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Falling Short

A Global Survey of Electricity Tariff Design

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Abstract

This paper provides a comprehensive overview of electricity pricing practices and tariff structure design in more than 60 developed and developing countries worldwide as of 2015-16. It evaluates the performance of electricity tariff designs according to a variety of important dimensions, notably cost recovery, vertical equity (affordability), and horizontal equity (or price differentiation). It also reflects on the extent to which current electricity tariff designs are well-suited to incentivize efficient adoption of emerging technologies, such as distributed generation and storage, electric vehicles, and demand-side participation. The results of the survey indicate that electricity tariffs stand at $0.13 per kilowatt-hour (when fully averaged across countries and customer groupings); but differ hugely across jurisdictions by a factor of 40:1. Electricity tariffs are far from recovering limited capital costs and have not kept up with inflation over time. Substantial price differentiation is the norm, and affordability remains a significant concern. Most countries' tariff structures are ill-adapted to emerging technological disruption in the sector, due to the scant use of load-related charges to cover the fixed costs of the network, the continued preponderance of increasing block tariffs for residential customers, and the limited application of time-of-use pricing.

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Falling Short: A Global Survey of Electricity Tariff Design

Vivien Foster[1] and Samantha Witte[2]

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[3] 2016 tariff and cost data were obtained from the 2018 iteration of the RISE project.

1. Introduction

The purpose of this paper is to survey prevailing electricity price levels and tariff structures as a reference for practitioners to benchmark tariff design across countries. The paper also provides simple indicators of the performance of tariff designs against standard design criteria such as cost recovery and affordability and investigates the extent to which tariff structures apply price differentiation across customer groups and consumption categories. The paper also considers to what extent prevailing electricity tariff designs are compatible with emerging technological trends in the sector, such as distributed generation, demand-side participation, and electrification of transport.

The paper adds to a sporadic existing literature surveying electricity tariff designs across countries and evaluating their performance against standard criteria such as cost-recovery and affordability. These range from regional studies involving Sub-Saharan African countries (Briceño-Garmendia and Shkaratan, 2011; The African Development Bank Group, 2019) to global surveys spanning both developed and developing countries (World Bank, 1990; Foster and Yepes, 2006). Existing studies find systematic patterns in electricity tariff design across countries. Ore et al., 2017 show that countries in Central America commonly differentiate volumetric tariffs across customer groups. Komives et al., 2005 show that rising block tariffs are widely used for residential customers often as a form of social tariff, but that they are not very effective at reaching poor households since electricity consumption is not a very strong proxy for household income.

A recurrent finding in the literature is the difficulty that low-income countries face in achieving cost recovery; even for operating costs (Huenteler et al., 2020). For instance, Briceño-Garmendia and Shkaratan, 2011 find that while about 80 percent of African power utilities achieved operating cost recovery, only 30 percent achieved full capital cost recovery. Later work by Trimble et al., 2016 finds that even the share of African power utilities reaching operating cost recovery had fallen to about 50 percent, while barely 5 percent attained full capital cost recovery. Furthermore, there are evident tensions between the achievement of cost-recovery and affordability in the design of electricity tariffs, particularly for lower income countries, notably in Latin America and to an even greater degree in Sub-Saharan Africa and South Asia (Foster and Yepes, 2006).

Finally, a new strand emerging in the literature explores to what extent prevalent electricity pricing structures are compatible with the adoption of new technologies, including rooftop solar and electric vehicles. The main finding to date is that widely practiced increasing block tariff structures for electricity may have the unintended effect of over-incentivizing adoption of rooftop solar while under-incentivizing uptake of electric vehicles, relative to the economic optimum (McRae and Wolak, 2019). This illustrates that in a world where consumers are no longer passive, the behavioral implications of electricity tariff design are becoming increasingly critical.

Compared to earlier studies, which focus primarily on design of residential electricity tariffs, this paper takes a more comprehensive look at charging practices across the full gamut of customer categories (including residential, industrial, agricultural and public sector). It also goes beyond volumetric tariffs, to consider the full range of load-based and Time-of-Use pricing practices. As a result, the paper is able not only to make the typical assessments of cost recovery and affordability, but also to comment on the prevalence of pricing practices that support the adoption of new technologies in the power sector.

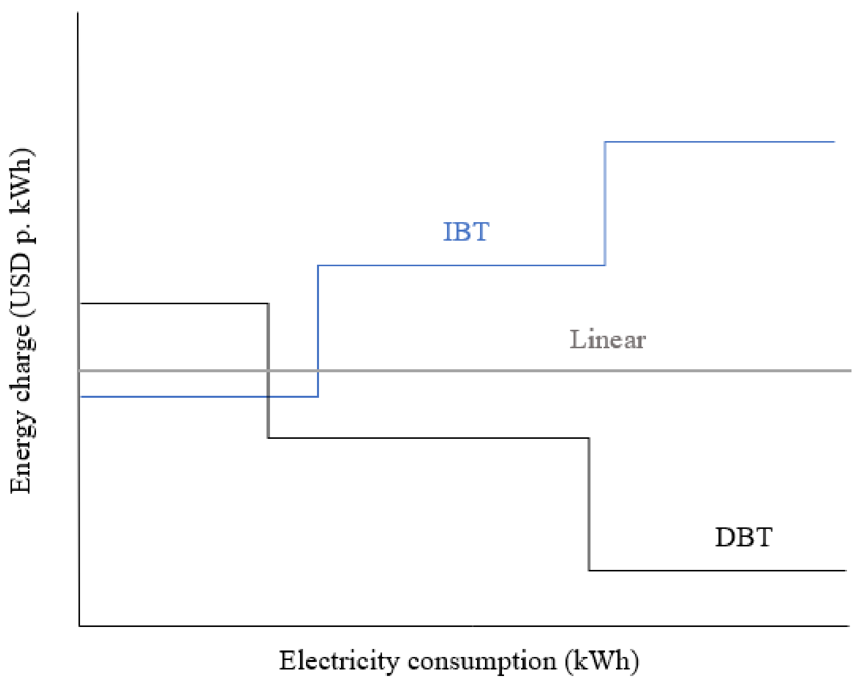
The remainder of the paper is organized as follows. Section 2 outlines the methodology. Section 3 presents results on the average level of electricity tariffs that are being charged in different countries to different customer groups and analyzes the pattern of cross-country variations. Section 4 looks more deeply at the design of tariff structures, whether they are based on volumetric drivers, load or time-of use. Section 5 characterizes the performance of the tariffs according to the three simple criteria of cost recovery, affordability and price differentiation. Section 6 concludes.

2. Methodology

The paper exploits a new database extracted from the electricity tariff schedules of over 60 developed and developing countries collected under the Regulatory Indicators for Sustainable Energy (RISE) project.[4] These comprise 7 high income countries, 35 middle income countries and 23 low income countries. The database contains detailed information on tariff schedules for the following five customer classes: residential, commercial, industrial, agricultural and public. Electricity tariffs are explored for the largest electric utility by customer base serving the largest business city. The paper begins by documenting the different types of electricity tariff designs in place, including the number of consumer categories, and the existence of tariff structures that differentiate according to consumption, load or time of use.

