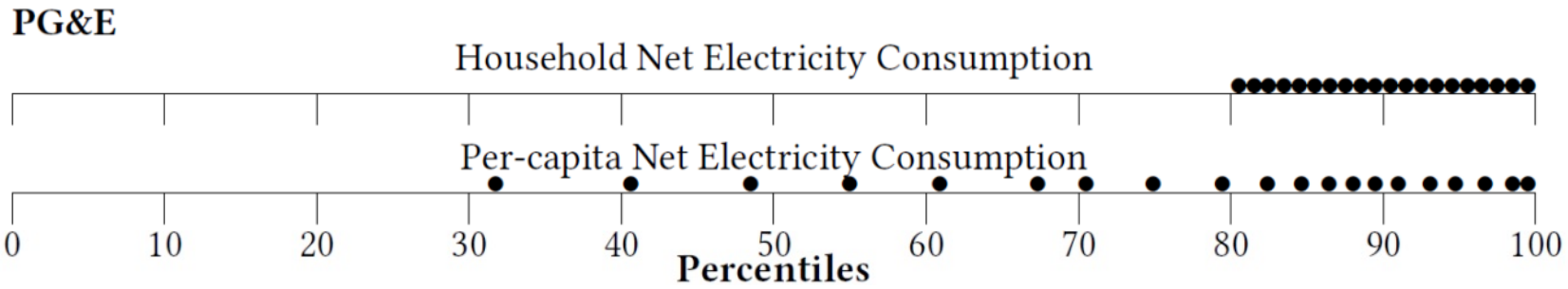
- PG&E is middle case of the 3 utilities

Represent the mean consumption of each percentile of those households with a dot

By that definition, when we look at household net electricity consumption, the hogs are all lined up between the 80th and 100th percentile

Now let’s adjust for some characteristics that virtually all would agree we don’t want to penalize. Start with number of household occupants.

Location of Energy Hogs in Overall Distribution of Electricity Consumption



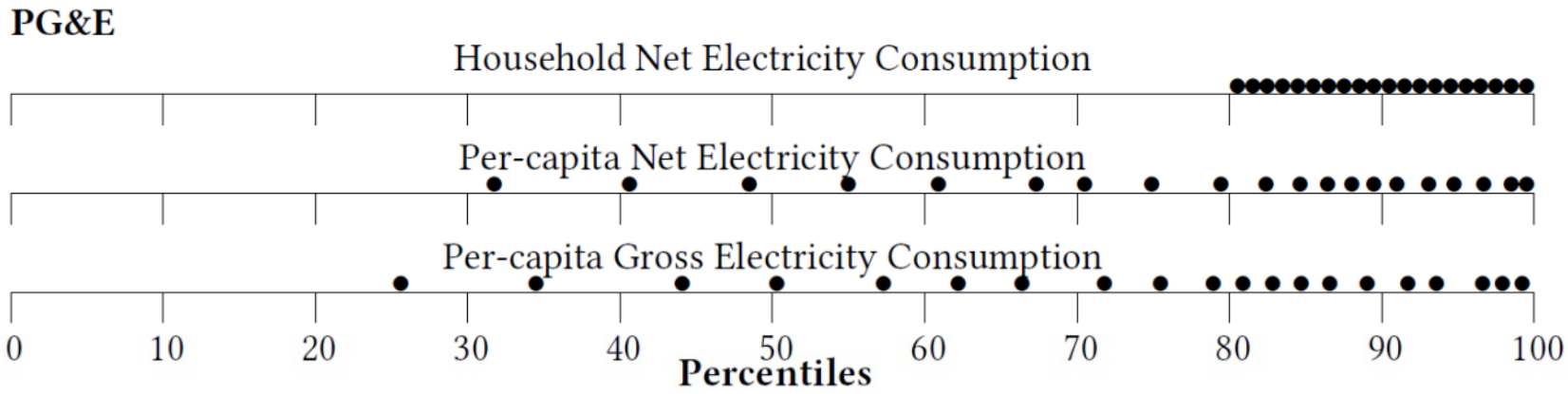
When we adjust for number of household occupants by looking at per capita consumption, about half of the energy hogs fall out of the top 20%

The lowest 5% of the hogs (1% of total population) have average per capita consumption at the 32nd percentile of the overall distribution. Consumption of the second lowest 5% of hogs averages is in the 41st percentile of the distribution. And so on.

