# Electricity is not a Right

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Electricity courses through our lives. Yet, there are still more than a billion people worldwide who are not connected to the grid, and many more get abysmal supply, unlike the 24/7/365 flow that rich countries take for granted. We argue that these shortfalls are due to a sad irony: treating electricity as a right for the poor has limited electricity access.

How does this noble social norm defeat itself? Consider a supply-side parable from the market for ice cream. You are the proprietor of a campus ice cream parlor—the only one, as the university has granted you an exclusive license. It is hot outside and the dorms lack AC, so you hope to sell a lot of cones and turn a nice profit. The University is concerned that everyone stays cool and decides to keep ice-cream prices low. You are told that although it costs $1 to produce an ice cream, you can only charge 91 cents for each. In return you receive 73 as a subsidy from the University, so that in theory you should be able to make 64 cents (=91+73-100) in profit on each sale.

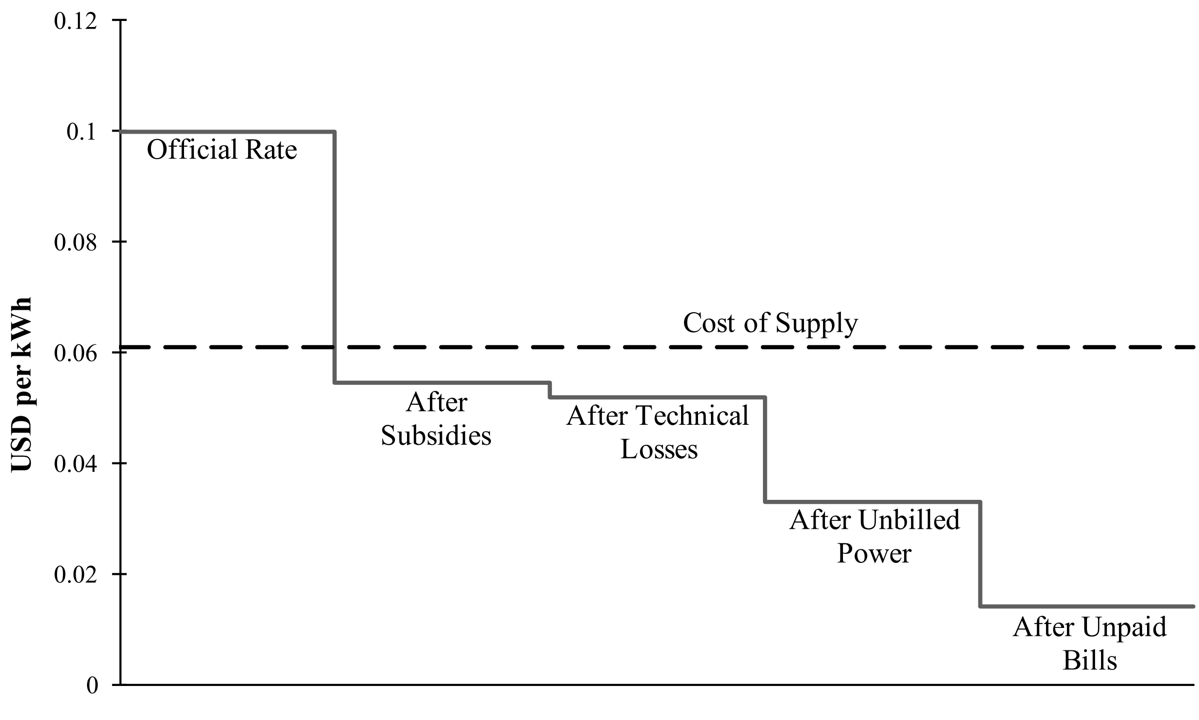
You soon run into trouble. Even with the best freezers, a small percentage of your ice cream melts on the drive from the creamery, bringing your average revenue per cone input down to 86 cents. Students jump shipments and eat ice cream for free, sometimes even sharing a scoop with the University police. You lose 2 of every 5 shipments to theft or melting, bringing revenue down to 55 cents per ice cream. Your student cashiers keep "forgetting" to charge their friends the posted prices. For every five ice creams supplied at the parlor, three go uncharged, bringing your effective revenue down to 23 cents per cone. Thanks to rampant theft and nonpayment, you end up recouping barely a third of the cost of production.

Because you only receive the 73 cent subsidy on ice cream that is *sold*, even with the university subsidy you take home just 41 cents per scoop against a $1 production cost. As a result, you are losing money and would very soon go out of business. However, by now students view ice creams as a necessity so the university, fearing student protests, decides to keep you afloat with occasional grants. You were grateful for the first grant but in bailing you out, the university only made things worse. The message to students is that ice-cream theft is not a big deal, indeed they have a right to free cones as part of the college experience. Having learned that protests not payment would get them ice cream, even fewer students bother to pay, and your revenues fall month-by-month.

Since the grants keep you afloat, the university administration becomes your only real customer. You are losing money on every ice cream sold. Although you started out imagining how to sell as many ice creams as possible, you want to sell fewer now, and you phone the creamery to cut back your orders to the bare minimum needed to meet the terms of your license. Long lines build up outside your parlor, with some students rejoicing at the occasional free cones and many others left wishing they could just buy ice-cream at the price where you could turn a profit. You decide that this is clearly not the profitable business you had hoped it would be and cancel your planned expansion.

The ice cream parable is the true story of electricity distribution companies across the developing world. The numbers from the ice cream store are proportional to the real prices and costs of electricity in Bihar, an Indian state of 100 million people (see Figure 1, replacing cones of ice cream with kilowatt-hours (kWh) of power). We argue that the social norm that electricity is a right generates losses, rationing and unmet demand for electricity, just as it does in our parable about ice cream. By "electricity as a right", we specifically refer to the social norm that all deserve power regardless of payment.

*Figure 1*
**Electricity Losses in Bihar, India**




Source: Bihar Electricity Project feeder data; Indian Ministry of Power; Bihar Electricity Regulatory Commission
Notes: The dotted line is the average cost of supplying one kWh of electricity in Bihar, including raw power, labor, and fixed costs of grid operation. The solid line shows average revenue after cumulatively accounting for various sources of electricity loss.

Given that societies wish to redistribute towards the poor, and governments do so in many domains, such as health, education and housing, why should we exempt electricity? Are not all these goods essential to each individual's development, and do they not therefore justify subsidized, public provision?

We argue that the interaction of the social norm that electricity is a right and a technological constraint makes the consequences of treating electricity as a right worse than for other private goods. The technological constraint is that it is costly to target electricity supply to particular (e.g., paying or poor) customers because almost everyone can (illegally) access the same electricity wires. The result is that electricity is not easily excludable. Social and political constraints make disconnecting consumers prohibitively costly, resulting in high levels of non-payment and theft.