Just about all electricity tariff structures incorporate pricing rules that are related to the volume of energy consumption. The simplest form of volumetric tariffs is a linear schedule, where every unit of consumption is charged at a constant rate. A popular variation is the increasing (or sometimes decreasing) block tariff where the volumetric rate increases (decreases) across successive bands of marginal consumption in a stepwise manner (Figure 1). A more unusual variation is the volume-differentiated tariff where the value of that linear tariff increases (or possibly decreases) as total monthly consumption increases. Unlike block tariffs, which charge different volumetric rates for each block of marginal consumption, volume-differentiated tariffs charge a single linear rate across the entirety of a user's consumption, yet that linear rate changes as overall monthly consumption crosses various volume thresholds.

Figure 1. Illustration of increasing block, decreasing block and linear tariffs



[4] *http://rise.esmap.org/*

In some countries, volumetric charges may be complemented by fixed load charges that differentiate according to the maximum capacity that the user draws from the system. These are relevant because capacity rather than energy is the major driver of fixed costs on the power system, making it relevant to structure tariffs around the amount of load that customers draw from the system. In almost all countries in which demand charges exist, these are linear load charges per kV. They are most prevalent in industrial tariff schedules, exist in approximately half of commercial tariff schedules, but are rare among residential tariffs.

Finally, countries are increasingly considering time-of-use charges that apply multipliers to standard charges depending on whether consumption takes place during peak or off-peak periods. In reality, it is not so much total load that drives investment costs on the system, as the peak-hour load. Time-of-use tariffs are a means of reflecting this reality in customer charges. In most countries time-of-use tariffs act as linear rates that vary by time block. In the majority of countries, time-of-use blocks consist of peak and off-peak hour blocks. Less common are broader divisions into day and night times, followed by seasonal variation. Time-of-use tariffs are prevalent in 40 percent of industrial tariff schedules and can be found in a third of all commercial tariff structures. Residential users are rarely subject to time-of-use tariffs.

For each customer category, the paper reports an average effective electricity tariff per kilowatt-hour, which allows for standardized price comparisons across a wide diversity of tariff designs. The average tariff is the price per kilowatt-hour of electricity consumed for a representative consumer once all charges — fixed, volumetric, load-based and time-of-use — have been fully incorporated (Box 1) (Briceno-Garmendia and Shkaratan, 2011). This requires assumptions to be made regarding the average monthly electricity bill. For residential customers, the average electricity consumption is derived from the IEA energy balances by taking the total residential electricity consumption and dividing by the number of connected households. Since there are limited data on the distribution of electricity consumption within a given country, median electricity consumption may lie below the lifeline tariff level in more cases than implied by the analysis. As a result, the results might overestimate the average electricity tariff faced by households in certain developing countries. For non-residential customers, a "representative" consumption level is adopted based on expert consultations and the characteristics of each sector. Commercial, agricultural and public sector consumption is assumed to be 1,000 kilowatt-hours per month, while industrial consumption is set at 5,000 kilowatt-hours per month.

Similarly, assumptions were made about the representative load level for each customer group, as well as the pattern of peak versus off-peak consumption in cases where time-of-use tariffs exist. Following internal consultations, the commercial load factor was set to 11 kilovolts, while the industrial load factor was set to 33 kilovolts. In cases where customer groups were not explicitly defined by the tariff schedule, these load factors were used for categorization.

In order to apply time-of-use to a single average nominal tariff for each customer group, a weighted average volumetric time-of-use charge was computed for each customer class based on the following time zones: peak times were defined as 6pm through 10pm for commercial customers, and as 6pm through 9pm for industrial users. Day time was defined as 8am through 6pm, and nighttime as 10pm through 8am for all users. Where a choice between linear tariffs and time-of-use tariffs was presented in the tariff schedule, the option resulting in the cheapest average nominal tariff based on the user's assumed monthly consumption level was selected.

Box 1: Formula for Average Electricity Tariff

$$\textbf{Average nominal tariff}(\textbf{USD p.kWh}) = \frac{\textbf{Monthly electricity bill } (\textbf{USD})}{\textbf{Average monthly electricity consumption } (\textbf{kWh})}$$

- $Monthly\ electricity\ bill\ (USD) =$

$$\sum_{e=1}^{E} Energy\ charge_e(USD\ p.kWh) \times Consumption\ block_e(kWh)$$
$$+$$
$$Demand\ charge(USD\ p.kW) \times Assumed\ capacity\ level(kW)$$
$$+$$
$$Fixed\ charge(USD)$$

- $Assumed\ capacity\ level\ (kW) = \begin{cases} \frac{Average\ monthly\ electricity\ consumption(kWh)}{720 \times Load\ factor} \\ Power\ factor \times Apparent\ power\ (kVA) \end{cases}$

The lack of cost-recovery through electricity tariffs is well known to have various negative impacts on utilities (Munasinghe, 1980) and the energy sector more broadly (Coady et al., 2015). To evaluate cost recovery, two benchmarks are considered: operating cost recovery and limited capital cost recovery (Box 2). The average operating costs of electricity supply are derived from the financial statements of the national utility or the largest utility operating in the country by customer base and involve dividing total operating cost (including the cost of electricity purchased, personnel expenses, wheeling charges and maintenance costs) by the total volume of electricity delivered. The same financial statements include information on debt service and principal repayment that can also be used to compute a benchmark for limited capital cost recovery, again by averaging across the total volume of electricity delivered and adding to the average operating cost. These two benchmarks are compared with the average electricity tariff faced by each customer group to gauge the extent of cost recovery that is being achieved. Operating cost recovery provides a measure of the utility's ability to function on a day-to-day basis with some financial autonomy, while limited capital cost recovery provides a measure of the utility's financial viability through its ability to cover the most pressing of capital expenses.

Since most utilities do not report consumption figures or cost figures broken down by customer class, the cost recovery benchmarks are based on averaging across the entire customer base. This introduces some distortion, given that the average cost of delivering power to industrial customers that take electricity directly from the medium and high voltage grid is significantly lower than that of delivering power to the remaining customer groups that take electricity from the low voltage grid. Essentially, the cost recovery benchmark would incorporate a substantial upward bias for industrial customers because it incorporates the costs of the low voltage distribution network. In recognition of this, the cost recovery analysis is not applied to industrial tariffs. By the same token, the incorporation of industrial consumption in the volume of electricity demand used to compute average cost benchmarks will lead to a downward bias in the cost recovery benchmark for non-industrial customers. However, this problem is believed to be less severe, particularly for developing countries where industrial demand may account for a relatively small share of total electricity consumption. The resulting cost-recovery figures are based on the *actual* cost of supply rather than the *efficient* cost of supply, as the magnitude of inefficiencies is unknown. In this sense, they represent a lower bound on the extent of efficient cost recovery. Further, the analysis focuses on average costs of electricity distribution, rather than the long-run marginal cost of electricity, which is unknown.

Since long-run marginal cost could be expected to lie above historic average cost, the resulting cost-recovery figures are therefore likely to overestimate the extent to which marginal costs are covered by tariffs.