Does rooftop solar constitute careful use of energy?

- If solar owners are really “prosumers” (who want to be treated like other producers), shouldn’t we separate consumption from production and judge hoggyness on gross consumption rather than net?

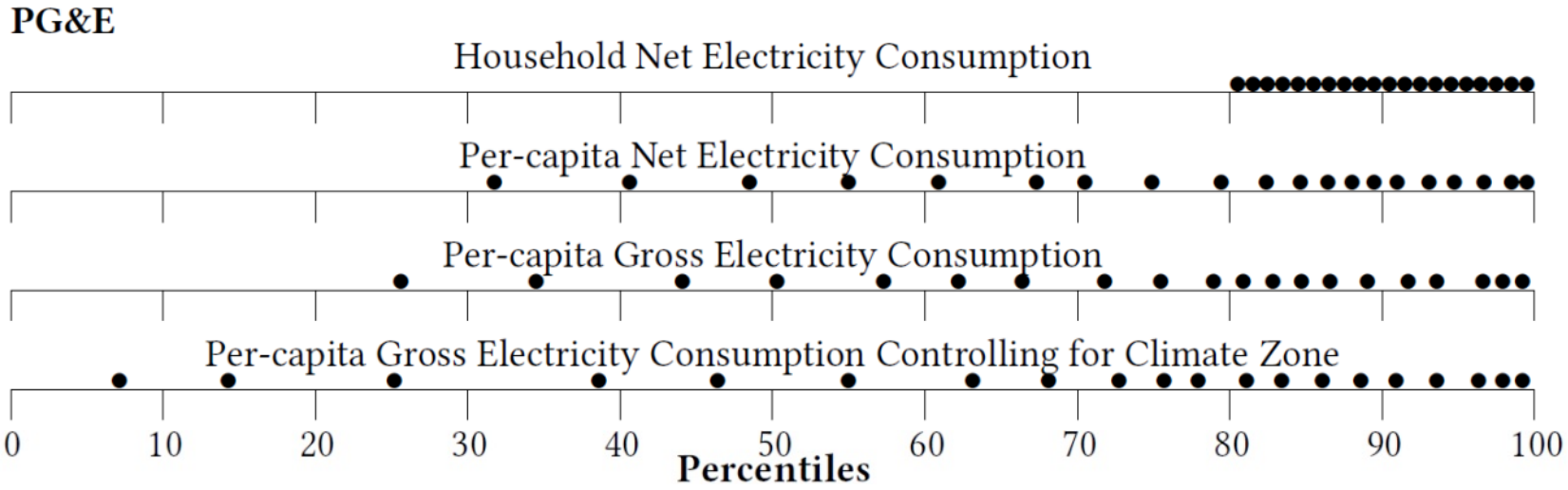
Adjusting for number of occupants and distributed generation



Where do energy hogs live?

- It also turns out that a disproportionate share of California's energy hogs live in hot climates such as the Central Valley, while a disproportionate share of "energy angels" live on the coast.
- Assuming that we do not want to punish people for where they live, we should be judging hoggyness after controlling for location
- I do so by regressing per capita net consumption on climate zone fixed effects and analyzing the distribution of the residuals
- Concern about correlation of climate with omitted factors