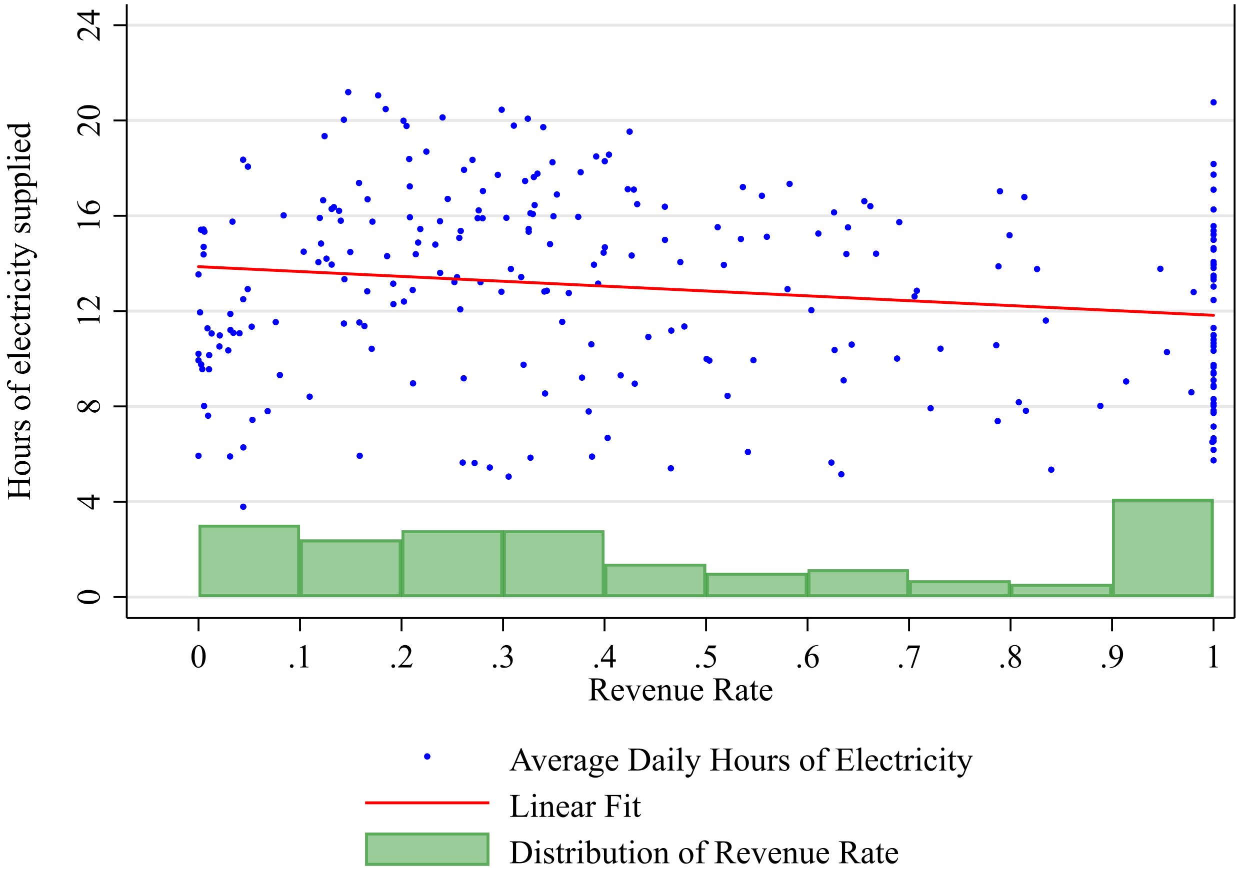
Just as in our ice cream analogy, the result of subsidies and a perceived right to service is that distribution companies incur huge losses. Although the budget constraints utilities face are often soft, because of government support or ownership, at some point they do start to bind. The utility then limits its losses by rationing supply. There is only one grid, and it becomes impossible to offer a higher quality of supply to those consumers who are willing, even desperate, to pay for it. Whole villages go dark and this is given technical terms like "load shedding" but at its core it reflects a decision by the utility to sell less. The non-payment social norm therefore implies that consumers cannot get all the electricity they are willing to pay for.

Figure 2 describes an electric utility in this equilibrium. The graph also uses data from rural Bihar, India where we have access to extraordinary administrative data based on our work there for nearly a decade. Every point represents an electricity feeder, a disaggregated level of the grid that serves about 2,500 households and businesses. The horizontal axis shows the share of expected revenue from energy pumped into the grid that is actually collected by the distribution company. The expected revenue is based on published prices. The vertical axis shows the hours of supply that each feeder receives per day.

The graph reveals three facts about how the retail electricity market works. First, supply is heavily rationed. In this sample of rural feeders, *no consumer* gets 24 hours of electricity; on average consumers receive about 12 hours a day, and some areas get only 6 hours a day. Second, payment rates are abysmal. Our revenue rate measure, the all-in ratio of revenue from customers over the value of energy injected, is smeared out along the horizontal axis. There is some mass of areas paying the full share of energy value, to the right, but more customers paying less than 0.20 share, on the left. The average revenue rate is 35% and 75% of feeders pay less than 40% of the value of energy injection. Third, and perhaps most striking, the scatter plot shows no relationship between how much supply people receive and how much they pay for the electricity they use. The solid red line of best fit is basically flat, or perhaps even slightly negative! Areas that pay for the entire cost of power get no more power than areas that pay nothing.

Think of how this graph would appear for power consumption in a developed country. Outage rates are extremely low so all areas would, to the eye, have exactly 24 hours of supply. Loss and payment rates are also low, so all areas would have a revenue rate of one. These scattered points would collapse to a single point in the northeast corner. In contrast, in Bihar the right to electricity, along with the high costs of targeting supply to select customers, has severed the link between payment and supply which underpins all markets for private goods.

*Figure 2*
**Hours of Electricity Provided in Bihar vs. Fraction of Revenue Collected**




Source: Bihar Electrification Project
Notes: This figure shows the average hours of electricity supplied to different areas each day (vertical axis) against the share of the cost of electricity that each area pays (horizontal axis) for roughly 52 feeders in north Bihar in each of 5 months before implementation of the Revenue-Linked Supply Scheme. Both variables are observed in administrative data at the level of electricity feeders serving approximately 13,000 people on average. The share of cost is calculated as the total payments for electricity divided by the procurement cost of energy injected, and so ranges between zero and one, for areas that pay none or all of their bills, respectively.

When public provision collapses in other domains, households often have good private substitutes. That cannot be the case for electricity. Electricity is a natural monopoly: average cost is decreasing for all quantities, so it is efficient to have one grid. Households do substitute, but they substitute to the equivalent of electricity autarky—off-grid diesel generators or solar panels that cost far more than grid electricity.

In the equilibrium we describe there is a pent-up demand for electricity from consumers who are *able and willing to pay for it.* The rationing of electricity, on the intensive margin of hours of supply per day, is also mirrored by the rationing of grid investment and expansion, on the extensive margin of who gets connected to the grid. Nearly a billion people in the developing world remain without access to electricity; we believe that a chunk of this number is made up of people who are effectively rationed off the grid, since the norm that electricity is a right combined with non-excludability make it money-losing to connect them in the first place.

A review of the impacts of electricity on growth is beyond the scope of this paper, however there is substantial evidence that access to reliable electricity can increase business profits, firm entry, labor productivity, and other inputs to growth (Allcott, Collard-Wexler, and O'Connell 2016, Dinkelman 2011, Kassem 2018, Fried and Lagakos 2017, Fried and Lagakos 2019). Electricity appears not only to boost output and labor supply in the short run but to raise long-run levels of productivity (Lipscomb et al 2013). Electricity is an essential input to production, consumption, communication and finance; there are no societies that have reached high living standards without consuming lots of energy. A well-intentioned "right to electricity" may therefore be a drag on economic development.

## I. A Kuznets Curve for Electricity

Two energy worlds coexist, one where consumers enjoy universal access 24 hours a day and another where many consumers are not on the grid and those who are connected suffer irregular supply. Panel A of Table 1 shows the differences in these worlds through statistics on electricity use for countries by quartiles of world income.

In some respects, the two energy worlds are only different in degree, in a way that may be taken as intrinsic to the differences in income levels between poor and rich countries. Electricity consumption in low income countries is a negligible 1% of that in the United States; inequality in electricity is larger than income inequality. All consumers in rich countries have electricity whereas only 35% do in the poorest quartile of countries. It is possible that these unconnected poor have low demand for electricity and it would lower social surplus to connect them to the grid (Lee, Miguel and Wolfram 2018). We present evidence that another reason for low access is due to electricity being treated as a right on the supply side of the market.

Other differences between the energy worlds are differences in kind that do not seem intrinsic to income. For example, transmission and distribution (T&D) losses are about four times higher in the poorest quartile of countries as in the richest (22.8% versus 6.1%). The technologies used for distribution are largely the same everywhere; though the levels of investment or structure of the distribution network may be different, there is no way to justify a four-fold difference in losses on technical grounds alone.

Poor countries also price power below cost. Table 1, Panel B shows that in the poorest quartile of countries utilities pay a mean power purchase cost of 6.4 cents per kWh and charge customers 3.6 cents per kWh for the same power. If we inflate power purchase costs by T&D losses, since utilities have to buy more input power to make up for the power they lose, then the input cost is 7.8 cents per kWh. Thus the average utility in a poor country makes 46 cents per dollar of input cost and this calculation excludes the non-energy variable costs of distribution and commercial losses from power billed but not paid for. Utilities in the second quartile of income also price power below cost (second column) but we do not see the same difference in rich countries (fourth column). At the top of the income distribution, the average price is roughly three times higher than the average power purchase cost (18.8 cents relative to 6.6 cents per kWh).

The last row of Table 1, which gives the difference between the average price the utility is paid and the average amount it must pay to generators, is therefore an upper bound on utility profit per kWh. The difference is negative for low and lower-middle income countries, suggesting that *utilities in poorer countries do not cover the raw costs of power acquired from generators*. Utilities in these income brackets are therefore unprofitable and must be supported by government subsidies and grants. Including commercial losses, power that is billed but not paid for, would further inflate these losses, as we have shown in Bihar.

