Energy Hogs and Energy Angels: What Does Residential Electricity Usage Really Tell Us About Profligate Consumption?

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Residential electricity prices in the US are often set with the goal of rewarding low usage and shifting the revenue burden more toward high-usage households. This is evident in increasing-block pricing (under which the marginal rate per kilowatt-hour increases with monthly usage) and in collecting relatively low fixed monthly charges while setting volumetric (per-kilowatt-hour) prices well above the marginal cost of incremental supply (Kahn, 1988). California is an extreme case, with the investor-owned utilities collecting virtually no fixed charges and setting volumetric prices at least 2-3 times higher than social marginal cost (SMC, inclusive of the damages from emissions) and rising rapidly (Borenstein, Fowlie and Sallee, 2022; Elmallah, Brockway and Callaway, 2022; CPUC, 2021).

Some justify a high volumetric price on conservation grounds, although it is inefficient in places where price is already above SMC, as in much of the US (Borenstein and Bushnell, 2022*a*). Others appeal to distributional concerns, premised on wealthier households buying more electricity on average. However, the correlation is becoming weaker over time—especially with adoption of rooftop solar disproportionately by wealthier households—and revenue collection through rates for non-marginal costs is far more regressive than income taxation or even sales taxes (Borenstein, Fowlie and Sallee, 2022). A third justification is that large consumers are more profligate in their use of electricity, and therefore it is appropriate to require them to pay more towards system fixed costs and state policies that are financed out of electricity rates.[1]

In this paper, I focus on this third, equity-based argument, that high net electricity demand by a household is a useful indicator of less careful or efficient usage, where *net* refers to the fact that nearly all US homes with rooftop solar generation are billed based on total consumption minus the generation from their solar system.[2] While it is difficult to know whether a customer is consuming electricity for uses that provide low social or private value, *i.e.,* whether the customer's usage is wasteful or imprudent, it is more straightforward to ask how much of the variation across households is associated with factors that most policymakers would agree are *not* profligate.

For instance, households with many occupants will use more electricity, but most policymakers would recognize that more occupants in a dwelling typically make it more efficient on a per capita usage basis. Likewise, installing rooftop solar doesn't address the prudence of a household's electricity consumption any more than if they

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[1] See Borenstein (2025) for examples of this view from policymakers, NGOs, and industry leaders.

[2] California modified this "net metering" policy in April 2023, but virtually all homes that installed solar before 2024 remain under net metering.

installed a diesel generator. I also consider the climate in which the household is located. The idea is that these factors play some role in household electricity consumption, but are generally not viewed as drivers of usage that merit disapproval or penalty. The analysis is not intended to reach causal conclusions, but rather to point out that judging the appropriateness of consumption yields very different results when viewed at the individual level, without netting out rooftop generation, and with recognition of the impact of local climate on demand.

Overall, I find that about 60% to 90% of the difference in consumption between heavier users and lighter users is not present after adjusting for these factors that are unrelated to prudent usage. Furthermore, statistics on economy-wide energy flows demonstrate that a household's electricity usage is a very small part of their total energy impact or greenhouse gas (GHG) emissions. Therefore, singling out household electricity consumption for disapproval or penalty seems misguided, particularly considering that most of this variation is absent when viewed on the basis of per capita total consumption within a local climate.

I. How Residential Rate Design Penalizes Heavy Usage

Residential electricity rates are structured in two ways that cause some customers to pay more than others in excess of the social marginal cost of serving them. First, for more than one-third of US households, heavy usage is penalized by increasing-block pricing.[3]

Less obvious, but likely more widespread, heavy users are penalized through volumetric rates that are above social marginal cost, even when they do not vary with usage. Setting volumetric price equal to social marginal cost (SMC) is economically efficient,[4] but two factors frequently lead to prices above SMC. First, transmission and distribution services are natural monopolies, which implies that marginal cost is below average cost.[5] Second, states frequently use volumetric electricity rates to fund energy policies that are not intrinsic to operation of the electric utility, such as energy efficiency programs, subsidies for low income customers and rooftop solar adopters, and R&D on new energy technologies. Offsetting these factors, utilities generally are responsible for negative pollution externalities for which they are not required to pay. The net impact depends on the gap between price and private marginal cost, and the damage from unpriced externalities.