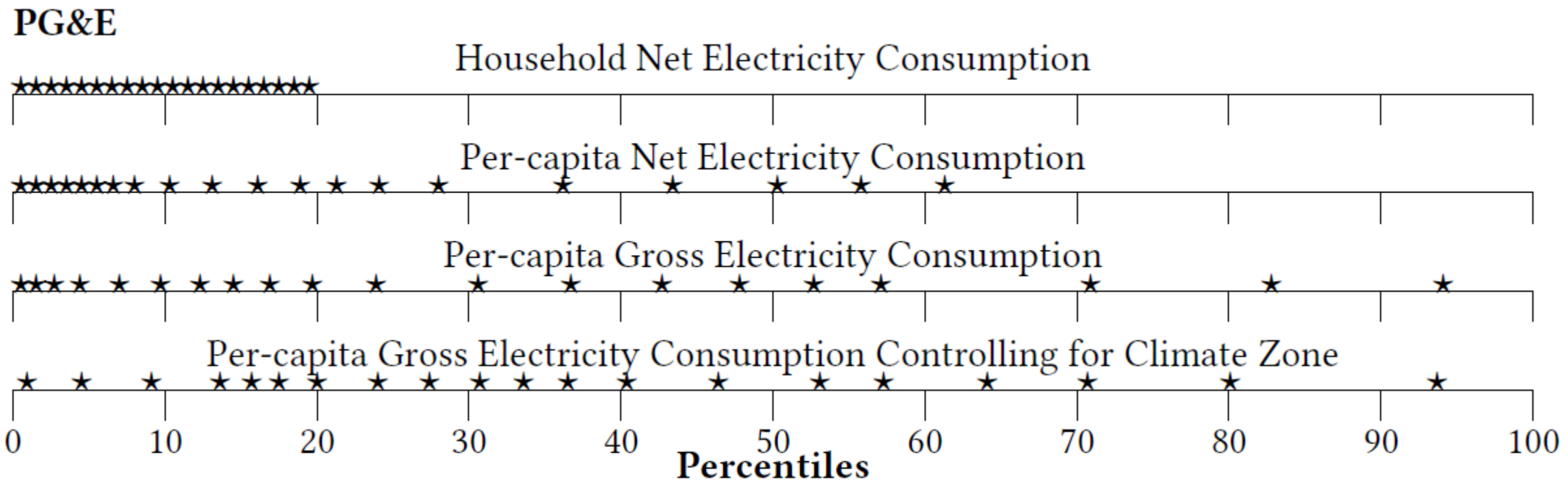
Adjusting for number of occupants, distributed generation and climate



What about the Energy Angels?

- Same analysis starting from the households in the lowest decile of net energy consumption

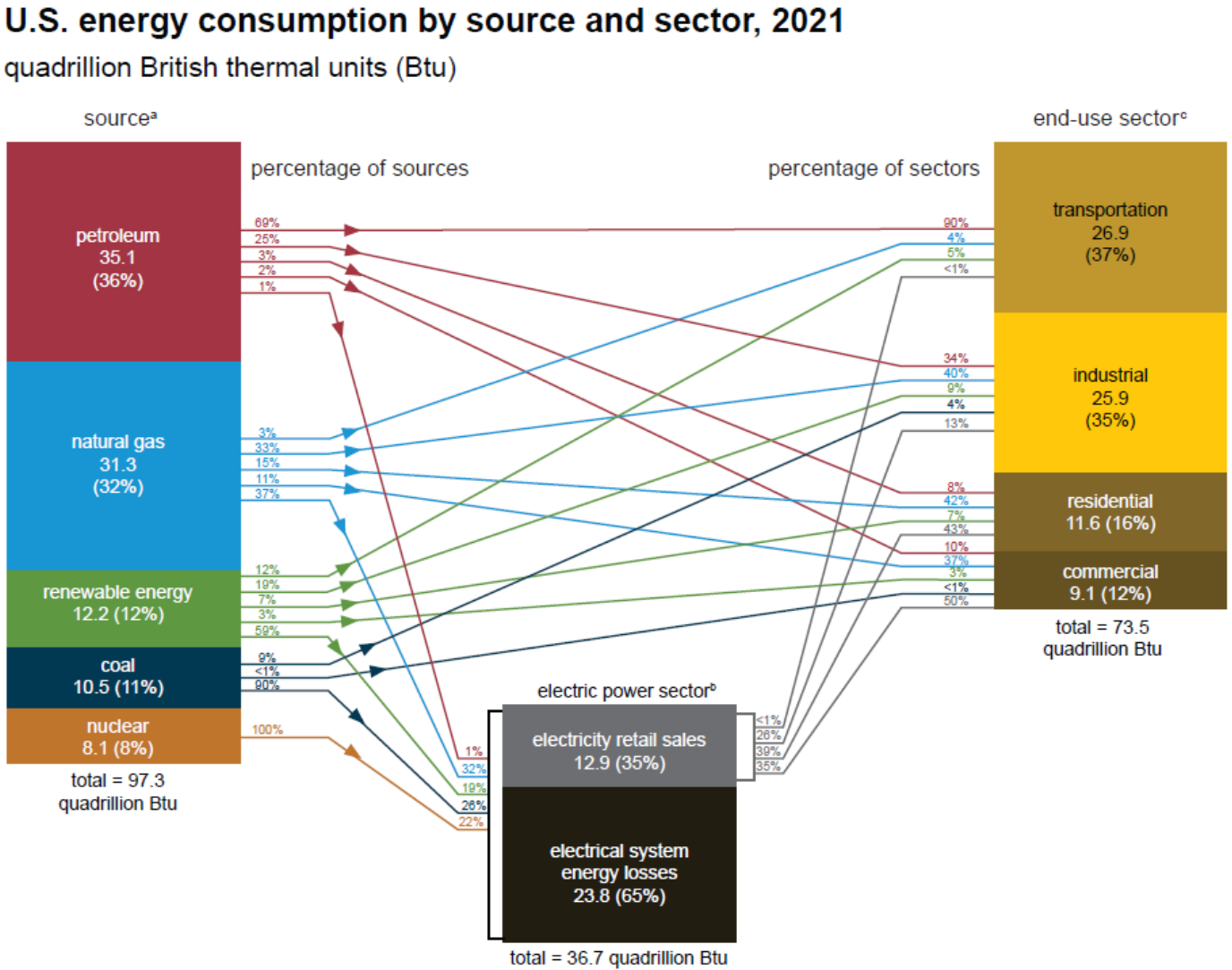
Location of Energy Angels in Overall Distribution of Electricity Consumption