We say that these differences are not intrinsic to poverty because it is clearly possible that poorer countries would manage well-run grids, with limited subsidies, where electricity was not lost and people just used little due to low demand for electricity at low incomes. But that is not the case—people do use little, but losses are high. The average price shown in Panel B is also lower in these countries, in large part due to subsidies, further increasing the gap between costs and revenues. In poor countries, therefore, utilities lose money on every unit they sell.

*Table 1*
**Key Electricity Summary Statistics, by Income Level**

| **Quartile** | Lowest | Lower-middle | Upper-middle | Highest |
|---|---|---|---|---|
| **Panel A: World Electricity Overview** | | | | |
| Population (millions) | 619 | 2,972 | 2,568 | 1,165 |
| GDP per capita in 2016 (% of US) | 2.9 | 10.7 | 26.7 | 79.8 |
| Electricity consumption per capita (% of US) | 1.1 | 5.9 | 27.2 | 69.9 |
| Connection to Grid (%) | 34.9 | 83.6 | 99.4 | 100.0 |
| T&D Loss (%) | 22.8 | 16.2 | 9.6 | 6.1 |
| Firm losses due to outages (% of output) | 8.7 | 6.6 | 2.1 | 1.6 |
| **Panel B: Pricing in Selected Countries** | | | | |
| Mean consumption of electrified households (kWh) | 98 | 103 | 162 | 574 |
| Mean price at mean consumption level (US cents/kWH) | 3.6 | 6.3 | 7.6 | 18.8 |
| Mean power purchase cost (US cents/kWH) | 6.4 | 7.2 | 6.6 | 6.2 |
| Power purchase cost after T&D loss adjustment (US cents/kWH) | 7.8 | 8.3 | 7.5 | 6.6 |
| Mean price less adj. power purchase cost (US cents/kWH) | -4.2 | -2.0 | 0.1 | 12.2 |

Source: World Bank, IEA, World Energy Council, country sources

Notes: This table shows electricity variables for four income categories of countries, using the 2018 World Bank thresholds of 2016 GNI per capita of ($1,005; $3,955; $12,235). Panel A displays population-weighted averages for all countries in each income category. In Panel B the sample consists of the ten largest countries worldwide by population as well as the three most populous in each WB income category: Ethiopia, DR Congo, and Tanzania (lowest); Bangladesh, India, Indonesia, Nigeria, Pakistan, and the Philippines (lower-middle); Brazil, China, Mexico, and Russia (upper-middle); and France, Japan, and the United States (highest). In Panel B, the first row is an unweighted average across selected countries. In other rows, average prices and costs are weighted by utility customers for the three largest utilities within selected countries, and unweighted across selected countries. The individual country sources include government statistics websites and specific utilities' websites.

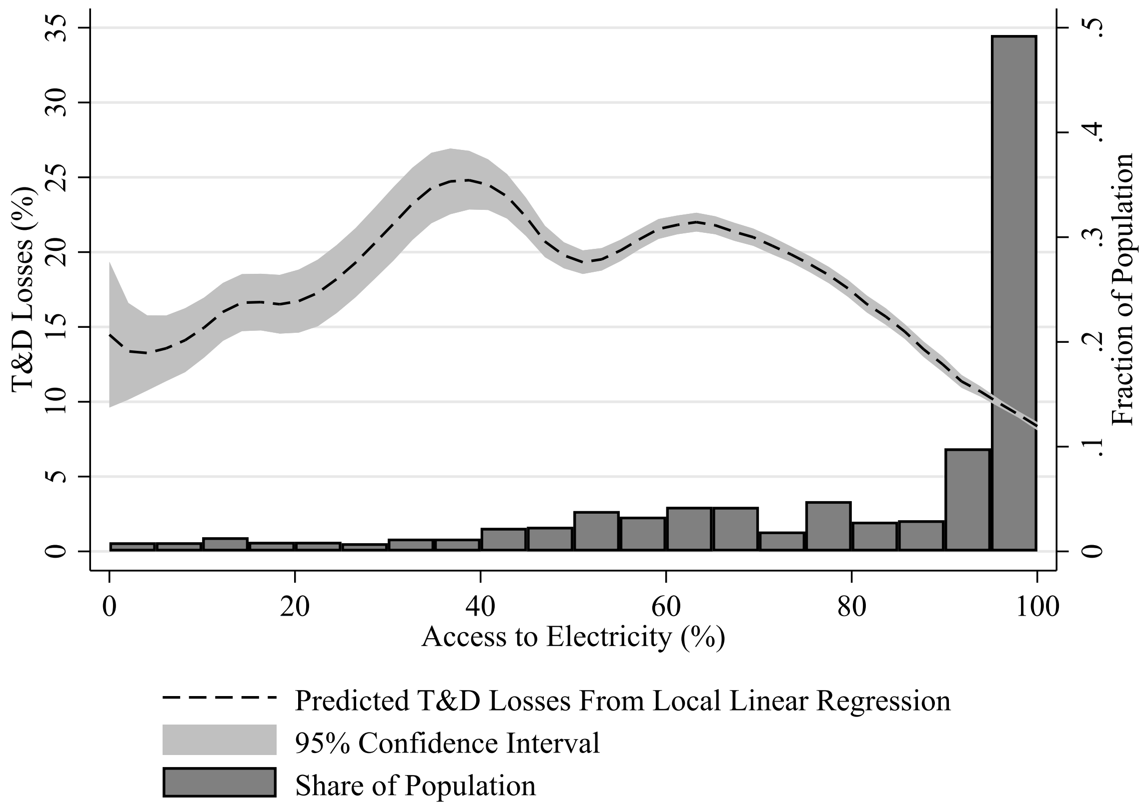
For the poorest quartile of countries, an implication of losing money on electricity supply is that expanding access will increase losses. To test this idea, we consider the evolution across countries of transmission and distribution (T&D) losses, as a proxy for power theft. T&D loss is the share of power generated that goes unbilled (as opposed to commercial losses, which are power billed, but not paid for). A small amount of power (around 5 to 10%) is lost for unavoidable technical reasons (line losses). Losses much above this level come from hooking onto distribution wires, unmetered power, meter tampering, or other forms of theft. To understand how T&D losses vary with electricity access, we plot T&D losses against percent access to electricity (the share of the population with a grid connection) from 1990-2014 for all countries with available data, and fit a nonparametric regression. Data from 142 countries are included with 125 of these countries having non-missing data in all 25 years.

Figure 3 plots the result, an inverse-U shape where losses rise and then fall in access. For countries in years where access is very low, T&D losses are high, but losses actually increase further as access expands before falling again as access approaches 100%. This means that countries which are trying to expand distribution (for example, into the countryside) face the highest rates of nonpayment for electricity. At the peak of the curve, countries with about 40% access to electricity lose 25% of their power before it is billed to any consumer.[1] T&D losses have an economic interpretation, not just a technical one. A 33% T&D loss rate implies the utility is giving away 1 in 3 units of electricity for free – in other words, the effective cost per kWh sold increases by 50%. Many states in Nigeria and India, among other places, exhibit T&D losses at least this high (UDAY 2019, NERC 2019). The fact that each new consumer adds a loss serves as a disincentive to expand access. Losses decline as repayment norms are established and enforced for richer countries at higher levels of access.

We call the inverse-U relationship in Figure 3 an electricity Kuznets curve. Much like the original Kuznets curve that documents an increase and subsequent decrease in inequality as a function of income, distribution companies see losses initially increase as we move up from low levels of access and then decline as access becomes more widespread. Because electricity distribution is loss-making, initial efforts by the government to reach more of the population lead to higher losses.

[1] Assuming technical losses make up 5% of the total, at least 20% of electricity is lost to consumers hooking into power lines, tampering with meters, or otherwise using power before a bill can be issued to someone.

*Figure 3*
**Access to Electricity and Transmission and Distribution (T&D) Losses**




Source: World Bank
Notes: Each point represents one country and year, for all 142 countries and years from 1990-2014 for which data are available. The local linear regression and histogram of access to electricity are both weighted by country population. T&D losses are defined as the percent of electricity generated by all power sources (in kWh) that is not billed to any consumer. Access data was originally gathered from household surveys and T&D data are originally from national energy agencies.

