The Electric Gini: Income Redistribution through Energy Prices

By Arik Levinson and Emilson Silva

In theory, regulators concerned about inequality will deviate from efficient two-part tariffs, charging lower-than-efficient fixed monthly fees and higher-than-efficient per-kilowatt-hour prices. To quantify that relationship, we develop a measure of the redistributive extent of utility tariffs: the “electric Gini.” Utilities with higher electric Ginis shift more costs from households using relatively little electricity to households using more. In practice, US utilities whose ratepayers have more unequal incomes have higher electric Ginis. But electricity demand is only loosely correlated with income, which means that electricity prices are an indirect and ineffective policy for countering income inequality. (JEL D31, L11, L94, L98)

Electricity is a textbook high-fixed-cost, low-marginal-cost industry. Power plants and transmission lines cost billions of dollars to build, regardless of how many kilowatt hours (kWh) are generated and transmitted. Producing an extra kWh of energy costs only pennies. Consequently, an efficient way for utilities to price their electricity is to use a two-part tariff (Bonbright, Danielsen, and Kamerschen 1988). A per-kWh volumetric charge covers the marginal cost of producing an extra kWh of electricity. And a fixed monthly charge covers any remaining fixed costs of building and operating the power plant and transmission lines.

In practice in the United States, residential electricity price schedules, or tariffs, are set by politically appointed or elected regulators and differ from this simple two-part tariff in two important ways. First, in most places, the volumetric price per kWh exceeds the marginal cost of producing electricity. That is often true even if we include the external social costs of pollution. Utilities charge inefficiently high per-kWh prices.

In a second departure from efficient tariffs, more and more electric utilities are charging increasing block prices, in which the price per kWh increases stepwise...
with consumption. These tiered prices are plainly inefficient—different customers pay different marginal per-kWh prices for electricity that costs the same to produce.

Why do regulators approve nonmarginal volumetric prices? One stated reason is to protect low-income households who use less electricity (Borenstein 2012, 2016). Low users, with presumably lower incomes, pay low access fees and low per-kWh rates. High users face the higher rates associated with upper tiers of increasing block prices. The websites and mission statements of some utilities and their regulators publicize this objective explicitly. California’s Public Utilities Commission seeks to ensure that rates are “just,” New York’s Department of Public Service aims for rates that are “affordable,” and the regulators in Ohio and Wisconsin both claim to strive for rates that are “fair.” Utilities—or their regulators—trade off efficiency for distributional objectives.

We ask two questions here. First, do utilities that serve customers with more unequal incomes have price structures that do more to protect low-income households? And second, how much redistribution takes place via electricity prices?

Two immediate objections might arise. First, do electricity costs constitute a sufficiently large household expense to affect income inequality? Figure 1 plots annual electricity bills as shares of Americans’ household incomes, by income and region of the country. Households with low incomes spend from 10 to 15 percent of their incomes on electricity; richer households spend far less. So electricity expenses are large, and redistributing them could potentially affect inequality. And second, don’t regulators have more direct mechanisms for addressing inequality, such as special means-tested rates for poor, disabled, or elderly customers? They do, but many utilities deploy both tactics: means-tested rates and non-marginal-cost, increasing block rates. We ask whether, given the availability of means-tested rates, utilities also appear to design their ordinary, non-means-tested tariffs with inequality objectives in mind and whether those tariffs affect inequality.

We begin by framing the questions with some simple theory. Absent redistributive goals, a two-part tariff is efficient, as has been recognized since at least Hotelling (1938), Coase (1946), and Feldstein (1972). A utility regulator with homogenous customers who all have identical incomes would have no reason to depart from that efficient two-part tariff. Per-kWh prices can match marginal costs, and fixed monthly fees can be high enough to cover the remaining fixed costs. But if a utility’s customers have unequal incomes, a regulator might want to favor low-income ratepayers who presumably use less electricity. A regulator who can set individualized tariffs will want to set uniform per-kWh prices equal to marginal costs and monthly access fees that vary with household income. If individualized fixed monthly fees are infeasible, the regulator can favor low-income ratepayers by charging individualized per-kWh prices or by setting prices based on electricity use, as with increasing block

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2 Utilities around the world are adopting these types of increasing block prices. See Kojima and Han (2017) and Zhang et al. (2017).

3 Note that this discussion ignores dynamic time-of-day or congestion pricing, for two reasons. First, few utilities in the United States charge such real-time prices. Until recently, the necessary smart meter technology was not available, and customers currently appear resistant to its implementation. Second, and more importantly, residential electricity customers appear to ignore marginal prices anyway, focusing only on their average price per kWh (Ito 2014). So even if utilities charged dynamic prices, the primary economic consequence would likely involve equity, not efficiency.
prices, charging lower-than-efficient prices to low users and higher-than-efficient prices to high users.

To see whether electricity tariffs reflect these distributional goals, we assemble a dataset of electricity tariffs for more than 1,300 electric utilities across the United States. We use those data to construct a new measure of the redistributational nature of the tariffs—the “electric Gini” of our title. We then match those tariffs and electric Ginis to US census data on the income inequality of their ratepayers, as measured by more familiar, standard income Gini coefficients. Those income Gini coefficients are correlated with electric Ginis, even after controlling for other utility and ratepayer characteristics. Utilities serving ratepayers with less equal incomes have price schedules with more redistribution, evidence that electricity pricing has a redistributive goal.

Our second question asks how much redistribution takes place via electricity pricing. That question necessarily has two parts. By how much does the rate structure redistribute costs from low users of electricity to high users? And how much does that redistribution among users redistribute costs across incomes? Those parts can have different answers because electricity use and incomes are not perfectly correlated. Electricity use is an indirect tool for addressing income inequality.

Utilities that serve households with income Gini coefficients 0.1 points higher (on a 0-to-1 scale) have electric Ginis that are 0.03 points higher during the summer and 0.015 to 0.03 points higher during the winter. That makes the redistribution sound significant. But because income is not well correlated with electricity consumption, those electricity tariffs with high electric Ginis have little effect on underlying income inequality.
To assess the effect of electricity tariffs on inequality, we subtract monthly electric bills from a representative distribution of households’ incomes, generating “net-of-electricity” incomes. In utilities with high electric Ginis, that shrinks the net-of-electricity income inequality. In utilities with low electric Ginis, utility bills enlarge the net-of-electricity inequality. But that difference is unnoticeably small. Even comparing 2 utilities with tariffs at the extremes of the distribution of electric Ginis—2 standard deviations above and below the mean—the difference in their tariffs only alters the net-of-electric income Ginis by 0.0003. By contrast, household income Ginis differ across regions of the United States by 0.13.