Few people would disagree with the assertion that raising the retail price of electricity to fund public schools, for example, penalizes heavy electricity users. Similarly, funding activities that are only indirectly related to a household's consumption of electricity allocates the burden of those policies across households based on their consumption, essentially a tax on electricity consumption.

II. Data

The primary dataset I use is the 2019 Residential Appliance Saturation Survey (RASS) created by the California Energy Commission.[6] This dataset incorporates responses from about 40,000 households in California. I focus on approximately 32,000 customers who are individually-metered and reside in the service territories of the three large California investor-owned electricity utilities, Pacific Gas & Electric (PG&E), Southern California Edison (SCE), and San Diego Gas & Electric (SDG&E). The survey includes utility-verified information on location, annual electricity and natural gas usage, and dis-

[3] Borenstein and Bushnell (2022*a*).

[4] This statement is strictly true only if all other goods in the economy are priced efficiently. Borenstein and Bushnell (2022*b*) finds that two of the most important substitutes for electricity—natural gas and gasoline—are also mispriced. At even a social cost of carbon of $100 per metric tonne, gasoline is underpriced nearly everywhere in the US, and natural gas is underpriced in most of the US, implying that the optimal price of electricity is likely to be below SMC. See Davis and Sallee (2020).

[5] For a more detailed discussion of the implications of natural monopoly, see Kahn (1988).

[6] https://www.energy.ca.gov/data-reports/surveys/2019-residential-appliance-saturation-study

tributed generation at the residence, as well as extensive household demographic information, appliance ownership and other variables. I use the RASS sample weights calculated to match the overall population demographics of the utility service territory.[7] The RASS data are augmented using data from Borenstein, Fowlie and Sallee (2022) that matches each responding household to utility billing data. This allows more precise estimation of rooftop solar generation for those who have installed it, and creates a consistent household consumption data series for nearly all responding households.

Further details on the construction of individual variables are available in Borenstein (2025).

III. What drives net electricity consumption?

There are many reasons a household may consume high quantities of electricity that very few would argue suggests excessive or profligate use. The most obvious reason is that households include differing numbers of individuals. By focusing on usage at the household level, electricity pricing favors individuals living alone, while penalizing large families or groups living together. This is particularly problematic, because living alone is likely to be the most resource-intensive form of housing. In addition, the climate of the household's location will drive heating and cooling demand and thus electricity demand. Finally, a large and increasing source of differentiation across homes in net electricity use is whether they have adopted distributed solar generation. Installing solar does not directly lower one's electricity usage or make it more prudent. In practice, rooftop solar operates as part of the grid supply.

The question that I pursue in the remainder of this section is how adjusting for these factors that are unrelated to the prudence of consumption changes how one might view households that have often been tagged as "energy hogs" in policy discussions. And, conversely, how such adjustments change the relative consumption of "energy angels", those who have particularly low net household electricity use. I begin by adjusting for the number of occupants, comparing net household electricity usage to net per capita electricity usage.[8]

Next, in order to observe actual usage unobscured by on-site generation, I add back in estimated distributed solar generation for those customers who have installed solar, yielding gross per capita electricity usage. Correction for local climate is done with a regression of gross per capita electricity usage on climate zone fixed effects and taking the residuals as the variation in usage that is not driven by climate. Such a regression approach is imperfect, because the regressors could be correlated with omitted variables that some may see as indicative of consumption prudence, such as if people who live in hotter climates are likely to have more efficient air conditioners. The RASS, however, does not include data on appliance efficiency and, in any case, does not have information on household *behavior* in energy consumption.