## II. A Model to Explain Rationing

In this section we examine the mechanism by which the treatment of electricity as a right and its non-excludability causes utilities to ration supply (see Figure 4). Consider the case of two types of consumers, H (the rich) and L (the poor). The demand curve of the H type is labeled H. The demand curve for the L type is denoted by $L^{PMWTP}$, which reflects their private marginal willingness to pay. The treatment of electricity as a right means that society values each unit of consumption by the poor above their own willingness to pay, which could be for a variety of reasons, including because the state finds it dignified that the poor have light in their homes, or due to market failures like credit constraints that limit the poor's ability to pay their full private valuation. This is reflected by $L^{SWTP}$, which represents societal willingness-to-pay of L consumers, lying above $L^{PMWTP}$. Indeed, the idea that social WTP is above private WTP—i.e., ability to pay—is a motivation for why public provision exists in the first place (Banerjee 1997).

At marginal cost MC the efficient quantities of consumption are $A_L$ and $A_H$. If the state set price this high, L consumers would only consume at $A_L$[2], generating a deadweight loss, relative to the social optimum that is determined by $L^{SWTP}$.; this deadweight loss is denoted by the grey triangle in the figure and labeled as L surplus lost. Marginal cost pricing fails to deliver the social optimum here, because society places a value on L consumers consumption that is over and above their own valuation. The state therefore sets a lower price, $P^{listed}$, which is below marginal cost to encourage additional consumption. At this price, the L types, whose consumption is valued by the state, would increase consumption to $B_{L,\ listed}$. The state would lose (MC – $P^{listed}$ ) $B_{L,\ listed}$ in subsidies but the poor consume closer to the efficient quantity.

But subsidies are not only explicit. The combination of the social norm that electricity is a right and the costs of making electricity excludable limit the ability of the state to collect revenue. The *effective* price that consumers face is therefore much lower, at $P^{Effective}$, and the poor consume $B_L$ at this lower price. The state makes a larger loss of (MC - $P^{Effective}$ ) $B_L$, but the poor consume even closer to the efficient quantity (i.e., $B_L$ is closer to $A_L$ than $B_{L,\ listed}$).

Now if this price were applied to both types, rich consumers would use "too much" and consume at point $B_H$. The loss associated with serving these consumers is larger than the loss from serving L types because the H types are richer and consume so much more. Furthermore, the state does not value the excess of their consumption over the efficient level and would makes enormous losses of (MC - $P^{Effective}$ ) $B_H$ on their supply.

One solution to this problem might be to use block-rate tariffs in which case rich and poor consumers do not face the same marginal price. The trouble is that the high costs of making electricity excludable, combined with widespread non-payment inevitably arising from the social norm, mean that in practice, the state is not able to price discriminate between H and L types. Therefore, the effective price is indeed low for everyone; we provide some empirical evidence for this assumption in Figure 6 where we show that non-payment rates are independent of consumption levels.

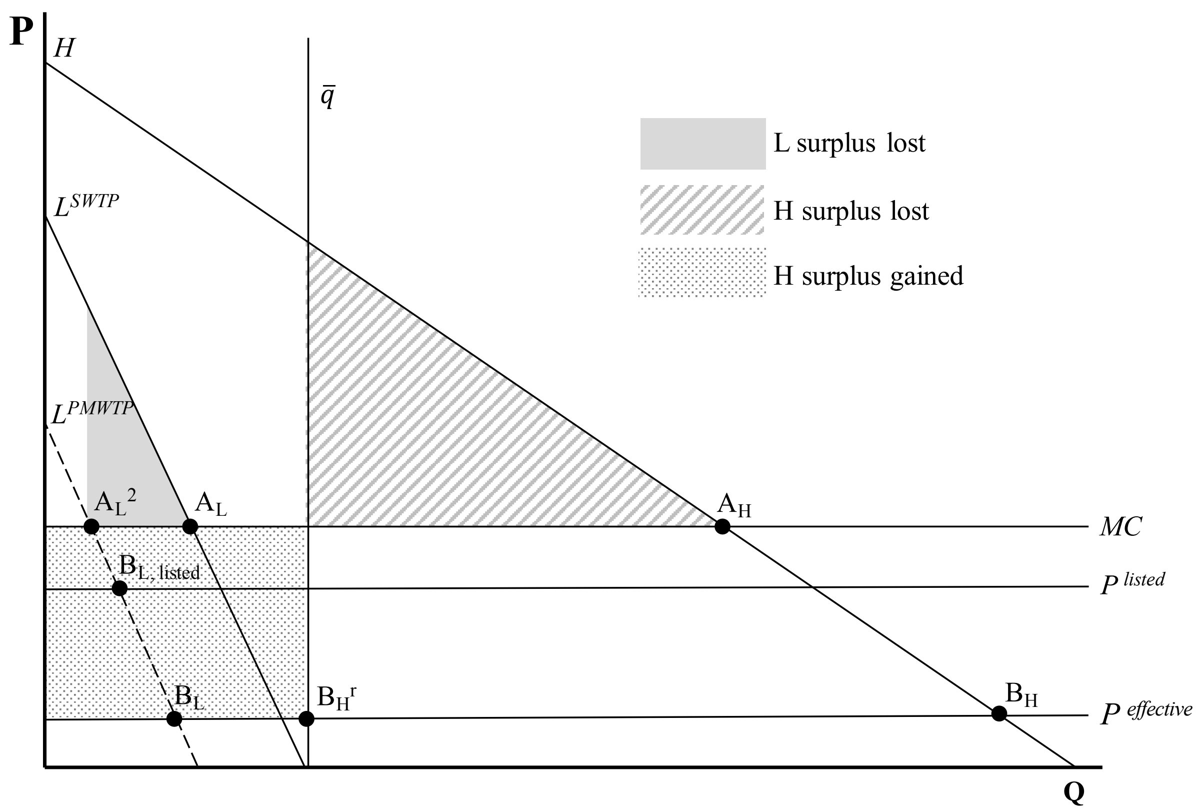
The state is therefore under severe budgetary pressure but has another instrument at its disposal - quantity rationing. One option is to limit supply to H types to the efficient level of $A_H$. However, at this level the state will still make large losses, and may not value the surplus of the H types at all. Furthermore, in a world there are many consumer types, the effective price may be very low, and the state is limited by its budget constraint. There is no reason to think utilities will be solvent with only the small degree of rationing to $A_H$.

Thus, in order to keep enough funds to continue supplying all the types together, the state may ration further to a point like $\bar{q}$. At $\bar{q}$, L type consumers are not much affected. They still use a quantity close to their efficient quantity and would not want to pay much higher prices for the small gain in gross surplus that pricing at cost would bring them. But H consumers have been cut back sharply to $B_H^r$. These consumers are using less than the efficient level of power; the well-off farmer will not have a refrigerator, for example, or a rural metal shop will continue to use only hand tools.

Despite the fact that the H types are paying low prices, their loss of surplus may be great enough that they would prefer a regime with full supply and prices raised to cover costs. The H consumer has gained the dotted area in the figure labeled "H surplus gained," since power is so cheap. However, the H consumer has lost the shaded triangle, "H surplus lost," which would have been part of his consumer surplus with marginal cost pricing and no rationing, due to the restriction of power supply. The lost surplus from rationing may well outweigh the gain from high prices; the sign of this trade-off is ambiguous. What is clear is that, due to rationing, the marginal unit of electricity for these consumers is valued far above the unit cost that they pay. Yet despite this, H consumers cannot buy more electricity.

*Figure 4*

**A Mechanism for Electricity Rationing**




## III. The Consequences of Treating Electricity as a Right

This section uses empirical data to walk through the different steps that begin with treating electricity as a right, and end with crippling electricity rationing. The facts that we will document are (i) energy is viewed as a right, (ii) this results in subsidies, theft, and distribution companies losing money, (iii) which leads to the rationing of supply and (iv) the delinking of supply from payment. All these four factors erode payment incentives for private consumers, reinforcing the viewpoint we started with, namely that electricity is a right and not a private good.

### A. Step 1: Electricity is seen as a right

Table 2 documents a set of beliefs that people hold about electricity, using survey data from Bihar. The vast majority of customers, both rich and poor, expect *no penalty* from paying a bill late, or illegally hooking into the grid, or wiring around a meter, or even bribing electricity officials to avoid payment. These attitudes are common across much of the developing world and stand in stark contrast to how the same consumers view payment for private goods like cell phones. We could debate whether cellphones are more important than electricity but, in Bihar we find that the poor spend three times *more* on cell phones than they do on electricity (1.7% versus 0.6% of total expenditure). These small expenditure shares suggest that is not the inability to pay but rather the norm of non-payment that is coming in the way of people paying for the electricity they use.