Box 2. Computation of Cost Recovery Indicator

$$\textit{Operating Cost Recovery Indicator} = \frac{\textit{Average nominal electricity tariff}}{\textit{Average operating cost}}$$

$$\textit{Limited Capital Cost Recovery Indicator} = \frac{\textit{Average nominal electricity tariff}}{\textit{Average operating cost plus interest and principal repayment}}$$

The concept of affordability (or vertical equity) is not very rigorously defined in the literature but refers to the fact that the expenditure burden of meeting basic energy needs should be kept within reasonable levels to ensure that households have adequate budgetary space to meet other basic needs. While there is no objective definition of what constitutes a reasonable level of expenditure, 5-10 percent of the household budget is a widely used rule of thumb in the literature (Lampietti et al. 2007 and Komives et al., 2005). Broadly, the 5 percent threshold is more applicable to tropical environments where electricity is primarily used for lighting and appliances, while the 10 percent threshold is more relevant to temperate environments where electricity may also be used in thermal applications. To gauge the affordability of electricity from the perspective of poor households, an affordability indicator is used, capturing the share of the average electricity bill in the household budget of the poorest 40 percent of the household income distribution (see Box 3). The average budget of the poorest 40 percent of each country's population is obtained from the World Bank World Development Indicators and converted into household terms through dividing by the population of the bottom 40 percent and multiplying by the household size.

Box 3. Computation of Affordability Indicator

$$\textit{Affordability Indicator} = \frac{\textit{Average monthly electricity bill}}{\textit{Income per household in bottom } 40\% \textit{ of Distribution}}$$

- $\textit{Income per household in bottom } 40\% = \frac{\textit{Total income of bottom } 40\% \textit{ of distribution}}{\textit{Number of households}}$
- $\textit{Number of households} = \frac{\textit{Total population}}{\textit{Average household size}}$

Cross-subsidization is widely practiced in the electricity sector, and entails charging some customer categories above the cost of service provision with a view to charging others below the cost of service provision. Cross-subsidization can be used to meet a variety of economic and social goals, such as promoting affordability for residential customers or enhancing the competitiveness of non-residential customers.

The precise definition and identification of cross-subsidy is notoriously difficult, due to the fact that in network industries the allocation of accounting costs to different customer groups always entails some degree of arbitrariness and can be done in a variety of defensible ways (according to volumetric consumption or load or location) that yield widely varying results. The economic definition of cross-subsidy has focused instead on game-theoretic approaches that consider the network as a club good. When a customer connects to the network, he or she imposes an incremental cost on the network provider, and at the same time avoids incurring a standalone cost for self-provision. Any price that is above incremental cost but below stand-alone cost will provide new users with the incentive to connect to the network, while at the same time benefiting existing users by sharing fixed costs over a larger customer base. Any prices falling in this relatively wide range can therefore be regarded as subsidy-free from an economic standpoint (Faulhaber, 1975). While conceptually attractive, economic definitions of subsidy-free pricing are even more difficult to apply in practice than accounting approaches. In either case, a detailed definition of the utility cost structure would be needed, as well as an understanding of the standalone alternatives available to different customer groups.

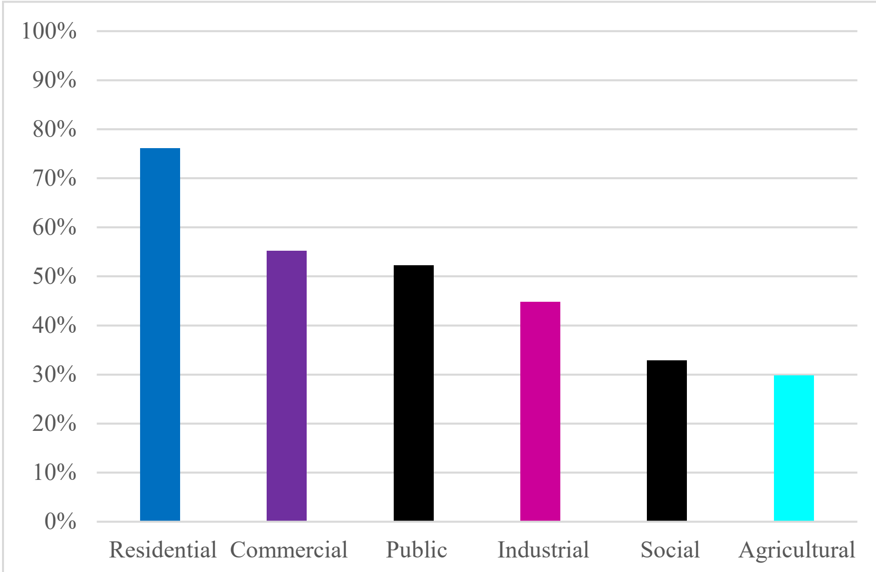
In view of these complications, the approach taken in this paper is simply to focus on price differentiation (or horizontal equity); that is, the extent to which different customer groups face different prices for the same service. While the existence of price differentiation in a tariff structure cannot be regarded as definitive proof of cross-subsidy, it is suggestive of economic distortions in electricity pricing that are likely to affect behavior in ways that reduce the overall efficiency of the system. The analysis of price differentiation will consider both how tariffs differ across customer categories (residential, commercial, industrial, agricultural, public) and how tariffs differ within customer groups at different levels of consumption (design of IBTs and related tariff structures).

3. Average Level of Electricity Tariffs

The purpose of this section is to summarize results on the average electricity tariffs that are being practiced across countries. These are presented separately for different customer groups, whose tariffs can vary quite widely even within countries. Variations across countries in the overall average electricity tariff are then explored.

Electricity tariff schedules in most countries comprise a complex series of alternative tariff structures that are differentiated by customer class (Figure 2). The vast majority of countries have a dedicated schedule for residential customers, and this can sometimes be broken into several categories, the most prevalent of these is the "social tariff" category that is found in around one-third of countries. In addition, many countries also have separate schedules for public sector, commercial and industrial clients. Although less common, around one-third of countries also include a separate agricultural tariff.

Figure 2. Share of countries with stand-alone customer classes



The range of average electricity tariffs observed across these groups differs widely (Figure 3). At one extreme, some customer groups in some jurisdictions can face electricity tariffs as low as $0.02 per kilowatt-hour (residential tariffs in Algeria), while in other cases tariffs can go as high as $0.82 per kilowatt-hour (industrial tariffs in the Solomon Islands). It is also striking that there is much less variation in average tariffs across countries for the agricultural and public sector customer groups, than for residential, commercial and industrial customers. The specific average electricity tariffs for each country and customer class available can be viewed in the series of bar (Figures 4 and 5), which are also color-coded to highlight practice in different country income groups.