Pieces of this analysis have been addressed in prior work. Borenstein and Davis (2012) show that natural gas use in the United States is weakly correlated with incomes, and so charging higher-than-efficient marginal prices is “only mildly progressive.” Borenstein (2012) poses similar questions for electricity use in California and finds only “modest” redistribution from current increasing-block tariffs. Burger et al. (2020) invert the question and ask how much more or less each income group would pay if Chicago-area electricity ratepayers were charged efficient tariffs. And Feger and Radulescu (2018) show that in one large Swiss city, electricity prices are marked up above marginal costs, in a way that implies that conservation goals dominate distributional concerns. Our analysis covers all of the United States, describes the degree to which utilities serving more unequal ratepayers charge more redistributive electricity tariffs, and measures how much redistribution those tariffs accomplish.

Our work thus has three conclusions. First, in theory, regulators concerned about income inequality can set electricity prices to meet distributional goals. Section I describes that theoretical result. Second, in practice, regulators in the United States seem to do just that—design electricity tariffs with distributional objectives. But third, because income and electricity use are only weakly correlated, the resulting redistribution of costs from low users of electricity to high users has little effect on underlying income inequities. Section II describes those empirical findings.

I. Theory: Efficiency versus Equity

Start with a general, admittedly simplistic model, in which one regulated utility serves $n$ identical households. Each representative household $i$ has welfare from electricity ($e^i$) and a numeraire good ($x^i$):

$$u(e^i, x^i).$$

Each identical household has income $w$ and a budget constraint

$$w = x^i + pe^i + t,$$

where $p$ is the price per kWh of electricity and $t$ is the fixed monthly access fee. Each household maximizes (1) subject to (2), leading to first-order conditions

$$u^i_{e}/u^i_{x} = p, \quad i = 1, \ldots, n$$
and equation (2), where \( u_x \equiv \partial u(e,x)/\partial x \) and \( u_e \equiv \partial u(e,x)/\partial e \).

Prices \( p \) and \( t \) are chosen by a utility regulator who maximizes the sum of household welfare:

\[
\sum_i u(e^i, w - t - pe^i)
\]

(substituting the household’s budget constraint in for \( x^i \)). That regulator has to ensure that the electricity producer breaks even, which means that revenues equal costs, or

\[
p \sum_i e^i + nt = c \sum_i e^i + F,
\]

where \( c \) is the marginal cost of producing electricity and \( F \) is the fixed cost. Maximizing (4) subject to (5) leads to first-order conditions

\[
u_e^i - pu_x^i + \lambda (p - c) = 0, \quad i = 1, \ldots, n,
\]

where \( \lambda \) is the Lagrange multiplier associated with constraint (5). Substituting in (3) leads to the result that

\[
c = p \quad \text{and} \quad t = F/n.
\]

The regulator should charge each identical household \( c \) for every kWh of electricity used and \( t = F/n \) for a proportional share of the fixed cost. For efficiency, the households should pay a price per kWh equal to the marginal production cost, \( c \). The fixed cost \( F \) can then be covered by the fixed monthly access fee \( t \). Economists have recognized this simple result since at least Hotelling (1938) and Coase (1946). But here, we are interested in the distributional concerns when households differ.

### A. Heterogeneous Households and Distributional Concerns

Now consider households with different incomes, \( w^i, i = 1, \ldots, n \). Begin by assuming that the regulator can charge each household a different price \( p^i \) and a different access fee \( t^i \). This allows us to characterize the first-best, efficient, welfare-maximizing tariff. Later, we analyze more realistic cases where the regulator cannot charge personalized access fees or prices. Define each household’s net income \( \hat{w}^i \) as its income minus the fixed part of its monthly electricity bill, \( t^i \). Then each household’s budget constraint is \( x^i + p^i e^i = \hat{w}^i \equiv w^i - t^i \).

Each household \( i \) takes its individual access fee \( (t^i) \) and price \( (p^i) \) as given and chooses the amount of electricity \( (e^i) \) to maximize \( u(e^i, \hat{w}^i - p^i e^i) \). A welfare-maximizing electricity regulator chooses prices \( \{p^1, \ldots, p^n, t^1, \ldots, t^n\} \) to

\(^4\)In what passes for an economic double entendre, the regulator here is “utilitarian.”

\(^5\)Unlike the standard Ramsey problem, the regulator here is endowed with a transfer instrument, which becomes important in the next section. In addition, we presume that electricity is a normal good.
maximize the sum of the indirect utilities of its customers \( \sum_{i=1}^{n} v(p^i, w^i - t^i) \), subject to the constraint that revenues cover costs:

\[
\sum_{i=1}^{n} \left[ t^i + (p^i - c)e^i(p^i, w^i - t^i) \right] = F.
\]

Using the first-order condition from this welfare maximization problem, Roy’s identity, and the Slutsky equation, we can then show that in the optimum, for all \( i, j = 1, \ldots, n, i \neq j \),

\[
p^i = p^i = c
\]

and

\[
\hat{w}^i \equiv w^i - t^i = w^j - t^j \equiv \hat{w}^j.
\]

The regulator should charge each person the same, constant per-kWh electricity price equal to the marginal production cost, \( c \), and an individualized access fee, \( t^i \), so that each person’s budget net of that access fee, \( \hat{w}^i \), is equal. (See online Appendix A for a proof.)

The results in (9) and (10) are intuitive. Given the option of individual prices and access fees, the welfare-maximizing regulator would choose uniform prices but individualized access fees. With a utilitarian goal of maximizing total welfare, the regulator should price electricity efficiently so that \( p^i = c \) for everybody and should redistribute income via the fixed access fees \( t^i \) to maximize welfare. In this simple case, where people differ only by their incomes, maximizing utility means equalizing incomes.