*Table 2*
**Customer Beliefs about Enforcement in Bihar, India**
Percentage responses to:
If you did X, how likely would it be that you would incur any penalty from the distribution company?

| | Likely | Neutral | Unlikely |
|---|---|---|---|
| Paying your bill late | 10.1 | 13.6 | 76.3 |
| Modifying your meter | 7.9 | 18.2 | 73.9 |
| Having an informal hooked connection | 7.6 | 14.4 | 78.0 |
| Bribing electricity officials | 12.2 | 24.5 | 63.3 |

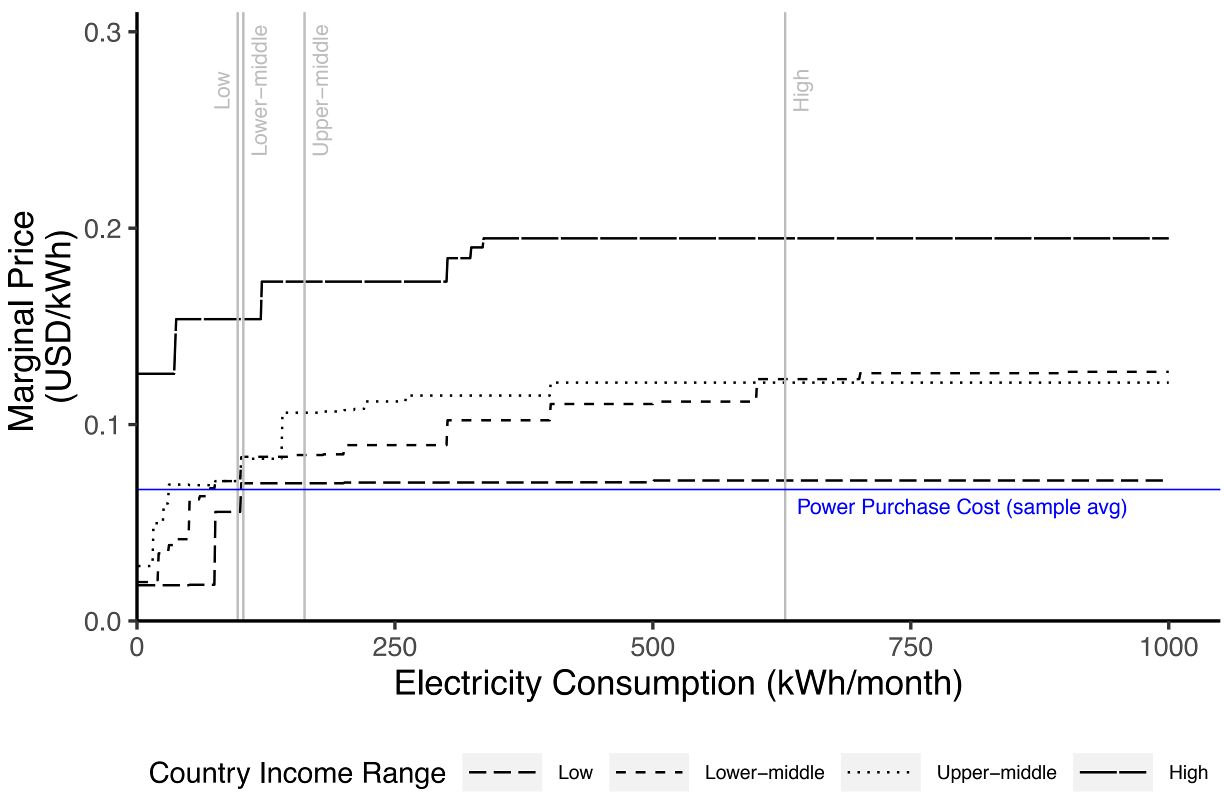
Source: Bihar Electrification Project endline household survey
Notes: Responses are from a survey of 7.071 households in rural Bihar. Modifying a meter, having an informal hooked connection, and bribing officials all prevent a utility from observing actual electricity consumed, and therefore constitute power theft.

A second piece of evidence showing how electricity is viewed as a right comes from how poor countries set electricity prices. Figure 5 plots the published marginal price of each kilowatt-hour (kWh) of electricity, averaged across countries within a World Bank income group. The vertical lines in the figure indicate the average level of consumption for consumers in each income quartile.

Utilities everywhere charge less for consumers who use small amounts of power. The price of power on the first step is low and then steps up for greater consumption. Across our sample of 30 utilities in 16 countries, almost every utility charges less for the first few kWh then for remaining units. Since the marginal cost of power does not change with an individual's consumption, the most likely explanation for increasing block pricing is distributional considerations. The first step of such tariffs are sometimes explicitly called "lifeline" tariffs.

While marginal prices increase with consumption in both low income and high income countries, the difference is much greater in low income countries (a factor of 3.9 rather than a factor of 1.5 in high income countries). Moreover, because poor consumers use less, many more people are consuming power at the highly subsidized initial rates. Even at higher energy consumption levels, tariff rates in low income countries tend to be much lower than in rich countries. It may be that fixed costs of distribution are also lower in poor countries, but this does not seem to be the main story, as the highest tariff steps are still below the cost of power purchase alone (Table 1). The pricing of power below cost means that distributional companies are set to lose money even if consumers paid all their bills. This is the first step down into insolvency shown in Figure 1.

*Figure 5*
**Explicit Subsidies in the Marginal Price of Power**




Source: Electricity tariff (rate) schedules published by selected utilities
Notes: The graph shows the published marginal price of an additional kWh of power for selected countries within a 2018 World Bank income group. In general, the cheapest available domestic/household rate is used. Selected countries are in the union of the three largest countries by population in each income group and the ten largest countries worldwide. We construct each country's price schedule separately and compute unweighted average prices at each kWh level. For countries with multiple rate schedules, we use the three largest utilities by number of customers (five for India) and take a weighted average by customer count to construct the country schedule. Utilities sometimes adjust fixed charges or the marginal price on previous units when a consumption threshold is exceeded; those one-time increases in the marginal price are not included.

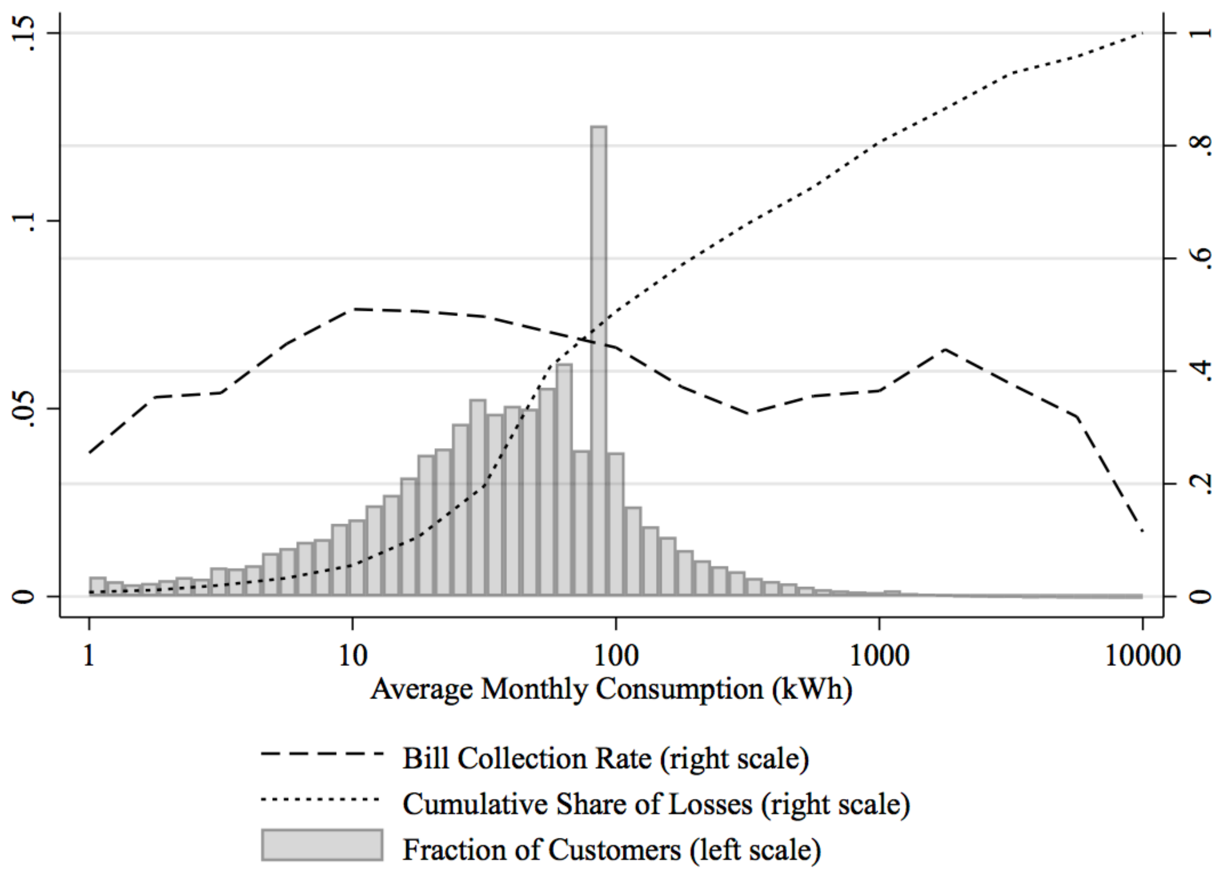
Theft and non-payment represent the next two steps down into insolvency (Figure 1). We have shown that T&D losses are higher in poor countries, but there is not comparable data breaking down power theft and non-payment across a range of countries. From our data on Bihar, however, we can look more carefully at how power is lost and who does not pay for it.