Figure 3. Range of electricity tariffs by customer class (US$/kWh)

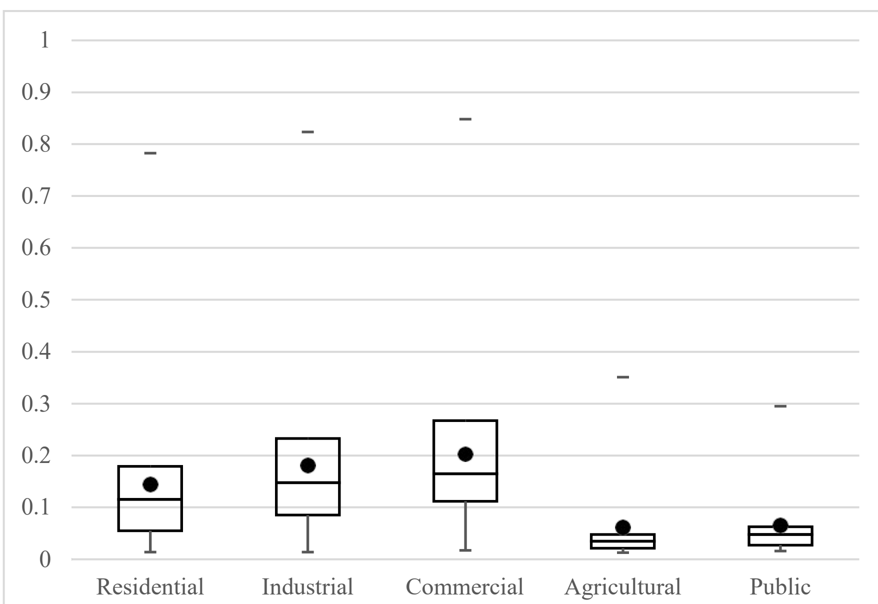


Figure notes: Bottom whisker cap = minimum; bottom box margin = 1st quartile; mid box bar = median; top box margin = 3rd quartile; top whisker cap = maximum.

Where separate agricultural tariffs exist, these tend to be by far the cheapest across all customer categories, with an overall average tariff level of $0.06 per kilowatt-hour (Figure 3). In fact, the vast majority of countries that include agricultural tariff schedules charge preferential rates of no more than $0.05 per kilowatt-hour. Nicaragua stands out as being the only country that sets agricultural tariffs at punitive rates in excess of $0.30 per kilowatt-hour, in part due to demand charges of $19 per kilowatt (Figure 5).

The next most preferential rates are typically offered to public sector clients. Public sector tariffs span across a range between $0.01-0.29 with average values of $0.07 per kilowatt-hour. Although there is much wider variation in practice for public sector clients across countries, Nigeria stands out for levying particularly high charges on public sector clients over US$0.20 per kilowatt-hour (Figure 5).

When it comes to commercial and industrial clients, the dispersion of average tariffs is similarly wide and quite similar across both customer groups. These commercial and industrial tariffs are typically concentrated between $0.10-0.30 per kilowatt-hour with average values around $0.20 per kilowatt-hour in both cases. Nevertheless, the range of practice is extremely wide. Both commercial and industrial tariffs range from around US$0.02 per kilowatt-hour in several emerging economies to around US$0.80 per kilowatt-hour in the Solomon Islands (Figures 4 and 5).

Turning to residential customers, there is also considerable dispersion, with average tariffs at $0.14 that lie below those for commercial and industrial customers, yet above those for agricultural and public sector consumers (Figure 4). The overall spread once again runs from negligible to prohibitive average tariff levels (Figure 5). It is striking that the most expensive residential tariffs are typically found in high income countries, while the most expensive non-residential tariffs are typically found in lower income countries.

Looking at the overall tariff in any particular country, by averaging across customer classes, reveals how electricity pricing systematically reflects geographic characteristics of the country that have a material impact on the cost of power generation. Some of the highest electricity tariffs in the world are found in countries that are Small Island Developing States (SIDs) (averaging $0.26 per kilowatt-hour) versus non-SIDs (averaging $0.16 per kilowatt-hour). SIDs are often dependent on small-scale oil-fired power generation and face high fuel and associated transportation costs that result in a price premium of 200% relative to countries that do not suffer these geographic handicaps. Salient examples of SIDS facing expensive electricity include Solomon Islands, Vanuatu, Haiti, and Madagascar. Equivalent examples from land-locked countries (LLCs) include Burkina Faso and Mali.

Another major influence on the level of electricity prices is the energy resource endowment. Some of the lowest electricity tariffs in the world are found either among countries that have large endowments of low-cost often fully-amortized hydro-power (such as Democratic Republic of Congo, Ethiopia, Kyrgyz Republic, or Guinea), with average tariffs per kilowatt-hour of $0.12, or among countries that are large fossil fuel exporters that heavily subsidize fuel use in power generation (such as Algeria, Angola, the Arab Republic of Egypt or the Islamic Republic of Iran), with average tariffs per kilowatt-hour of $0.15.

There are also substantial differences in average electricity tariffs across country income groups. Overall, the most expensive electricity tariffs (across all customer categories) are to be found in high-income countries at $0.23 per kilowatt-hour on average. By contrast, average tariffs in low- and middle-income countries average at $0.16 and $0.15 respectively per kilowatt-hour. These differences can be explained in terms of wider practice of cost recovery pricing principles in high income countries, as well as greater prevalence of high environmental standards (for example in countries such as Germany, Japan and Chile).

Figure 4. Average residential and commercial electricity tariff by country (USD p. kWh)