This setup—individualized electricity tariffs—is obviously unrealistic. The fixed access fees, \( t^i \), act as lump-sum taxes and transfers that redistribute income. Given declining marginal utility and a utilitarian objective, the regulator here uses the access fees to completely equalize incomes. That is not only politically unlikely, it is also technically impractical given that incomes differ by far more than electricity bills. Such a scheme would require confiscatory access fees for some high-income ratepayers and large access subsidies for low-income ones. As a step toward more realism, next we consider instead uniform monthly access fees, \( t \), but individualized prices, \( p^i \).

**B. Constrained Optimum: Uniform Access Fees (t) and Individualized Prices (p^i)**

Consider now the same problem as above, but with an additional constraint that the regulator cannot set individualized access fees: \( t^i = t \) for all \( i \). The regulator’s problem becomes the choice of \( \{p^1, \ldots, p^n, t\} \) to maximize welfare \( \sum_{i} v(p^i, w^i - t) \) subject to the utility’s break-even condition:

\[
t + \sum_{i}(p^i - c)e^i(p^i, w^i - t) = F.
\]
In online Appendix B, we show that the solution to this problem implies that

$$\left(12\right) \quad L^j \equiv \frac{p^j - c}{p^j} = -1 \frac{1}{\varepsilon_p^j} \left[ 1 - \left( \frac{\nu_i^v}{\sum_i \nu_i^v} \right) \left( n - \sum_i (p^i - c)e_i^\epsilon \right) \right], \quad \forall j,$$

where $L^j$ is a version of the Lerner index of monopoly power with respect to household $j$ and $\varepsilon_p^j$ is household $j$’s price elasticity of electricity demand: 

$$(\partial e^j/\partial p^j)(p/e) < 0.$$ 

The left-hand side of (12) is just the markup (or markdown) of prices relative to the marginal cost of electricity. On the right-hand side, the first term, $-1/\varepsilon_p$, is the standard Lerner index. The monopoly markup $(p^j - c)$ decreases with the demand elasticity of the monopolized good $(\varepsilon_p^j)$. In this case, the regulator cares about distributional effects, so equation (12) adjusts for each household’s share of the total marginal utility of income (the $\nu_i^v$ term) times the marginal revenue associated with incrementally raising the fixed access fee, the fraction inside the right-most bracketed term on the right side of (12). The whole term in square brackets in (12) can be positive or negative, so price $(p^j)$ can be higher or lower than marginal cost $(c)$. Since low-income customers have higher-than-average marginal utility of income, they pay prices that are lower than marginal cost, and high-income customers pay prices higher than marginal cost.

As we show empirically later, households’ electricity demands differ for many reasons aside from income. That means that in practice, varying electricity prices redistribute costs from low electricity users to high users—but not necessarily from low-income households to high-income ones. To model that distinction, we add endowments of electricity consumption to the model.

C. Solar Panels and Other Sources of Electricity Demand Heterogeneity Aside from Income

Some high-income households do not use much electricity at their billing address. Consider two high-earning spouses working long days outside their home, or a wealthy family that travels often or has a weekend home, or a homeowner with solar panels on the roof. These high-income households will purchase less electricity from the grid—at any particular address—and contribute less to per-kWh revenues of the utility, $p^i e^i$. At the same time, some low-income households use a lot of electricity. Consider a large extended family in a poorly insulated home with inefficient window air conditioners or electric space heating.

To capture this nonincome heterogeneity, we modify the model by assuming that household $i$ is endowed with $\tilde{e}^i$ units of electricity. Think of a solar roof that generates $\tilde{e}^i$ per month or a periodic vacation during which household demand declines by $\tilde{e}^i$. These electricity endowments are not necessarily related to household incomes. Household $i$’s budget constraint is then $x^i + p^i (e^i - \tilde{e}^i) = w^i - t$. Define $\tilde{w}^i$ as the household’s exogenous income, including the value of its electricity endowment and net of access fees: $\tilde{w}^i \equiv w^i + p^i \tilde{e}^i - t$. Household $i$’s net electricity demand
is $v_i(p^i, \tilde{w}^i)$, and indirect utility is $v_i(p^i, \tilde{w}^i)$. The regulator chooses $\{p^1, \ldots, p^n, t\}$ to maximize $\sum_i v_i(p^i, \tilde{w}^i)$ subject to

$$nt + \sum_i (p^i - c)e^i(p^i, \tilde{w}^i) = F.$$  

In online Appendix C, we show that the solution to this problem implies that

$$L^j \equiv p^j - c$$

$$= \frac{-1}{\left(\frac{\tilde{e}^j}{e^j} + p^j \frac{\tilde{e}_{\hat{w}}^j}{e^j \tilde{e}_{\hat{w}}^j}\right)} \left[1 - \left(\frac{\tilde{e}_{\hat{w}}^j}{\sum_i \tilde{e}_{\hat{w}}^i}\right) \left(\frac{e^j - \tilde{e}^j}{e^j}\right) \left(n - \sum_i (p^i - c) e^i_{\hat{w}}\right)\right], \forall j,$$

where again $L^j$ is a version of the Lerner index of monopoly power and $\varepsilon^j_p$ is household $j$’s price elasticity of electricity demand.

Equation (14) differs from (12) in two places. The new term in the denominator, $(\tilde{e}^j/e^j)p^j e^j_{\hat{w}}$, is a function of the ratio of $j$’s electricity endowment $\tilde{e}^j$ to its electricity demand $e^j$. We know from the Slutsky equation that the whole denominator is negative (see online Appendix C), and if electricity is a normal good ($e^j_{\hat{w}} > 0$), then the second term in that denominator is positive. So the larger is $\tilde{e}^j$ relative to $e^j$, the smaller in absolute value is the entire denominator, and the larger is the markup $p^j - c$. The regulator should mark up prices higher above costs for households with larger electricity endowments. People with solar panels or who are away from home more often should pay higher prices per kWh, for reasons related to equity, not efficiency.

The second difference between equations (14) and (12) is the term $((e^j - \tilde{e}^j)/e^j)$ inside the square brackets. That term is the share of the household’s electricity purchased from the utility. The larger that share, the more likely is the entire right-hand side to be negative, and the more likely is the optimal price charged to $j$ to be lower than marginal cost. So two conditions lead to $p^j > c$: first, if the household has low marginal utility of income, presumably because it has high income, as was discussed for equation (12), and now, second, if the household is endowed with a higher share of its electricity consumption.6

In practice, most utilities do not charge prices that differ by household income and instead charge prices that differ by usage, as with increasing block pricing. And even the few states that do have income-based electricity price subsidies—like the California Alternate Rates for Energy program, New York’s Utility Assistance Program, and Lite-up Texas—also use increasing block pricing. Thus, we next add that one final element of realism to the model.