Implications for residential rate design

- Overall about 3/4 of the difference in usage between the top half of household consumers and the bottom half disappears when adjusting for number of occupants, rooftop solar, and climate differences
  - The hogs (and angels) aren't that different from the rest of us
- Categorizing "hogs" and "angels" without adjusting for these factors
  - Overstates share of low-income households among the "hogs"
  - Overstates share of Latinx households among the "hogs"
  - Overstates share of White households among the "angels"
- Using a smaller national sample, my research shows the same issue nationwide: most hog/angel differences are not due to profligate/conscientious usage decisions

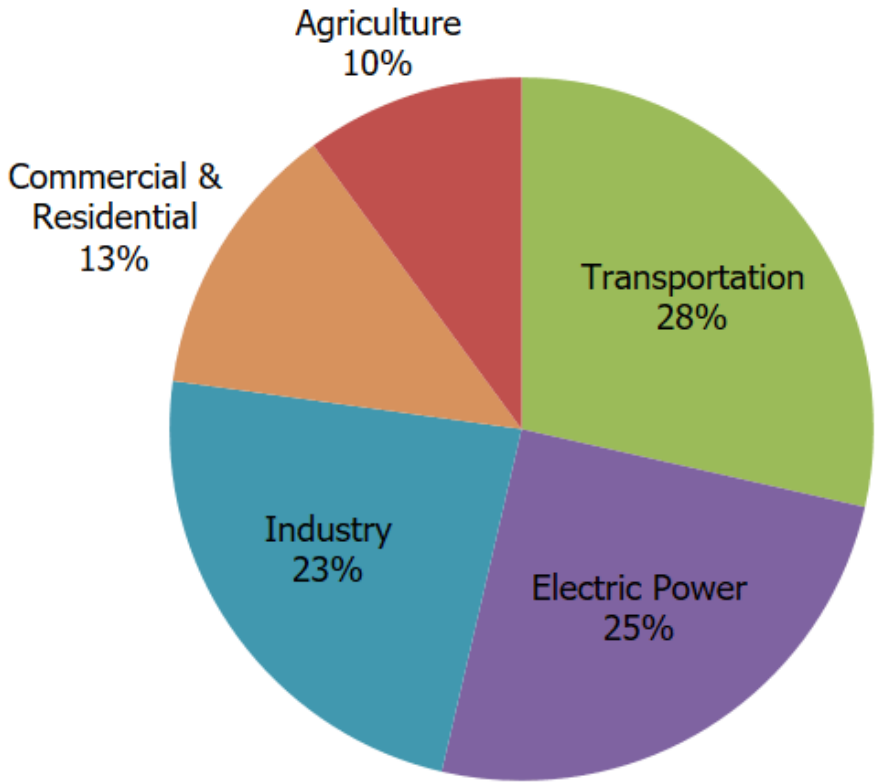
Besides, if we really care about energy hogs and angels, aren't we thinking too small?