Each set of results is presented separately for the three investor-owned utilities, PG&E, SCE, and SDG&E. Borenstein (2025) presents the details of the empirical analysis, and additional analysis that controls for share of occupants who are children or senior citizens, year-round occupancy of the house, occupants working from home, and choice of electric versus natural gas appliances. These factors significantly affect consumption, but have small relative effects on high versus low consuming households.

A. *The impact of adjustments on relative electricity use*

Table 1 presents the ratios of average consumption of the customers who are above

[7] See 2019 California Residential Appliance Saturation Survey, Volume I: Methodology, available at https://webtools.dnv.com/CA_RASS/Uploads/CEC-200-2021-005-MTHLGY.pdf

[8] An alternative approach some have suggested is setting baseline consumption levels for households with different numbers of occupants based on the average usage of all households of the same size. However, that would result in zero credit/penalty on average for households with any given number of occupants.

Table 1—Ratio of Average Consumption of Above-median vs Below-median Net Consumption Households

Utility	PG&E	SCE	SDG&E
Net Household Consumption	3.08	2.68	3.11
Net Per Capita Consumption	2.31	2.04	2.23
Gross Per Capita Consumption	1.83	1.85	1.46
+ control for Climate Zone	1.53	1.69	1.40

Note: This table presents the ratio of the average consumption of households whose net consumption is above the median of all households of the utility in the RASS to the average consumption of households whose net consumption is below the median. The top line shows the ratio of average net household consumption. The second line shows the ratio of average net per capita consumption. The third line shows the ratio of average gross (after estimated distributed solar generation is added back in) per capita consumption. The fourth line shows the ratio when also controlling for differences in average consumption across climate zones, as explained in the text.

the median in net household consumption to those who are below the median in net household consumption, and how ratios change with these adjustments.

The top row of Table 1 shows that the average consumption of PG&E residential customers who are above the median in net household consumption is 3.08 times higher than the average consumption of PG&E customers who are below the median in net household consumption. The second row shows that the ratio of consumption between those same households drops to 2.31 when calculated on a per capita basis. And the third row shows that the ratio drops to 1.83 when distributed solar generation is included. The ratio drops to 1.53 when controls for climate zone are also included. Put differently, the results for PG&E show that customers who are above median in net household consumption use 208% more electricity than customers who are below median, but expressed as per capita consumption, adjusted for distributed solar generation, and controlling for climate zone, they consume 53% more. That is, about 74% of the difference between households that are above median and those that are below median in net household consumption is absent when viewed on a per capita basis and adjusted for distributed solar generation and climate. The share attributed to these three factors is somewhat smaller for SCE customers (59%) and somewhat larger for SDG&E customers (81%).

Borenstein (2025) shows that the relative magnitudes of these adjustments are not substantially affected by the order in which they are made. Number of household occupants and rooftop solar adjustments have much larger impacts than climate or household demographics. That analysis also demonstrates that the impact of these three factors is robust to examining the median consumption of above-median versus below-median households or focusing on the ratio of the top 20% of household consumers versus the bottom 20%.

B. The Demographics of Hogs and Angels

These adjustments affect not only the average differential between high-consuming and low-consuming households, but also which households that fall into each category. Table 2 presents the changes for the three demographic designations that are most affected by these adjustments. Due to space constraints, results are shown only for PG&E, but results for the other utilities in Borenstein (2025) show a similar pattern. Designating high-consuming and low-consuming electricity housesholds without making these adjustments very substantially under-represents low-income and Latinx households among the "angels" and over-represents them among the "hogs", while overstating share of angel household who identify as white, and understating their share among those in the hog category.