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6 Note that if the endowed electricity $\tilde{e}^j = 0$, equation (14) collapses to equation (12).
D. Increasing Block Pricing

Consider a regulator that cannot charge prices based on income but can charge increasing block prices. To simplify as much as possible, we assume that the access fee $t = 0$. Further simplifying, we assume that an exogenous rule determines the number of households facing each of two price tiers: $n_L$ low-using customers face price $p_L$ for each kWh of electricity up to threshold quantity $q$, and $n_H$ high-using customers face price $p_H$ for each kWh above $q$.

The regulator chooses the two prices and the threshold, $\{p_L, p_H, q\}$, to maximize the sum of the indirect utilities of the customers of both types, constrained such that total revenues equal total costs. In online Appendix D, we derive the resulting three first-order conditions with respect to $p_L$, $p_H$, and $q$. We show that they can be rearranged such that

$$p_L < c < p_H,$$

that the rate at which low-demand customers are subsidized with prices below marginal cost is proportional to the size of the gap between the high and low prices, and that the marginal social rate of substitution between the high and low electricity prices is proportional to the marginal social rate of transformation between high and low prices. In other words, the rate at which $p_L$ can be lowered and $p_H$ can be raised while holding utility constant is proportional to the rate at which those two prices can be altered while holding revenue constant.

The summary so far is straightforward. If the regulator can set individualized prices and access fees, the solution is prices equal to marginal cost ($p = c$) and access fees that redistribute income to equalize marginal utility. If individualized access fees are not feasible but individualized prices are, the solution is to charge high-income households prices above marginal cost and low-income households prices below marginal cost. And if income-based prices are infeasible, the solution involves usage-based prices, like increasing block pricing, where high users pay higher prices for electricity consumed above some threshold.

The actual realizations of access fees and prices thus depend on the amount of redistribution desired, which in turn depends on the degree of income inequality among ratepayers and ratepayers’ and voters’ preferences about income inequality and the welfare of lower-income households. The efficacy of that redistribution depends on the strength of the correlation between electricity use and household incomes. In Section II, we test both propositions, asking how much the redistributive nature of US electricity prices depends on the income inequality and political preferences of utilities’ ratepayers and how much those different prices affect underlying income inequality.

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[7] Some utilities do charge zero flat fees, instead applying a minimum monthly usage that is surpassed by most ratepayers.
II. Empirics: Do Electricity Prices Respond to Income Inequality?

To study the distributional causes and consequences of electricity pricing in the United States, we start with the US Utility Rate Database (National Renewable Energy Laboratory (NREL) 2019). Those data cover 2,500 utilities, with 7,600 different tariffs. We eliminate special tariffs, and we average across tariffs that apply to different jurisdictions within a utility’s service area, such as those applying to different towns or separate rates for rural and urban customers.\(^8\)

For local population characteristics, including average household incomes and Gini coefficients of household income, we turn to the 2015 American Community Survey (US Census Bureau 2015). Those data are organized by county. We combine them with county-level party vote shares, averaged across the 2000 to 2016 presidential elections.\(^9\)

To match those county characteristics to particular utilities, we create a concordance based on zip codes. We know the zip codes served by each utility (NREL 2015), so to merge those data with the county demographic information, we need two more things: (i) the zip codes corresponding to each county and (ii) the population of each zip code. We then construct a weighted average of the county characteristics, weighted by the combined populations of the zip codes served by each utility.\(^10\) The zip code–to–county crosswalk comes from the US Department of Housing and Urban Development.\(^11\) The number of households per zip code comes from the US Census Bureau, via American Factfinder.\(^12\)

Combining these sources yields a dataset of 1,308 tariffs, 1 for each utility, matched with local population demographics.\(^13\) Those utility-specific population characteristics—incomes, income inequality, and political vote shares—are the weighted average of the characteristics of the counties served by each utility, where the weights are the populations of the zip codes served by the utility in each county.

Table 1 describes the tariffs. Because many utilities have rate structures that vary by season, we call the August rates for each utility “summer” and the January rates “winter.” A plurality of the utilities have fixed monthly fees and uniform flat rates per kWh. But 515 have a second summer tier, more than 200 others have a third, and several dozens have more than that. We merge those price data with US Energy Information Administration data that contain information about each utility’s ownership, fuel sources, and number of residential, commercial, and industrial customers. Table 2 describes five example tariffs, chosen to represent the range of pricing in the actual data. Each tariff is constructed so that if a nationwide sample of households faced those prices, their average monthly electric bill would match the true average, $107. The first representative tariff charges only a monthly fixed fee, with zero price per kWh. None of the tariffs in the data do that, but we include it here as

\(^8\) In particular, we ignore special tariffs that apply to water heaters, pumps, three-phase wiring systems, irrigation, public housing, or homes with electric cars or solar panels. We eliminate time-of-use tariffs and special tariffs for senior citizens and people with medical needs.


\(^10\) The zip codes served by each utility are at http://en.openei.org/.

\(^11\) The crosswalk from zip codes to counties is at https://www.huduser.gov/portal/datasets/usps_crosswalk.html.

\(^12\) https://data.census.gov/cedsci/ (accessed August 2017).

\(^13\) The sample creation steps are outlined in online Appendix Table E1.
one extreme. The last one on the table charges only a flat per-kWh price, with no monthly fixed fee. The middle tariff charges the average fixed monthly fee and the average per-kWh price, from Table 1. And the second and fourth represent tariffs that are 2 standard deviations more redistributive and 2 standard deviations less redistributive, respectively, using a metric to be defined shortly.