- Residential electricity is (36.7/97.3)*39% = 15% of US primary energy use
- What about the other 85%?
  - All part of final consumption
    - air/vehicle transport
    - goods production
    - housing
    - services
  - None of it subject to penalty pricing or energy hoggyness judgements

But is energy the right concern at all? Isn't pollution/GHG emissions the problem?

- **Total U.S. Greenhouse Gas Emissions by Economic Sector in 2021**



- Residential electricity is 25%*39% = 10% of US GHG emissions
- And probably a much smaller share of damage from local pollutants, at least in California
- What about the other 90% or more?

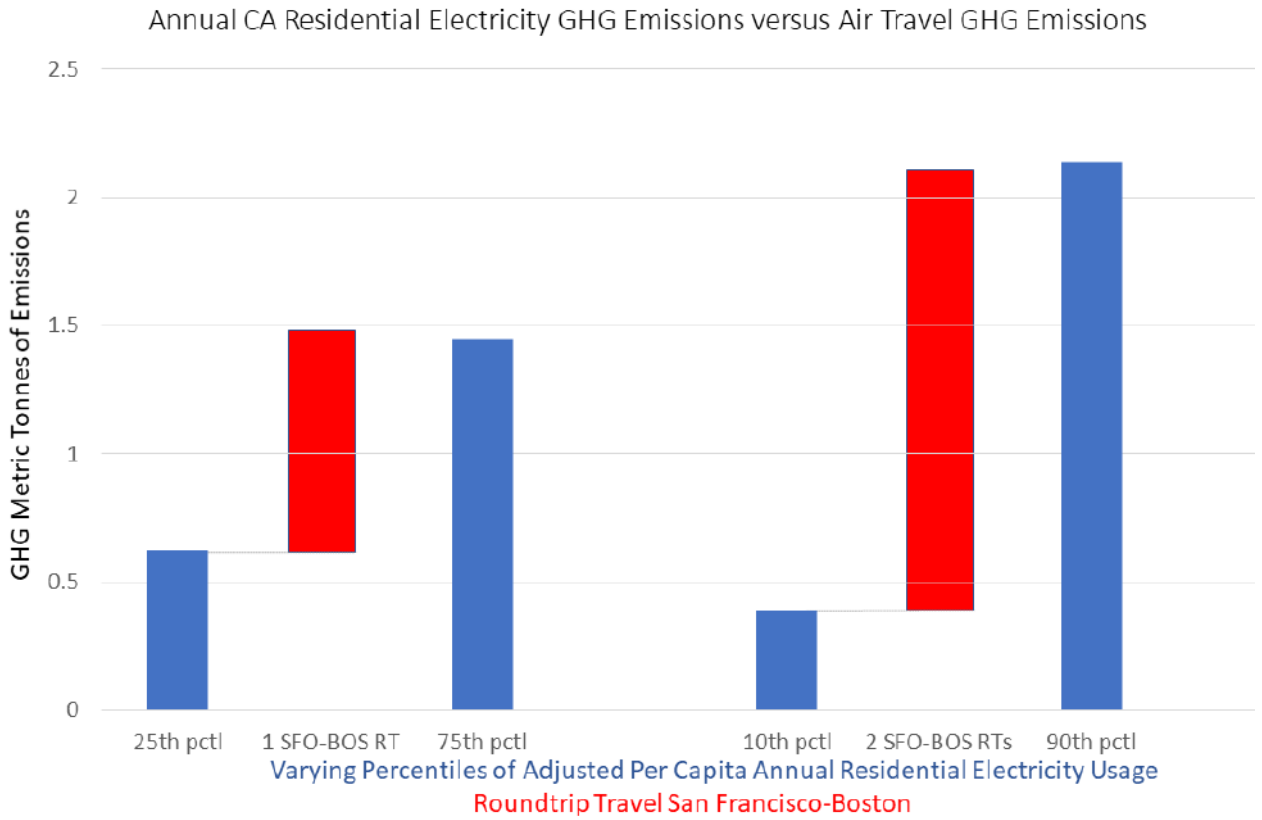
A final thought for context

- After controlling for the non-hoggy causes of household electricity consumption, the difference between 25th and 75th percentile consumption in per-capita gross consumption is 2058 kWh per year