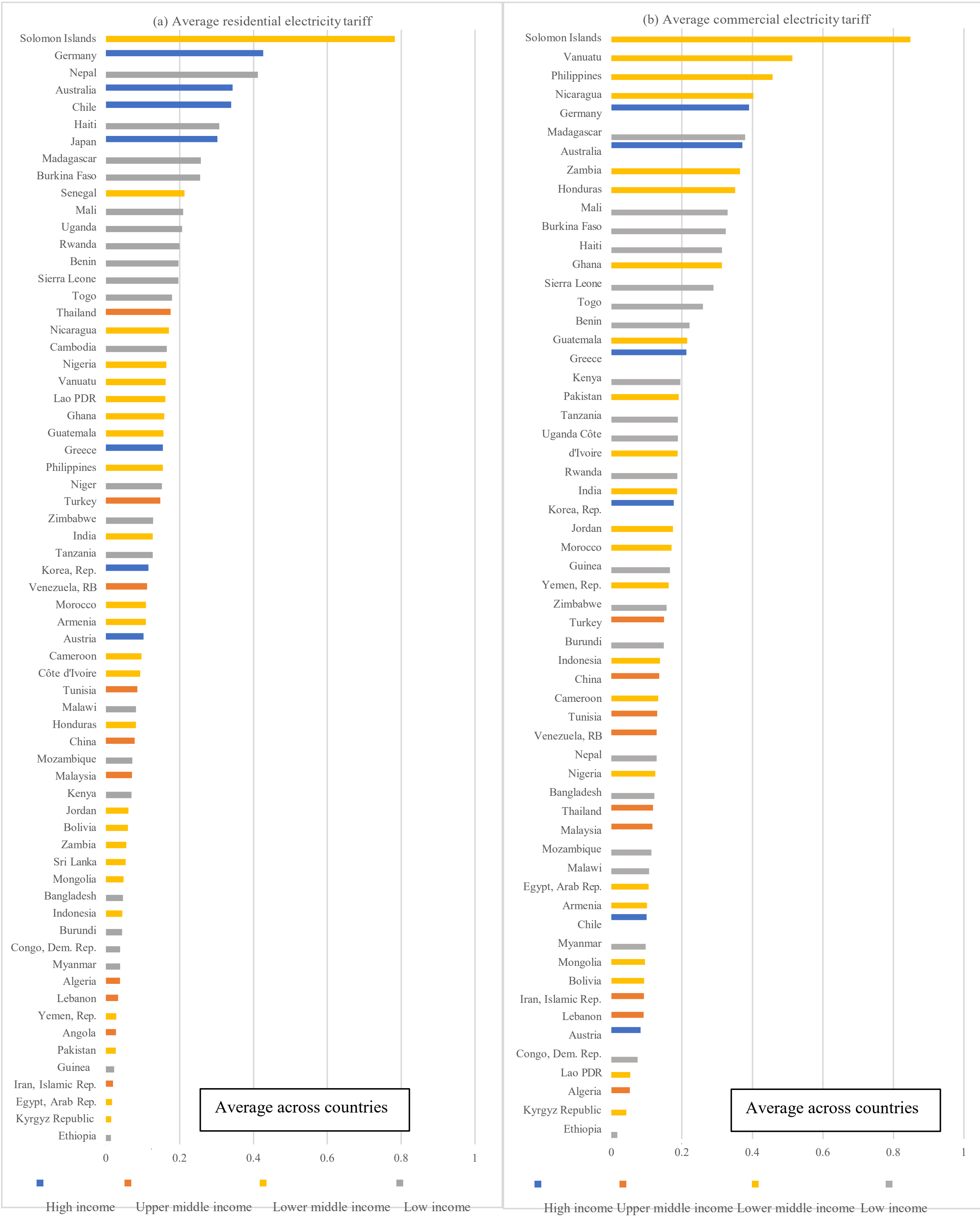
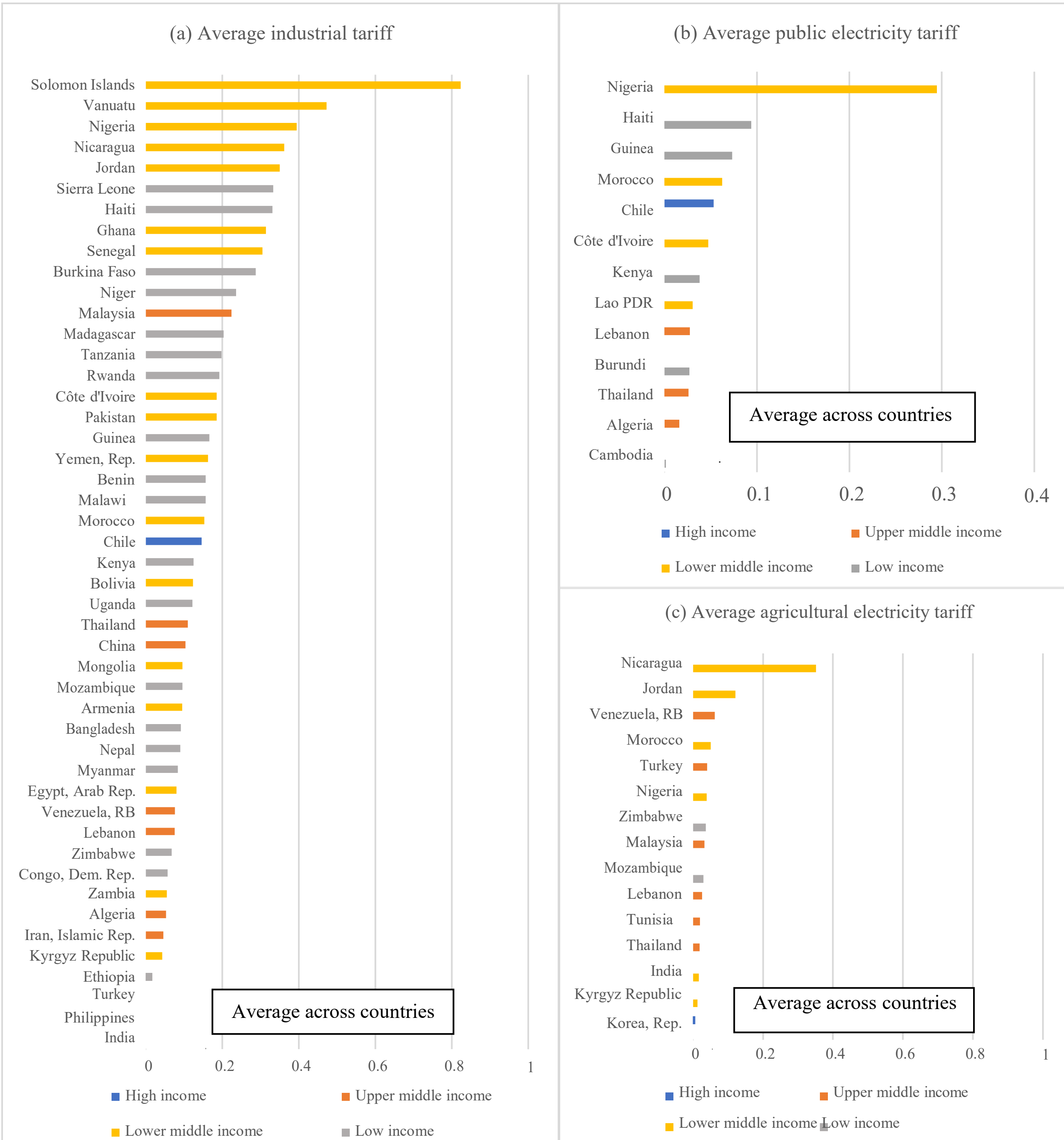


Figure 5. Average industrial, agricultural and public electricity tariff by country (USD p. kWh)



4. Design of Electricity Tariff Structures

The purpose of this section is to portray how electricity tariff structures are designed. Separate consideration will be given to structures based on volumetric consumption, and those that reflect load or time-of-use.

As noted above, around the world, countries invariably apply some form of volumetric charging for energy, typically based on linear or increasing block tariff structures (Figure 6a). While linear tariffs are the norm for public sector consumers, and widespread among agricultural and industrial schedules, they are less frequently applied for commercial and residential consumers. In the case of residential customers, about 60 percent of countries make use of Increasing Block Tariffs (IBTs), or some other form of complex volumetric design, including decreasing or non-monotonic block structures. Volumetrically differentiated charges are applied to residential tariff schedules in some 10 percent of all countries surveyed.

Tariffs with demand-based charges are more widely used for commercial and industrial customers (almost a fifth of industrial schedules contain load-differentiated tariffs) (Figure 6b). Load-based tariffs are in addition found in combination with other volumetric tariff structures in commercial and industrial schedules – in figure 6b these cases fall under the "Other" category. Demand-based schedules are rarely used in the case of residential customers, and then only in a handful of high-income countries.