We showed earlier that overall rates of collection are astonishingly low (Figure 2). Low collection could be due to outright theft, beyond the utility's control, or due to commercial losses and non-payment. Here we show that a surprisingly large part of losses stem from known, formal customers not paying their bills.

Figure 6 utilizes administrative billing data from Bihar and plots the collection rate against monthly electricity consumed, averaged across each month in 2018 for the subset of households that actually receive bills. The mean collection rate for billed consumers in Bihar is 42%, as it was for our fictional ice cream store. Moreover, the collection rate conditional on consumption (dashed line) is roughly flat across the consumption distribution, or even slightly declining, implying that bigger consumers are just as delinquent on their electricity bills as smaller ones. More than half of collection losses are due to nonpayment by consumers using over 100 kWh per month (one minus the dotted line), though the histogram shows that they are a small subset of domestic consumers in Bihar.

*Figure 6*

**Cost Recovery and Bill Payment in Bihar**




Source: Bihar Electrification Project

Notes: The graph shows average collection rates by kWh consumption level, as well as the share of collection losses accounted for by consumers below that level. Only consumers who are actually billed are included. The collection rate equals revenue received as a share of the billed amount, and therefore does not account for outright power theft. Consumption brackets are 0-0.25 $\log_{10}$ kWh, 0.25-0.50 $\log_{10}$ kWh, etc. Customers with monthly household consumption above 100 kWh account for half of all collection losses.

These findings support our assumption that low effective prices are not confined to the poor. If electricity as a right were confined to the poor we would expect to observe substantially higher collection rates on bills issued to the biggest consumers, with most losses due to nonpayment by small-time customers. The finding that non-payment conditional on being a formal customer and receiving a bill is both high and constant across the distribution of consumption suggests that *de facto* low effective prices are an accepted and agreed upon policy of the state. These are customers that are administratively known to the utility, visible in their data, who are not paying and yet who remain connected customers, piling up debt month after month.

### B. Step 2: Electricity distribution is loss-making

Thanks to large subsidies, theft and nonpayment, utilities in poor countries lose a lot of money. For Bihar, the revenue rate we computed earlier is essentially an all-in measure of losses. The mean revenue rate in Bihar is 30%. In other words, across a state of 100 million people, the electric utilities can only manage to recover revenues equivalent to one-third of the cost of power. Almost two-thirds of the costs are covered through per-unit government subsidies, government bailouts, and running up debt. Utilities across the developing world similarly earn less per unit of power sold, even ignoring losses from theft and non-payment. Our analysis of Table 1 showed that utilities in countries in the bottom half of the world income distribution make negative profits per unit.

The problem with a power sector reliant on debt and subsidies is that the commitment to power subsidies, while large, is bounded. Eventually utilities run out of other people's money. A number of countries have run up substantial power sector debt and in some cases it has been large enough to have macroeconomic implications. Accumulated electricity debt in Pakistan counts for almost 4% of GDP (Babar 2018). India was facing stressed power debts of $62.5 billion in mid-2018, amounting to 2.4% of GDP (FTE 2018). These debts, including $30 billion of loans directly to distribution companies, threatened to instigate a financial crisis. Underscoring the speed at which power debt can accumulate, it should be noted that India's current distribution company debts exist in spite of a USD 42 billion central government bailout in 2016 and 2017 to save states from insolvency, which followed earlier bailouts in 2011 and 2002 (Business Today India 2018). There is thus a roughly 7-10 year epicycle of power sector bailouts in India. At the peak of the Puerto Rico debt crisis in the United States, the state-run power utility owed $9 billion in debt, in part because it gave free power for years to government-owned agencies and businesses (Walsh 2016). Power sector debt in Nigeria has also been reported to scare off private investments in generation and in Ghana leads to power rationing (Akwagyriram and Carsten 2018; "Power rationing imminent" 2018).

### C. Step 3: Distribution companies ration supply

Utility debts matter because they lead us to the defining characteristic of electricity in poor countries: rationing. Losing money on each unit sold, and unable to simply shut down, due to their public mandate, the only option left for utilities is to sell less by purposefully restricting supply. This is given fancy names, like load shedding, but at its core it is a company choosing to sell less of its product even though there are customers willing to pay more than the cost of supply. In practice quantity is rationed by restricting the hours of supply on the grid (Figure 2). In Bihar, this literally means that there is a man at each electricity feeder who switches the power grid off and on with a large switch. (We will return to his decision-making later.)

India is the largest country by population that still faces electricity rationing. Figure 7 gives the distribution of daily hours of supply across the country. In rural areas the median household receives under 10 hours of electricity per day. Urban areas receive over 19 hours. But only a small proportion of the population enjoys 24-hour electricity.

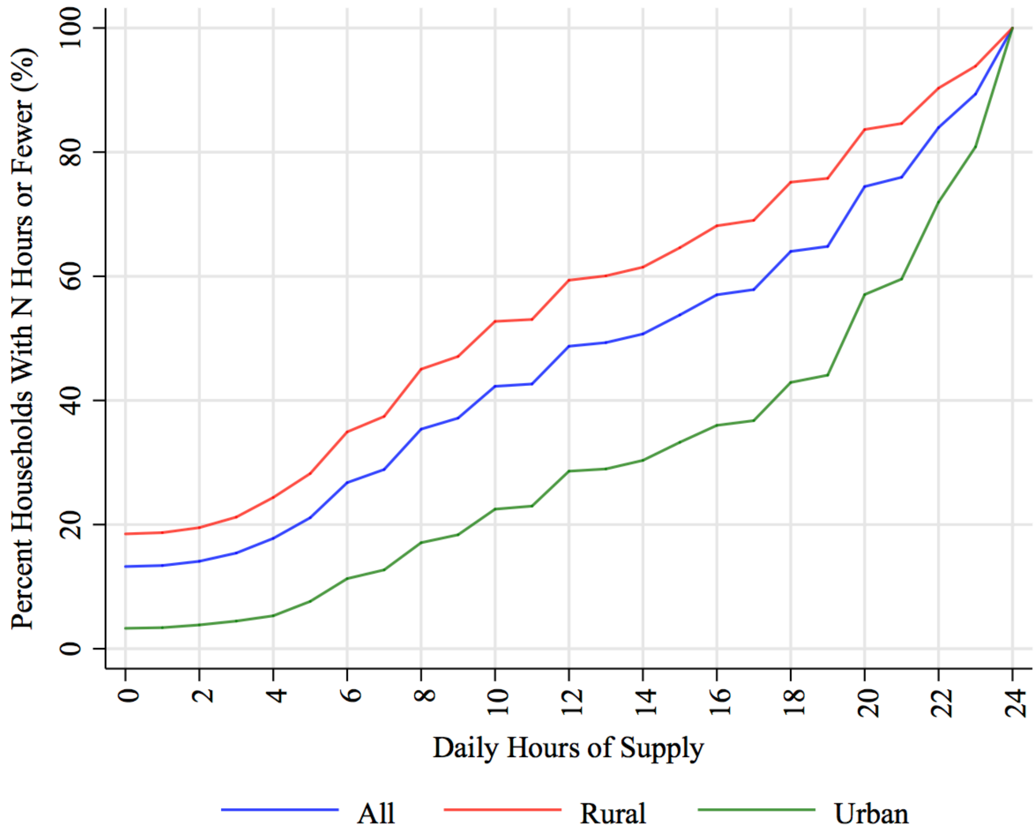
Rationing is not due to any absolute scarcity. In 2012, the year the data for Figure 7 was collected, coal plant utilization in India was under 70%, and in 2018 it is 55%. From the point of view of Bihar, which uses a small share of India's power and is connected to a national grid, an essentially perfectly elastic supply of power is available at a reasonable cost on wholesale power markets. *India has the capacity to keep the lights on, but power utilities do not have the incentive to do so.*

Power rationing parallels Sen's (1982) analysis of famine. He argues that during the Great Bengal famine of 1943 there was not any shortage of food in the aggregate sense, but rather in the famine affected individuals were not capable to buy the food they wanted. Similarly, the allocation of power is broken, and like the H types, many people cannot buy the power they want. The same is true of places like Pakistan, which is now backing down Chinese-funded coal plants and Ethiopia, which benefits from abundant hydropower resources.