  - At 0.4 tonnes of GHG per MWh marginal emissions rate, that's a 0.82 tonnes difference

- The US domestic airline industry averages about 63 passenger-miles per gallon of jet fuel (in 2021) and emits about 0.01 tonnes of GHG per gallon

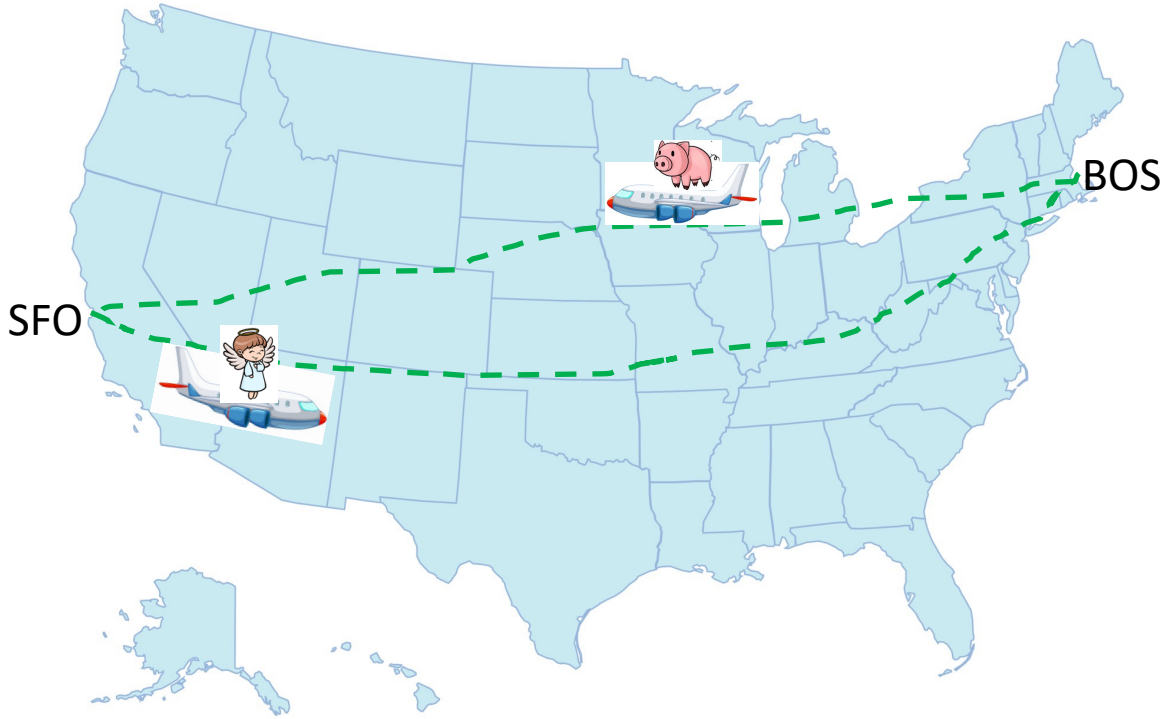
- So, doing a little arithmetic ….

A final thought for context



- One 5400-mile round trip from San Francisco to Boston creates about 0.86 tonnes of GHG, more than the inter-quartile (25^{th}/75^{th}) range in emissions from California residential electricity
  - Two trans-continental round trips create about the same GHG as the $10/90^{th}$ range in per capita electricity emissions (4372 kWh/year, 1.72 tonnes GHG/year)

Thank You!



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