Figure 6a. Share of countries with different types of volumetric tariff structures, by customer class

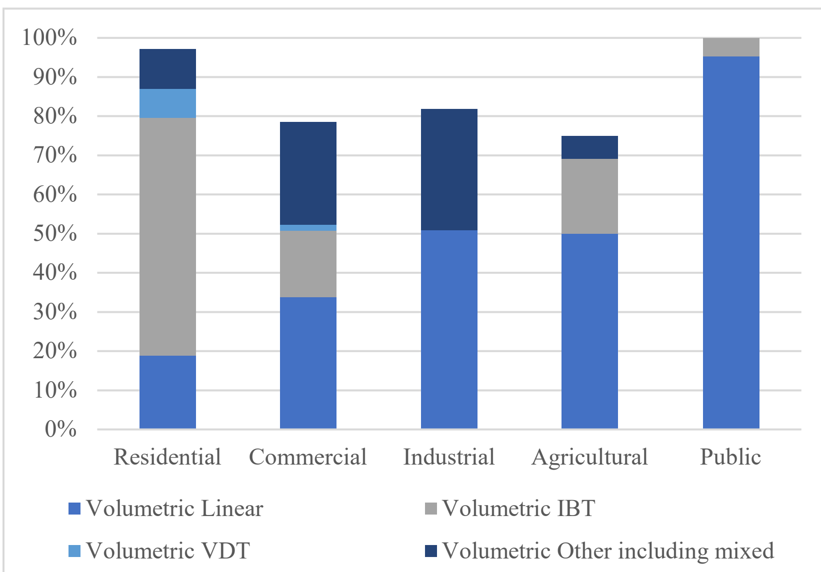
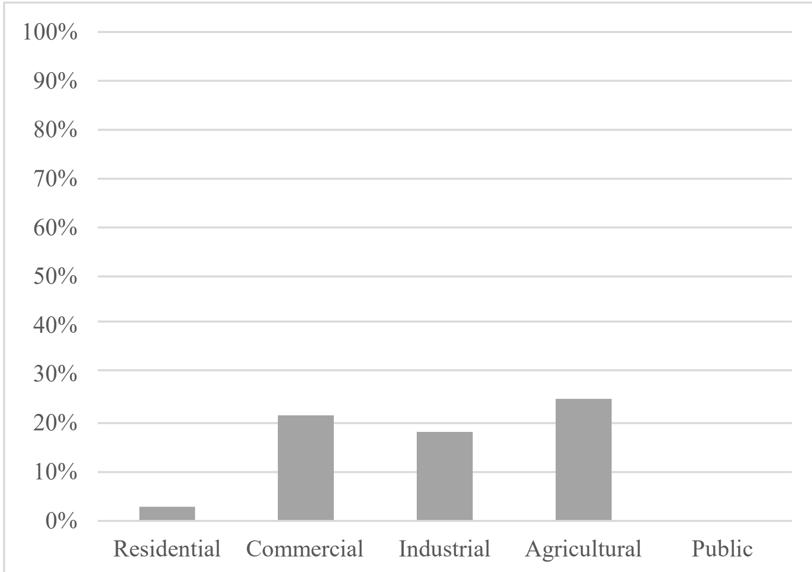
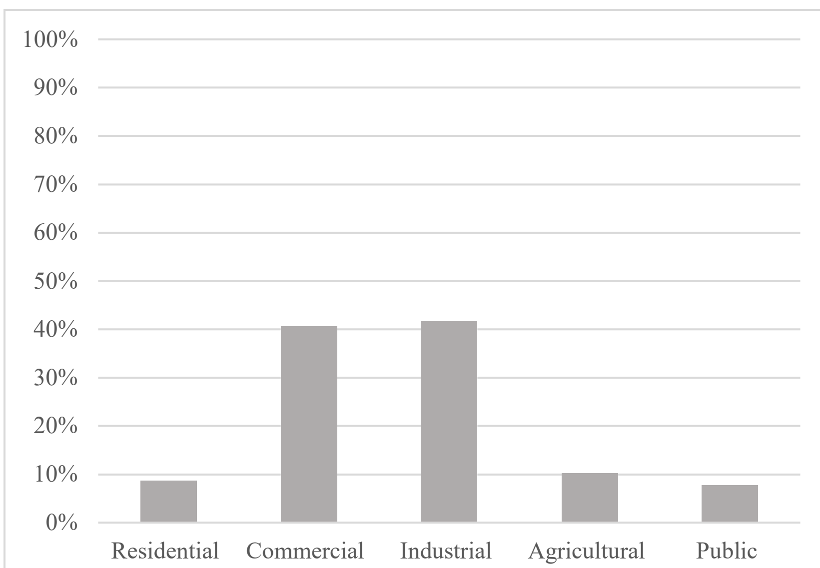


Figure 6b. Share of countries with load-based tariff structures, by customer class



Time-of-use charges remain comparatively rare for all but large industrial and commercial customers, for whom they are already practiced in 40 percent of the countries surveyed (Figure 6c).

Figure 6c. Share of countries with TOU tariffs, by customer class



4.1 Volumetric Tariff Structures

This section will focus primarily on the design of IBTs, which are by far the most prevalent tariff structures for residential customers. The rationale for adopting this kind of tariff structure is to provide a 'social safety net' whereby all consumers can access a basic subsistence volume of consumption at a very affordable tariff, while ensuring that the resulting revenue shortfall is recovered by surcharges on the largest consumers.

IBTs may incorporate a fixed charge that is incurred before any electricity is consumed, and which is (at least notionally) designed to recover the administrative costs associated with billing customers. Such charges are relatively common, found in 65 percent of countries practicing IBTs, but they are typically very small, amounting to no more than $1.9 per month on average or less than 10 percent of the average monthly bill.

The design of IBTs hinges on the number of blocks, the size of those blocks, and the unit price that attaches to consumption in each of those blocks. Looking across the countries surveyed, the number of blocks incorporated in the residential tariff design varies significantly from two to eight, with an average value of 4. The size of the first block averages at 149 kilowatt-hours with a range of 15-2,000 kilowatt-hours, while the size of the final block averages at 430 kilowatt-hours with a range of 25-2,000 kilowatt-hours (Figure 7a).

More significant than the absolute sizes of these consumption blocks is their size relative to average consumption in the respective country. In order for the IBT structure to function as intended, the size of the first block should fall well below average consumption to avoid a situation where a majority of consumers are paying the discounted price associated with the first block. At the same time, the size of the last block should not fall too far above the average consumption to ensure that a significant proportion of consumers are contributing the surcharges needed to keep the structure in balance. The analysis of these ratios shows that the first consumption block represents about 50 percent of average monthly electricity consumption, with a range of 60 to 1200 percent (Figure 7b). The last consumption block takes up on average 70 percent of the average monthly electricity consumption. Median electricity consumption lies at 90 percent of the first block and 30 percent of the last block. These ratios suggest that, at least on average, the design of IBTs ensures that a substantial share of residential consumption falls into the higher blocks. On average, the threshold for the last consumption block is almost seven times the ceiling on the first consumption block, with an average spread of 228 kWh between the two.