Figure 2 illustrates the example tariffs in Table 2 data by describing how electric bills would differ for customers of each, as a function of the customers’ monthly usage. The flat line at $107 is, of course, the tariff that only charges a monthly

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**Table 1—Characteristics of US Residential Electricity Bills**

<table>
<thead>
<tr>
<th>Description</th>
<th>Utilities (Average kWh)</th>
<th>Rates (Average $)</th>
<th>Thresholds (Average $)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Summer rates</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First tier</td>
<td></td>
<td>0.099</td>
<td>1,308</td>
</tr>
<tr>
<td>Second</td>
<td></td>
<td>0.105</td>
<td>685</td>
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<tr>
<td>Third</td>
<td></td>
<td>0.110</td>
<td>1,498</td>
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<tr>
<td>Fourth</td>
<td></td>
<td>0.120</td>
<td>2,129</td>
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<tr>
<td>Fifth</td>
<td></td>
<td>0.124</td>
<td>1,490</td>
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<tr>
<td>Sixth</td>
<td></td>
<td>0.085</td>
<td>1,933</td>
</tr>
<tr>
<td>Increasing block prices</td>
<td></td>
<td></td>
<td>243</td>
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<tr>
<td>Decreasing block prices</td>
<td></td>
<td></td>
<td>256</td>
</tr>
<tr>
<td><strong>Winter rates</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First tier</td>
<td></td>
<td>0.098</td>
<td>1,308</td>
</tr>
<tr>
<td>Second</td>
<td></td>
<td>0.095</td>
<td>686</td>
</tr>
<tr>
<td>Third</td>
<td></td>
<td>0.100</td>
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<tr>
<td>Fourth</td>
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<td>Fifth</td>
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<td>Sixth</td>
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<td>Decreasing block prices</td>
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<td></td>
<td>395</td>
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<tr>
<td><strong>Fixed monthly charge</strong></td>
<td></td>
<td>$14.24</td>
<td>1,257</td>
</tr>
</tbody>
</table>

*Source: US Utility Rate Database, https://openei.org/*

**Table 2—Five Example Tariffs**

<table>
<thead>
<tr>
<th>Description</th>
<th>Electric Gini (1)</th>
<th>Per-kWh charge (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed charge only</td>
<td>0</td>
<td>$0.00</td>
</tr>
<tr>
<td>Low electric Gini</td>
<td>0.245</td>
<td>8.0</td>
</tr>
<tr>
<td>Average electric Gini</td>
<td>0.303</td>
<td>9.9</td>
</tr>
<tr>
<td>High electric Gini</td>
<td>0.357</td>
<td>$0.10 up to 814 kWh, then $0.125</td>
</tr>
<tr>
<td>Per-kWh charge only</td>
<td>0.349</td>
<td>$0.114</td>
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</tbody>
</table>

*Notes: Applying the average monthly usage in the RECS data (941 kWh) to the 1,308 residential rates, the average monthly household bill would be $107, and the average electric Gini would be 0.30, with a standard deviation of 0.032. The “Average electric Gini” rates in row 3 were designed to yield the average; the “Low” rates in row 2 were designed to yield an electric Gini 2 standard deviations below that mean; the “High” rates in row 4 yield an electric Gini 2 standard deviations above the mean.*
fee. The steepest solid line through the origin depicts the tariff that only charges a per-kWh price. Our objective is to characterize the tariff differences like these across all electric utilities in the United States and see whether those differences relate to the underlying income inequality of the utilities’ ratepayers. The next step is to create a measure of the redistributive nature of the tariffs.

A. Calculating the Electric Gini

To assess how each utility’s tariff redistributes costs among ratepayers, we estimate what the hypothetical distribution of electricity bills would look like for each utility if it had customers that were representative of all US households. To construct those hypothetical bills, we use data from the RECS, a nationally representative survey of more than 12,000 households conducted in 2009 by the US Energy Information Administration. We use the 2009 RECS because it reports 24 categories of household income and 27 region descriptors, instead of the more recent 2015 RECS that reports only 8 categories of income and 10 census regions.

Note that we are not using each utility’s actual customers’ usage. The practical reason is that we do not have samples of ratepayers’ bills for 1,308 different utilities. But there’s also an analytical rationale for using the nationally representative RECS households. Utilities’ ratepayers’ actual bills differ for two reasons: (i) the utilities...
charge different tariffs, and (ii) based in part on those tariffs, the ratepayers choose different amounts of electricity. That second reason means that the bills are endogenous; ratepayers’ electricity usage will be a function of the tariffs they face. We want to focus solely on the utilities’ choice of tariff design, not the ratepayers’ choices of consumption, which is why we construct hypothetical bills based on representative ratepayers.

Those hypothetical sets of electricity bills vary across utilities based only on differences in the utilities’ rate structures. In service areas with high fixed monthly charges and low or declining per-kWh prices, households that use less electricity end up paying more on average. In service areas with low monthly charges and high or increasing per-kWh prices, the heavy users pay more.

To quantify how redistributive those rate structures are, we plot Lorenz curves for the electricity bills from each utility as if the RECS survey participants were customers of that utility. Figure 3 plots those electricity bill Lorenz curves for the five example tariffs in Table 2 and Figure 2. The upper solid line in Figure 3 plots the Lorenz curve for the tariff that contains only a fixed monthly charge. Since every household pays the same $107 per month, any given share of the population pays that same given share of total electricity bills. Hence, the Lorenz curve lies along the 45-degree line. The lower solid line in Figure 3 plots the curve for the tariff containing only a per-kWh price. It matches the national distribution of

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**Figure 3. Electricity Lorenz Curves for Example Utilities**

*Source: Calculations combining the 2009 RECS and the URDB*

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15 Jacobson et al. (2005) plot electricity consumption Lorenz curves, for different countries and regions of the United States. We are plotting the electric bill Lorenz curves, for different utilities in the United States but the same distribution of consumption.
electricity use, and because some households use more than others, it hangs below the 45-degree line.

Note that these bill Lorenz curves involve expenditures, not income, and so they have a different interpretation from standard income-inequality Lorenz curves. Along the 45-degree line in a standard Lorenz curve, all households have the same income. Lower-hanging curves are less progressive, representing more income inequality. Along the 45-degree line in Figure 3, all households pay the same for electricity regardless of their usage. Lower-hanging curves are more progressive, representing larger shares of total utility revenues coming from households that use more electricity.