Developing countries do also experience physical shortages of power and blackouts due to exogenous technical shocks, like the over-heating of a transmission line. These shortages are best thought of as rationing in the long run. Shortages are ultimately the result of mispricing and losses in electricity distribution, when a lack of revenue flowing into the sector undercuts investment in generation and transmission. Ghana's most recent power crisis provides an example of this type (Kumi 2017). McRae (2015) shows how utilities serving a population of poor (L type) consumers may provide low quality supply if consumers are unwilling to pay for power but the utility is subsidized for its losses in serving them at average cost. The utility provides better quality to richer consumers who do pay their bills. The social norm of electricity being a right breaks down this distinction, since *both* types choose to steal power, and consequently supply is rationed everywhere.

*Figure 7*

**Cumulative Distribution Function of Hours of Power Supply in India**




Source: IHDS 2011-12
Notes: This figure shows the empirical cumulative distribution function of the hours of electricity supply reported by rural (red), urban (green), and all (blue) households in the India Human Development Survey, 2011-12. Households reporting no electricity have been considered to receive zero hours of daily supply. At each point in the distribution, rural households have fewer hours of electricity than urban households. The median urban household receives over 19 hours of electricity per day, while the median rural household receives under 10 hours of electricity per day.

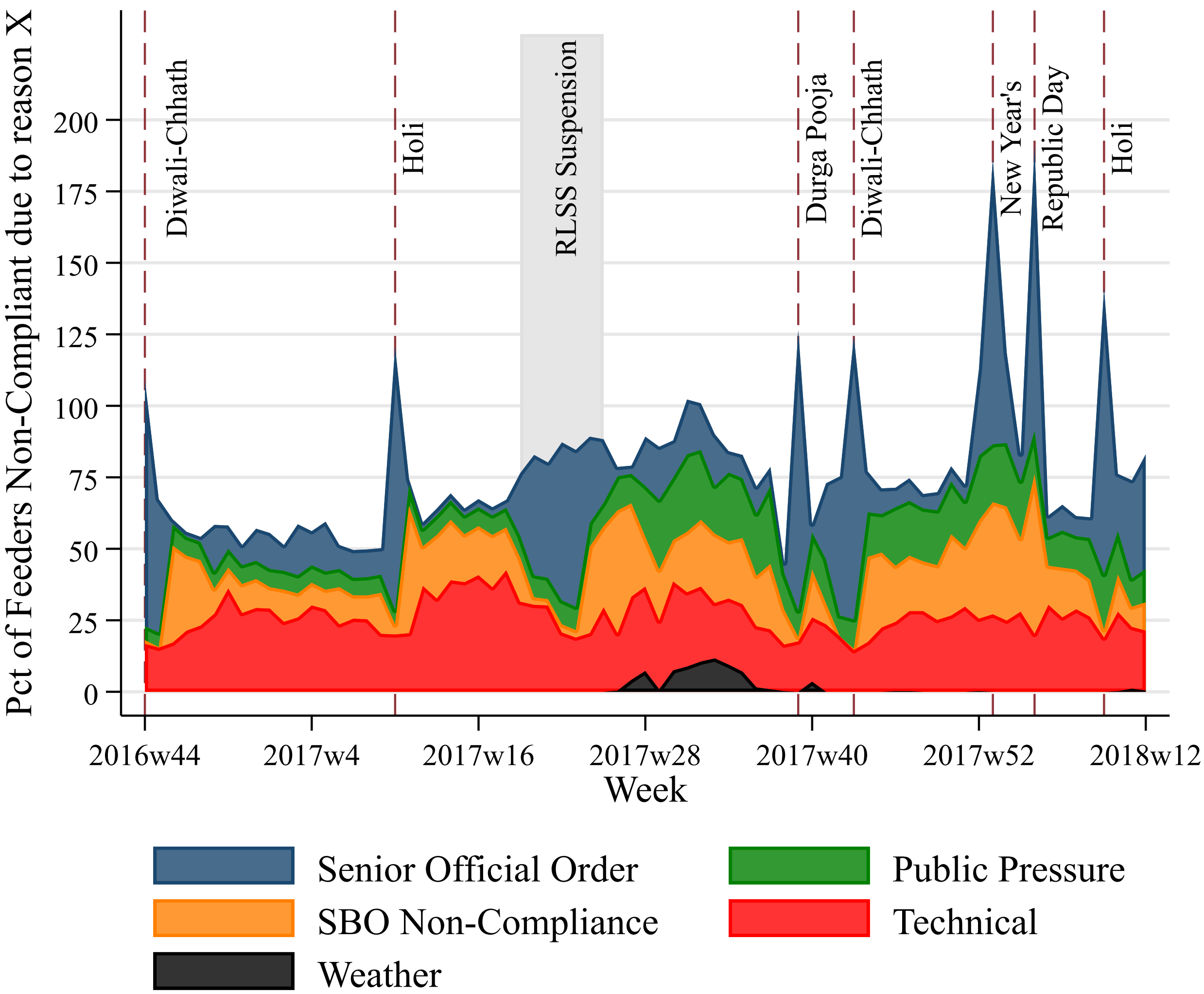
### D. Step 4: Supply and payment become delinked

Though payment is below cost it is not so far below everywhere (Figure 2). So, in principle, a utility could respect its budget constraint by rationing judiciously, giving 24 hours of electricity to areas that pay, and less to those that do not. Or, it may give more power to areas that have a higher value, for example because they include more businesses or public facilities like hospitals. At a higher level of aggregation electricity is perfectly excludable.

But the right to electricity is a social concept, not a technical one. Even if a utility is physically able to cut off a group of delinquent customers, the right of all citizens to electricity may render it unwilling to do so. So in Figure 2 rationing of power bears no relation to the payment rates of different areas. In continuing to keep the lights on for nonpayers, the utility reveals it is unwilling to act like a profit-maximizing business.

*Figure 8*

**Non-Market Influences on Supply**




Source: Bihar Electrification Project
Notes: This figure shows the percentage of feeders in the Revenue-Linked Supply Scheme in Bihar that are non-compliant with their supply schedule within the week for each week from November 2016 to March 2018. A feeder can be non-compliant for multiple reasons within the same week. There were 454 feeders in all weeks throughout Bihar that were used in the creation of this figure.

A narrow interpretation is that utilities do not take this approach because of a technical limitation, that they cannot ration finely enough. Each point in Figure 2 represents a feeder, which serves a community, not individual people. Thus even if supply were linked to feeder-level payment, customers end up being accountable for the power theft of their neighbors. Economic rationing may therefore be unfair. It may also be ineffective, due to the public goods nature of payments, since people are probably willing to pay very little to light up their neighbors' homes. If the utility were able to selectively and inexpensively cut-off individual consumers, perhaps it would do so.

A broader interpretation is that under the social norm that energy is a right the allocation of power is no longer done on economic grounds, just as the pricing of power is not. The right to electricity affects not just payment but allocation. If citizens engage in protests regarding electricity received, or equivalently if politicians promise to deliver more power in exchange for votes, the right to electricity can feed directly into utility supply decisions through politics.