Figure 7a: Distribution of the absolute size of consumption blocks for residential IBTs (kWh)

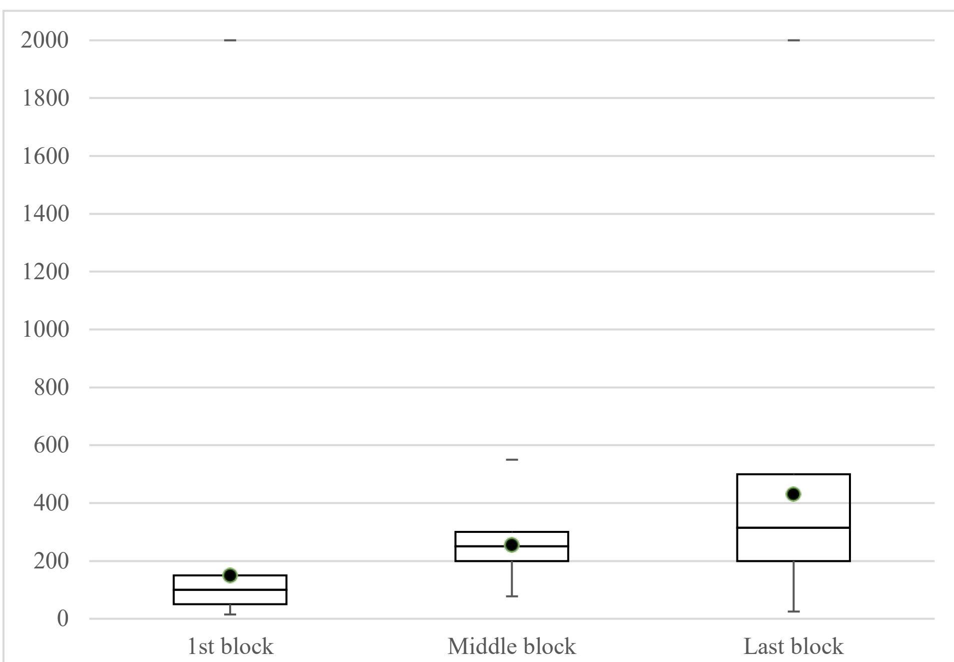


Figure notes: Bottom whisker cap = minimum; bottom box margin = 1st quartile; mid box bar = median; top box margin = 3rd quartile; top whisker cap = maximum.

Figure 7b: Distribution of the average residential electricity consumption to the relative size of consumption blocks for residential IBTs in each respective country (kWh)

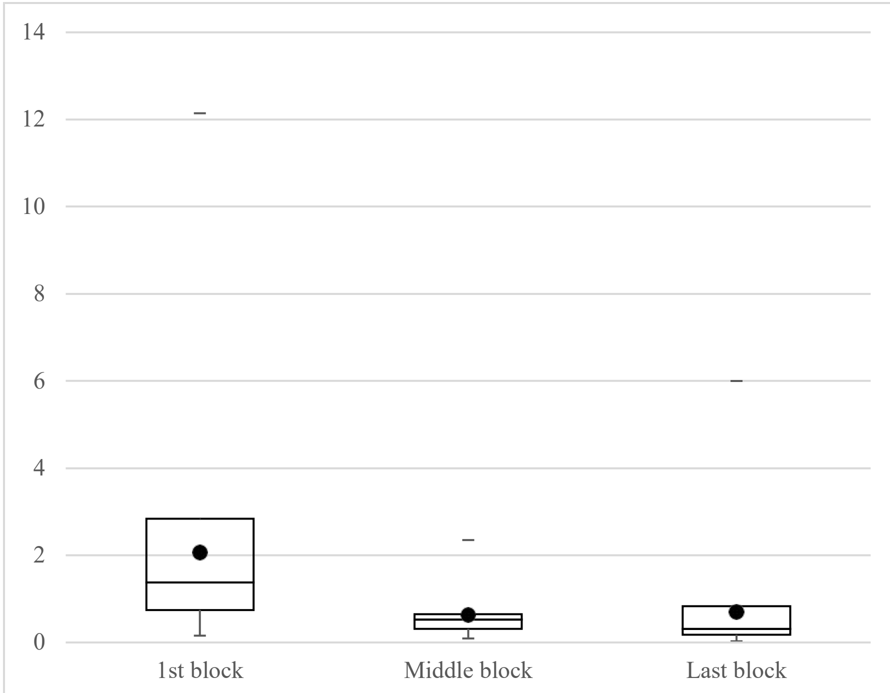


Figure notes: Bottom whisker cap = minimum; bottom box margin = 1st quartile; mid box bar = median; top box margin = 3rd quartile; top whisker cap = maximum.

The same exercise can be performed for the unit price attaching to each of these consumption blocks. The average unit price for the first block is $0.09 per kilowatt-hour with an interquartile range of $0.01-$0.26. By the time the last block of consumption is reached, the unit price has risen on average to $0.18 per kilowatt-hour with an interquartile range of $0.03-$0.65 (Figure 8a).

Once again, it is not so much the absolute value of the unit price that matters, but the extent to which it is high enough to recover the full costs of the electricity service. While the consumption of the first block may legitimately be priced below cost recovery level, the expectation is that consumption in the middle blocks should be priced at cost recovery, while consumption in the last block should be priced above cost recovery to compensate for the first block. These properties of the tariff structure can be explored by looking at the distribution of the ratio of the unit price in each block to the limited capital cost recovery benchmark in each respective country. The analysis of these ratios shows the charge on the first consumption block on average covers about 57 percent of operating costs, while the charge on the last consumption block represents 101 percent of operating cost (Figure 8b).[5]

[5] In the case of commercial customers, a similar pattern of results holds.

Figure 8a: Distribution of the absolute value of block prices for residential IBTs (USD p. kWh)

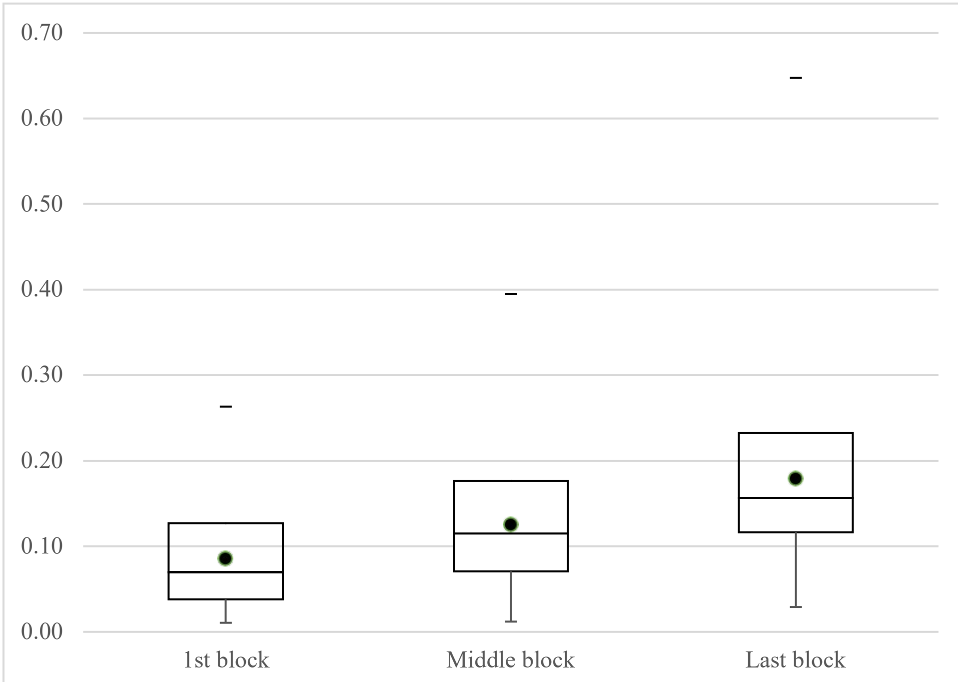


Figure notes: Bottom whisker cap = minimum; bottom box margin = 1st quartile; mid box bar = median; top box margin = 3rd quartile; top whisker cap = maximum.