C. Is California a Special Case?

The analysis here focuses on California both because its rate structure so heav-

Table 2—Demographics of "Hogs" and "Angels" Categories with Adjustments

	Low Income		White		Latinx	
PG&E	Angels	Hogs	Angels	Hogs	Angels	Hogs
Net Household Consumption	26%	26%	51%	57%	21%	19%
Net Per Capita Consumption	36%	22%	37%	70%	33%	8%
Gross Per Capita Consumption	44%	19%	30%	69%	37%	10%
+ Climate Zone	49%	18%	36%	68%	38%	10%

Note: This table presents the share of households falling into the Angels and Hogs categories (bottom 20 percentile and top 20 percentile of households) who are drawn from the demographic group, based on net household consumption (top line) and then after adjustments for each factor. Low income is based on percent of poverty guideline. See Borenstein (2025) for details of variable construction.

ily penalizes large residential consumers—no fixed charges, volumetric prices well above SMC, and the use of increasing-block pricing—and because the RASS dataset is well-suited to analyzing the differences among residential customers. Though fixed charges for residential customers are common among other utilities in the US, nationally they still average only about 10% of the total bill (Borenstein and Bushnell, 2022*a*). Beyond California, much of New York, New England, Colorado and the Southwest have retail prices well above efficient levels (Borenstein and Bushnell, 2022*b*), and increasing-block pricing is common in many of these areas.

Though no data set as rich as the RASS appears to exist on a national basis, the Department of Energy's 2020 Residential Energy Consumption Survey (RECS) provides data that allow a similar analysis, albeit with much thinner coverage of any one state, ranging from 143 observations in Delaware to 1152 in California. Using those data, I carry out a similar analysis, the details of which are reported in Borenstein (2025). The results are shown in Table 3. Adjusting for rooftop solar production has much less effect outside of California, which is not surprising given the much lower rate of solar penetration, and adjusting for climate has less effect, probably due to smaller climate variations within most states other than for California. But the impact of adjusting to per capita consumption is somewhat larger in other states. Overall, outside of California, controlling for household occupancy, climate, and rooftop solar still accounts for 61% of the difference in consumption between households above the median and households below the median.

IV. Energy Hogs and Angels in the Larger Context

Beyond the somewhat arbitrary characterization of some households as profligate and others as more careful users of residential electricity, these judgment-laden categories miss the larger context of energy use. Using data from the 2021 Energy Information Administration's energy flows summary for the US, Borenstein (2025) calculates that about 15% of US primary energy use is attributable to residential electricity consumption.[9] An even smaller share of economy-wide GHG emissions, around 10%, is the result of household electricity use.

Nearly all of the remaining energy consumption, and the resulting GHG emissions, benefit people who live in households. Yet, prices for gasoline, air travel, energy-intensive production goods, housing, food, and all of the other goods and services apart from household energy use are set by market forces. Prudence of consumption plays no role. In fact, many such goods are sold

[9] In some parts of the country, ratemaking for residential natural gas also uses the rhetoric of consumption prudence, and some use IBP, but including residential natural gas still only raises the share to 20%.

Table 3—Ratio of Average Consumption of Above-median vs Below-median Net Consumption Households

Sample Region	All US	Without CA	CA
Net Household Consumption	2.76	2.66	3.52
Net Per Capita Consumption	1.86	1.80	2.30
Gross Per Capita Consumption	1.70	1.71	1.65
+ control for climate	1.63	1.65	1.45

Note: This table presents the ratio of the average consumption of households whose net consumption is above the (weighted) state-median of households in the RECS to the average consumption of households whose net consumption is below the state-median. State-level results are aggregated by taking the weighted average where the weights are the total of the weights of households in each state. The top line shows the ratio of average net household consumption. The second line shows the ratio of average net per capita consumption. The third line shows the ratio of average gross (after estimated distributed solar generation is added back in) per capita consumption. The fourth line shows the ratio after controlling for average cooling degree days and heating degree days. Regressions for the last adjustment are shown in Borenstein (2025).

with quantity discounts or benefits to customers who consume large quantities, such as through customer loyalty programs. As a result, households whose consumption preferences tilt more towards staying at home are harmed relative to those who choose to spend a higher share of their income on travel, dining out, and consuming goods and services. It is hard to come up with an equity-grounded argument for such asymmetric treatment.

It is noteworthy, however, that residential electricity is one of a fairly small number of consumer goods for which consumption quantities are directly observable by a single delivering entity and its economic regulator, creating opportunity for burden allocation based on moral judgment, rather than cost or economic efficiency.

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