Those electricity Lorenz curves can be used to calculate the electricity Gini coefficients that give this paper its title. The lower the Gini, the less progressive it is—the less it redistributes costs from low-using households to higher users. The tariff with only a fixed monthly fee lying along the 45-degree line has an electric Gini of 0. The tariff with only a per-kWh price has an electric Gini of 0.349. (See Table 2.) Across all 1,308 tariffs, the average electric Gini is 0.30, with a standard deviation of 0.032. The “Low electric Gini” tariff in row 3 of Table 2 was designed to yield an electric Gini 2 standard deviations below that average; the “High” rates in row 4 yield an electric Gini 2 standard deviations above the average.

The mission statements of utility regulators and our theoretical section above both suggest that regulators set more redistributive tariffs in places where ratepayers’ incomes are less equal. That means that we should see a positive correlation between electric Ginis and income Ginis. In the next section, we test that empirical relationship.

B. Electric Ginis and Income Inequality

Table 3 begins by regressing the electric Ginis on the household income Ginis, with no other covariates (column 2). The coefficient on that income Gini (0.40) is positive and statistically significant. That’s the fitted line in Figure 4. Utilities that serve ratepayers with more unequal incomes have more progressive electricity prices—shifting relatively more costs from low- to high-use ratepayers. We discuss the magnitude of that effect in the next section, but first, we examine other characteristics of utilities and their ratepayers that may be driving that correlation.

Peer reviews of this manuscript differed as to whether the regressions should be weighted by the number of customers, although the answer depends more on what question is being posed than on econometrics. In Table 3, we include weights. For the unweighted versions, see online Appendix Tables E3 and E4 or the working paper version of this project.
Other candidate determinants of electricity tariff progressivity are poverty and average incomes. Column 3 substitutes the share of households below the federal poverty line in place of the household income Gini. That coefficient (−0.104) is negative. Utilities serving more low-income customers redistribute less of their total cost from low to high users. In column 4, we substitute ratepayers’ average household incomes. Utilities serving higher-income ratepayers redistribute more costs from low to high users.17

Column 5 of Table 3 adds other covariates. The first measures the effect of the tax and transfer system in the state in which the utility’s ratepayers reside on the state’s income inequality. The variable is the difference in the state-level income Gini before and after taxes and transfers.18 On average, state fiscal policy reduces the income Gini by 0.065 (column 1). It would have been natural to expect states with progressive taxes and transfer policies, all else equal, to have less need for redistributive electricity prices. States where tax policy has a larger negative effect on income inequality should have lower electric Ginis. But the insignificant negative coefficient in column 5 suggests otherwise. If anything, the variable may be reflecting local tastes for redistributive policies of all flavors. States that elect liberal-leaning legislators, who enact progressive tax and transfer policies, also

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17 We do not include all three income variables—income Gini, share below the poverty line, and average income—because including the latter two provides an alternative measure of the first. Places with more people in poverty, holding average income constant, have more income inequality.

18 Calculated using the National Bureau of Economic Research TAXSIM model (Feenberg and Coutts 1993).
appoint liberal-leaning utility regulators, who similarly enact progressive electricity tariffs.¹⁹

Online Appendix Figure F1 maps the regional distribution of income Gini coefficients. Online Appendix Figure F2 maps the electric Ginis. They do not appear to be regionally correlated. And versions of column 5 with region fixed effects show similar results.

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Table 3—Summer Electricity Gini and Local Population Characteristics

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<thead>
<tr>
<th>Variables</th>
<th>Means</th>
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<td>(3)</td>
<td>(4)</td>
<td>(5)</td>
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<td>Household income Gini 2015</td>
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<td>0.290</td>
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<td>Share below poverty line</td>
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<tr>
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<td>(0.056)</td>
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<td>Average income ($10,000)</td>
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<td>0.003</td>
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<td>(0.037)</td>
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<td>(0.003)</td>
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<td>State tax/transfer effect on Gini</td>
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<td>−0.174</td>
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<td>(0.000)</td>
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<td>(0.536)</td>
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<td>(0.033)</td>
<td>(0.031)</td>
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<tr>
<td>Fraction of sales residential</td>
<td>0.453</td>
<td>−0.041</td>
<td>−0.046</td>
<td>−0.047</td>
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<td>(0.005)</td>
<td>(0.016)</td>
<td>(0.016)</td>
<td>(0.016)</td>
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<td>Res. customers (mill.)</td>
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<td>0.001</td>
<td>−0.001</td>
<td>−0.003</td>
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<td></td>
<td>(0.006)</td>
<td>(0.003)</td>
<td>(0.003)</td>
<td>(0.002)</td>
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<tr>
<td>Average electricity price ($/kWh)</td>
<td>0.107</td>
<td>0.075</td>
<td>0.069</td>
<td>0.050</td>
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<td>(0.071)</td>
<td>(0.068)</td>
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<td>Investor-owned utility</td>
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<td>0.015</td>
<td>0.017</td>
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<td>Cooperative</td>
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<td>(0.005)</td>
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<td>Has a means-tested rate</td>
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<td>−0.007</td>
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<td>Noncompliance with National Ambient Air Quality Standards</td>
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<td>(0.000)</td>
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<td>Correlation (income, elect)</td>
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<td>−0.037</td>
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<td>(0.042)</td>
<td>(0.056)</td>
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<tr>
<td>Share electricity from gas</td>
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<tr>
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<td>(0.016)</td>
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<tr>
<td>Share electricity from nuclear</td>
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<td>−0.007</td>
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<tr>
<td></td>
<td>(0.004)</td>
<td></td>
<td>(0.017)</td>
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<tr>
<td>Share electricity from hydro</td>
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<tr>
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<td></td>
<td>(0.032)</td>
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</tr>
<tr>
<td>Share electricity from petroleum</td>
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<td>(0.249)</td>
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<td></td>
<td>0.140</td>
<td>0.340</td>
<td>0.258</td>
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<tr>
<td></td>
<td>(0.068)</td>
<td>(0.011)</td>
<td>(0.013)</td>
<td>(0.076)</td>
<td>(0.078)</td>
<td></td>
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<tr>
<td>Observations</td>
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<td>1.308</td>
<td>1.308</td>
<td>1.308</td>
<td>1.308</td>
<td>1.308</td>
<td>1.308</td>
</tr>
<tr>
<td></td>
<td>0.05</td>
<td>0.02</td>
<td>0.14</td>
<td>0.38</td>
<td>0.41</td>
<td>0.41</td>
<td>0.47</td>
</tr>
<tr>
<td>Note: Column 1 reports the means and standard deviations of all variables. All regressions are weighted by the number of ratepayers. Standard errors (in parentheses) clustered by state.</td>
<td></td>
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</tbody>
</table>
Politics, as measured by the average democratic vote share in the last five presidential elections, do not seem to matter, once we account for other local ratepayer and utility characteristics. Electricity costs, as measured by the average price (total revenues divided by kWh), do matter. Places with more expensive electricity distribute more of the costs to high users, all else equal. Utilities for which residential customers make up more of the ratepayer base (as opposed to commercial and industrial customers) have less opportunity to cross subsidize their residential rates. That may explain why electric Ginis are lower where the share of sales to residential customers is higher.