In Figure 8 we try to deconstruct the reasons for power allocation using administrative data from Bihar. Every feeder has a schedule of supply, and we collect daily data on the reasons for deviations from the schedules over the course of 1.5 years. There are exogenous technical shocks due to outages (black) and weather (red), plotted in the bottom two segments. However, most deviations from the schedule are political or bureaucratic in nature. The biggest spikes in deviation, when many areas get more power, are for widely celebrated public holidays, when senior officials pass down orders to liberalize rationing.[2]

When the public agitates against rationing, at any time of year, more power might be given (green segment). The operators of feeders have a fair amount of discretion and deviate from power supply schedules at times (orange segment). The distinction between public pressure and operator discretion is not sharp. In collecting this data, we heard anecdotes from operators who were threatened or physically beaten over power supply decisions. The threat of such action may induce operators to change supply (orange) before public pressure is observed (green). Officials of the distribution company who themselves fall under the influence of their political masters can also give orders at other times that supply be increased or cut back. These observations join a growing literature that documents political influences on electricity supply (Mahadevan 2018; Asher and Novosad 2017; Baskaran, Min and Uppal 2015; Shaukat 2018).

When power is rationed on politics rather than payment, consumers have little incentive to pay for electricity. They quickly learn that the way to get more power for their communities is to appeal to the local electricity grid operator or elected representative. In other words, electricity as a right becomes a self-fulfilling prophecy. Consequently, the cycle we have described in Parts 1-4 will repeat itself.

Rationing leads to losses because people who value electricity at more than its cost are unable to purchase it. The current system of allocation does not direct the rationed supplies of electricity to the customers who value it the most, but to those who demand it by force, or to those who are celebrating a holiday. As we have documented, political and other considerations come into play. The result is that there are surely substantial allocative inefficiencies, even after accounting for the difference between social willingness to pay and private willingness to pay.

## IV. Conclusions

The consequence of the social norm that electricity is a right is that firms and people in developing countries cannot choose how much power to use. A whole range of consumption and production activities that could be taken up in a world with 24-hour electricity are foreclosed. A large array of potential firms cannot enter and existing firms cut output or rely on costly diesel generators

[2] In Pakistan, similarly, utilities declare that power cuts for non-payment will be strictly enforced during the month of Ramadan – except at mealtimes that precede and follow the daytime fast.

(Allcott et al., 2016). Households, rationed off the grid altogether, substitute to costly alternatives like diesel and off-grid solar power and are unable to make use of a whole range of utility enhancing appliances (Burgess et al., 2019). We never observe the latent demand that firms and people have for continuous, reliable electricity, because it is never offered.

What is the way out? We offer a taxonomy of reform in four areas: explicit subsidy reform, changing social norms, better technology, and privatization. Many of these policies are complements. They often focus narrowly on creating incentives for payment and collection, but they all share a longer-run goal of changing the way people think about electricity—that is, their aim is to break the social norm that electricity is a right.

The first category of reform is to reduce explicit subsidies for electricity in size and in scope. This involves separating the objective of supplying electricity at full cost from the redistributive function of government. These two functions have often become intertwined in current electricity policy in developing countries, leading to the perception that electricity is a right for all. This is especially so because subsidies on electricity are often enjoyed by consumers across the income distribution, which both makes them regressive and furthers the notion that power is an entitlement.

One way out is to remove subsidies from the tariff schedule charged by distribution companies. Instead, it would be much more effective to use transfer programs to provide any assistance deemed necessary for poorer consumers. Subsidies could be bundled into a system of unconditional direct benefit transfers which are targeted at the poorest members of society. If needed for the transition, a well-defined category of poor consumers may receive a "tagged" subsidy payment equal to the subsidies they would have received under current tariff schedules (see Figure 5). Indonesia moved away from energy subsidies towards direct transfers, though its policy has wavered lately (Burke and Kurniawati 2018).

The second category of reforms aims to reduce theft and nonpayment of bills and in the process cause people to consider electricity a private good, much like cell phones. Relinking payment performance with supply is key to these efforts. In Bihar we engaged in a large-scale experiment involving twenty eight million consumers with the government to enact such a scheme. Under this initiative, the hours of electricity provided by the utility to a feeder were explicitly linked to bill collection rates via a transparent and heavily publicized schedule. This policy targets utility supply. Preliminary results suggest that linking leads to a simultaneous increase in revenue and energy supply. However, losses remain high, since we can target payment by groups of 13,000 people but not individual customers. A similar initiative is underway nationally in Pakistan, allowing utilities there to cut off the most egregious offenders. Critical to these efforts is to communicate the benefits of paying for electricity. In Bihar where bill inserts, posters, sms messages and public announcements were used to relay how communities paying more would result in longer hours of electricity. Similarly, in Sao Paulo utilities held meetings with de facto leaders of slums before introducing billing, and in Delhi one utility hired 800 women from informal settlements to act as community liaisons (Lawaetz 2018).

A related set of reforms tries to break down the agency problems that have developed under the right to electricity by incentivizing the personnel that collect electricity payments to increase their collections. In theory, these high-performance incentives both elicit greater collection effort and break collusion between the bill collector and consumer of electricity, whereby bribes are paid in order to avoid having to pay for electricity. We are involved in evaluating an experimentally assigned scheme where utility employees in Bihar move from flat payments to one where they also retain a proportion of revenue from bills collected.

Leveraging the identities of bill collectors and other utility employees may also improve bill collection. Rural electrification in the United States was achieved largely through rural electrification cooperatives (RECs), which were groups of farmers that maintained the grid and collected bills (Lewis and Severnini 2015; Kitchens and Fishback 2015). Bill collection may therefore be aided by social trust – when the collectors are your neighbors it is harder to ignore them. The history of electrification in China also involved local engagement with the electricity sector. Initial electrification was mainly funded by communities rather than the national government, and in some cases farmers were hired part-time as bill collectors (Aklin et al. 2018; Niez 2010). Rural communities were eventually connected to the national grid in the 2000s but reported electricity losses remained low, perhaps because of early local buy-in (Bhattacharya and Ohaire 2012).

A third category of reform relies on the goddess of technology to make electricity excludable therefore making it possible to explicitly link payments and supply at the individual level. Smart meters can require payments in advance or allow the utility to cut off household electricity supply remotely, thus rationing individual households rather than whole towns and villages. Smart meters have been shown to reduce power consumption in some contexts (Jack and Smith 2015). That said, there remains a need for more evidence from high-theft environments, because even the best meter does nothing if a consumer connects themselves directly to the line on the street or is 'allowed' to wire around a meter. Work in healthcare shows that better monitoring can be undercut by bureaucratic collusion (Banerjee, Duflo and Glennerster 2008).

This policy agenda may seem incremental relative to the scale of the problem we have described. Why not directly leap to the goal, and privatize distribution in the hope that this leads to a market for electricity that looks more like the cellphone market? Indeed, it is natural to consider privatization as a fourth reform category.

While appealing in theory, the political economy of electricity distribution makes the leap to privatization in many developing country contexts nearly impossible. Since the right to electricity is a social norm, sanctioned by the state, accepted by all parties, and coordinated by politicians and the public, the state must lead reform to break the right *before* privatization is feasible (Reddy and Sumithra 1997). The case of Odisha, a poor state neighboring Bihar, is illustrative. The state distribution companies were among the earliest in India to be restructured and privatized but have continued to have some of the highest loss rates in the country for two decades (as high as 34% as of 2018) and require continued subsidization (PowerLine 2018).

By contrast, in areas where there is enough public support, privatization might improve efficiency. For example, Delhi privatized distribution in 2002 and has seen incredibly rapid reductions in losses and improvements of supply, partly through the social engagement and technical reforms recommended above. Even so, power prices have remained a political hot button. In 2015 the Delhi Government reintroduced a significant 50% power subsidy for all consumers who use less than 400 kWh per month (Tongia 2017). The high threshold means over 80% of households in the city receive the subsidy. Beyond the large direct costs of this policy, it remains to be seen whether such policy might reintroduce the norm of electricity being a right and affect payment behavior more broadly, including among the middle and upper classes to whom the subsidy sometimes applies. This type of anecdote underscores the fragility of a high payment equilibria in a world where electricity is still broadly seen as an entitlement.

To zoom back out from particular reforms, we conclude with the observation that whilst 24/7/365 electricity holds immense potential it remains out of reach for the majority of developing countries. Macro solutions, like privatization or construction of ever more wires and plants, come into and out of favor, but we believe they are targeting the symptoms, not the cause. In our view, the only reliable solution is to eliminate the seemingly socially desirable, but ultimately pernicious, social norm that electricity is a right.

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