Column 6 adds three variables of particular interest. The first is a dummy for whether the utility also has a means-tested rate. About 8 percent of the utilities in our sample also have a special rate for eligible low-income ratepayers in addition to the default tariff that we are including in the regression. It would be natural to assume that utilities with means-tested rates would have less need for progressivity in the default tariffs that they charge to nonpoor ratepayers. The two policies—means-tested rates and progressive tariffs—seem like substitutes. The means-tested coefficient \((-0.006)\) suggests that that is not true. In Table 5, however, which we discuss below, we control for the share of customers on means-tested rates instead of just the presence of those rates, with a somewhat different answer.

Next, many utilities and regulators express environmental concern in their mission statements and on their web pages. And those environmental concerns are often a justification for increasing block pricing—to encourage conservation by high-demand households while protecting low users from steep price increases. So in column 6, we add a measure of local air pollution: the number of years from 2010 to 2018 that the local county violated national air quality standards for each of six criteria pollutants. The coefficient is positive but quite small. An extra year of noncompliance with respect to 1 of the 6 pollutants is associated with an increase in the electric Gini of 0.001.

The last covariate in column 6 is the correlation between household incomes and electricity use, from the 2009 RECS. If utilities or their regulators hope to favor low-income ratepayers, as opposed to low-electricity users who may or may not have low incomes, then that goal can be achieved by tariffs with high electric Ginis only if income and electricity use are correlated. In regions where the correlation is high, tariffs with high electric Ginis will favor low-income ratepayers. In regions where the correlation is low, high electric Ginis will end up granting low rates to high-income households that do not use much electricity and charging high rates to low-income households that happen to use a lot. All else equal, if the correlation between income and electricity use is higher, electricity tariffs are a better tool for redistributing income. We would expect, therefore, that the coefficient on that correlation would be positive. Instead, that coefficient \((-0.037)\) is negative.

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20 Brolinson (2019).
21 See US Environmental Protection Agency (various years).
22 See online Appendix Figure F5.
Column 7 of Table 3 adds the share of each utility’s power generated from various fuel sources as well as dummies for each of ten regions. Utilities generating more electricity from hydroelectric power plants have more redistributive tariffs. Including all those fuel shares leaves the coefficient on the income Gini coefficient almost unchanged.

Table 4 adds a measure of typical local temperatures to the regressions, on the theory that utility regulators’ concerns about income inequality will be greater if the utilities’ service areas have more demand for air conditioning and heating. In column 2, we replicate column 7 from Table 3 but add the number of cooling degree days. Places with a lot more cooling degree days per year do not have more redistributive tariffs. Column 3 adds heating degree days instead of cooling degree days and examines the winter tariffs, with the same outcome. Regulators in regions with hotter summers do not set more redistributive summer tariffs, and regulators in regions with colder winters do not set more redistributive winter tariffs. But regulators in regions with more income inequality do.

In Table 5, we explore four alternatives suggested by reviewers. Each column after the first contains a version of the regression in column 7 of Table 3. Column 2 adds the share of residential customers statewide who receive benefits from the federal Low Income Home Energy Assistance Program (LIHEAP) (2015), which finances some of the means-tested rates. In theory, that program is a policy alternative to redistributive primary tariffs, and in practice, the coefficient (−0.299) is negative. Utilities serving more customers with LIHEAP benefits have less progressive primary tariffs. But the income inequality coefficient (0.373) remains large and significant. Utilities serving more unequal populations have more redistributive default rates, regardless of how many customers are on means-tested rates. In column 3, we proxy for lifetime income inequality by including the ratio of the ninetieth to the tenth percentile of annual household expenditures, from the Consumer Expenditure Survey (Levinson and O’Brien 2019). That coefficient is positive and reduces the income Gini coefficient by a bit, but annual income inequality remains important. Column 4 adds the difference between annual cooling degree days during summer months and those during spring and fall months to capture demand-smoothing motives for increasing-price electricity tariffs. The effect is inconsequential. And finally, in column 5, we estimate a version that includes only those utilities for which there is one main residential tariff and where we haven’t averaged rates across local towns or between cities and suburbs. None of the variants in Table 5 alter the basic finding.

In the end, though, Tables 3–5 are nothing more than cross-section regressions, providing little scope for addressing potentially omitted variables other than by including as many correlates as we or reviewers can think of. Utilities serving

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23 North American Electric Reliability Corporation (NERC) regions.
24 The coal share serves as a benchmark. It is omitted from the regressions because for each utility, all the fuel shares add to one.
25 Online Appendix Table E2 repeats the exercise in Table 3 using winter electricity tariffs, with nearly identical implications, although the magnitudes are smaller.
26 A cooling degree day is the difference between the average of the daily maximum and minimum temperatures and 65°F, when that average is greater than 65°. Data from National Oceanic and Atmospheric Administration (various years) https://www.cpc.ncep.noaa.gov/products/analysis_monitoring/cdus/degree_days/.
customers with more unequal incomes, all else equal, have more redistributive tariffs. The results suggest that one motive for the tariff design is redistribution. The other question we pose here, aside from motive, is consequence. And that question is important regardless of the motive. Whatever their intent, the tariffs charged by utilities do have distributional consequences.

C. Consequences: How Much Do Electricity Prices Redistribute Income?

It seems from Tables 3–5 that electricity pricing serves a redistributive goal. Utilities whose ratepayers have more unequal incomes set prices more favorable to ratepayers who use less electricity. Figure 3 makes it seem as though that redistribution is large, because the electricity Lorenz curves differ so much across those example utilities. But electricity bills are only one part of a households’ costs, and electricity use is not perfectly correlated with income. So even though utilities
whose ratepayers have unequal incomes may favor low users, that redistribution of
costs among electricity users only redistributes income to the extent that electricity
bills are large and correlated with income.

To illustrate this point, Figure 5 plots the household electricity bills for RECS
households if they faced the example tariffs in Table 2, by decile of electricity con-
sumption. The lowest decile of users would pay $49 per month under the tariff
with the low electric Gini and $27 per month under the tariff with the high electric
Gini, or $265 less per year. At the other end of Figure 5, the highest decile of users
would pay $691 more per year under the high electric Gini tariff than under the low.
That represents a nontrivial redistribution of electricity costs from low users to high
users.

But Figure 5 characterizes the differences in electricity bills by electricity use,
not by income. To compare the effect of the different tariffs on high-income and
low-income ratepayers, Figure 6 plots the same data as Figure 5, reported by deciles
of household income rather than by electricity use. Households in the lowest income
decile would pay $132 less per year under the high electric Gini than under the low.
Households in the highest income decile would pay $144 per year more. Figure 6
makes the difference between the two tariffs appear more modest.

Why does the plot of electricity bills by consumption decile look so much more
redistributive than it does by income category? The implication is that income is not
closely correlated with consumption.

The white outlined columns in Figure 6 illustrate this last point. They plot the
electricity bills by decile if households faced a tariff that only charged a per-kWh
price with no fixed monthly charge. That captures precisely the distribution of
electricity use by income for the representative households in the RECS, and the
distribution is fairly flat. The highest-income households do use 75 percent more
electricity than the lowest-income households, but they have 10 or 20 times as much
income. Some high-income households use a small amount of electricity, and some
low-income households use a large amount. Charging low monthly rates or steeply
rising block prices ends up favoring some high-income households that do not use
very much electricity and hurting some low-income households that use a lot.

Figure 7 presents this in even starker terms. We approximate households’ incomes
by taking midpoints of the income categories in the RECS. We then calculate the
average electricity bill for households in each income category for each utility and
subtract that bill from the approximated household incomes to get net-of-electricity
incomes. Those net-of-electricity incomes differ based solely on the different utili-
ties’ tariffs. We then calculate Gini coefficients for these net-of-electricity incomes.
Figure 7 plots Lorenz curves for the two extreme example tariffs used in Figures 5
and 6: the one with the electric Gini 2 standard deviations higher than the mean
and the one 2 standard deviations lower. The tariff differences have an almost
unnoticeable effect on the distribution of net-of-electricity income. The regressive
low-electric-Gini tariff, with a high monthly fee and a low-per-kWh price, increases
the household income Gini from 0.3757 before electricity bills to 0.3775 after. The
progressive high-electric-Gini tariff also increases the net-of-electricity income
Gini, but by slightly less, to 0.3772. We need to go to the fourth decimal place to see
a difference, and it is imperceptible in Figure 7.
By contrast, Figure 8 plots the income Lorenz curves (without subtracting electricity bills) for each of the 27 geographic areas of the United States identified in the 2009 RECS. The income Gini coefficients range from 0.32 for the most equal states (Idaho, Montana, Utah, and Wyoming) to 0.45 for the least equal states.
Arkansas, Louisiana, and Oklahoma. Regions of the United States differ far more in their income inequality than any redistribution among ratepayers within utilities depicted in Figure 7.

Again, progressive electricity tariffs shift costs from low users of electricity to high users. But they do not necessarily shift costs from low-income ratepayers.
to high-income ratepayers. The reason is that income and electricity use are only weakly correlated. To illustrate that, Figure 9 plots the distribution of electricity use for the different income bins in the RECS data.\(^{27}\) High-income households do use more electricity than low-income ones; the thicker lines representing higher-income households are shifted to the right—but not by much. Many high-income households spend very little on electricity, and a lot of low-income ones pay high electric bills.\(^{28}\)

Why is the correlation between electricity and income so low? We can think of two explanations with empirical support. First, high-income households spend less time at home. People who live in households with incomes between $10,000 and $20,000 are home more than 50 percent of the time. In households with incomes above $150,000, that drops below 40 percent.\(^{29}\) Time at home cannot entirely explain why electricity and income are so uncorrelated, but it is surely part of the story.

Another part of the explanation may involve energy efficiency investments. In theory, we should expect higher-income households to insulate their homes better and to buy more efficient appliances, and in practice that is what we see (Levinson 2019). Homes occupied by higher-income residents have more insulation, better

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\(^{27}\) The idea for this figure came from Brolinson (2020), which contains a similarly drawn figure using ratepayer data from two utilities in California.

\(^{28}\) Figure 9 depicts distributions of annual averages for the whole country. That aggregation may mask some of the correlation if, for example, low-income households use more electricity for heating during winters in the Midwest, or for air conditioning during summers in the Southwest. Online Appendix Figure F3 plots a similar set of distributions of electricity use by income, but restricted only to one utility and one month’s bills: California’s Pacific Gas and Electric Company customers in August. It shows the same thing: a remarkably low correlation between electricity use and income.

\(^{29}\) Online Appendix Figure F4 plots time at home by household income, using the 2017 American Time Use Survey.
windows, more efficient lighting, and appliances that are more likely to be classified as “Energy Star” by the US Department of Energy.

III. Conclusions

Public utility regulators in the United States claim that they set electricity prices with a goal of protecting the well-being of low-income ratepayers. In theory, regulators who care about income inequality, and who cannot simply vary the fixed monthly fee on a household-by-household basis, will charge higher-than-efficient per-kWh prices and lower monthly fees.

Perhaps surprisingly, that is exactly what happens in practice. Across the United States, utilities serving customers with more unequal incomes depart more from the efficient two-part tariff, charging higher or increasing per-kWh prices and lower fixed monthly fees. Utilities appear to be doing what their mission statements claim.

Those efforts may be less than effective, however, because income and electricity consumption are so weakly correlated. When utilities redistribute income by raising per-kWh prices and lowering monthly fees, they do shift costs from low users of electricity to high users. But that does not significantly shift costs from low-income households to high-income ones. Electricity pricing is an indirect tool for addressing income inequality. Perhaps unsurprisingly, it is also not an effective tool.

REFERENCES