Figure 8b: Distribution of the relative level of block prices for residential IBTs to operating cost recovery benchmark in each respective country

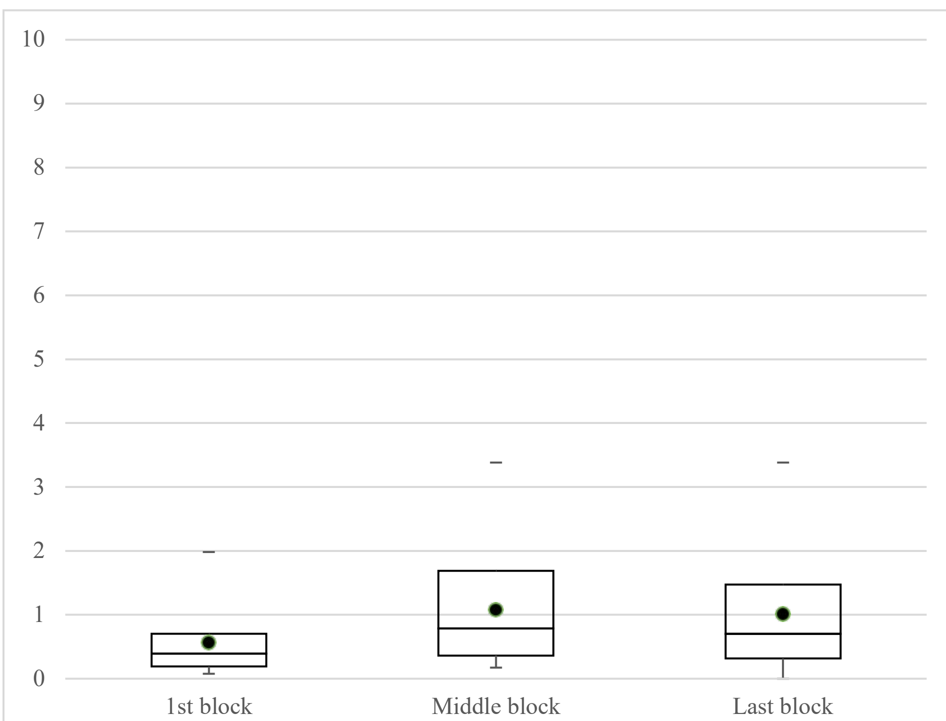
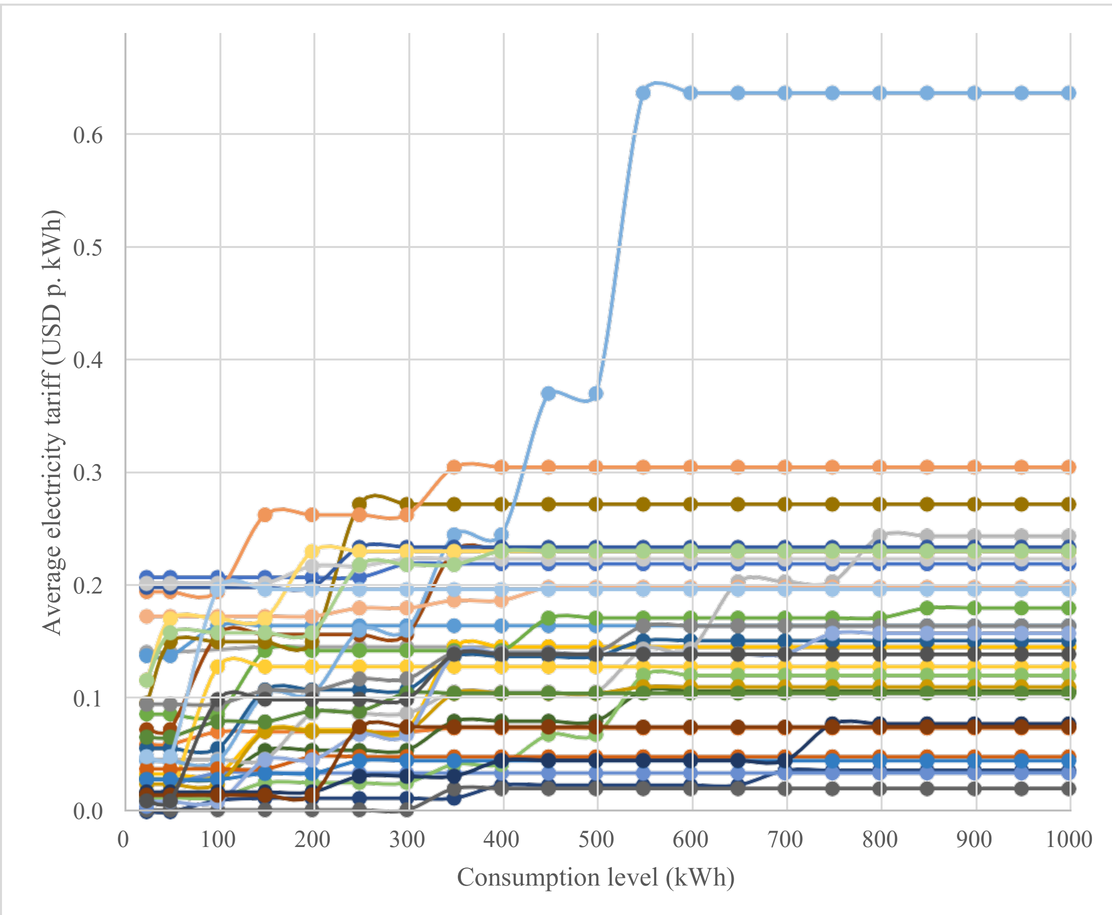


Figure notes: Bottom whisker cap = minimum; bottom box margin = 1st quartile; mid box bar = median; top box margin = 3rd quartile; top whisker cap = maximum.

One way of summarizing the overall IBT structure is to calculate the gradient of unit prices against consumption levels for each country, which is to say the change in unit price between the first and last blocks over the difference between the ceiling of the first block and the threshold of the last block. On average, this gradient is such that the unit price of electricity rises by $0.004 per kilowatt-hour (or just under half a dollar cent) for every additional 50 kilowatt-hours of monthly consumption.

Finally, it can be helpful to visualize the IBT structures by plotting all of them on a single chart (Figure 9). From the resulting cloud of lines, it becomes possible to identify outliers. The Republic of Korea stands out as exhibiting a steep IBT structure, with the highest IBT block price at $0.64, while Guinea's IBT is relatively flat, rising from $0.01 to $0.03.

Figure 9: Visualization of gradients across residential IBTs



In sum, IBT structures have been popular and widely promoted, due to the belief that they combine protection for small and vulnerable consumers with strong incentives for efficient usage among larger more affluent consumers. Nevertheless, there is extensive evidence that IBTs are not very effective at protecting poorer customers, and even when they do so this comes at the cost of subsidizing a large share of customers who do not fall into the low-income group (Komives et al., 2005 and Angel-Urdinola and Wodon, 2007). Another concern is that – in the context of technological change – IBTs may over-incentivize the adoption of rooftop solar by large consumers, while under-incentivizing the adoption of electric vehicles (McRae and Wolak, 2019).

4.2 Time-of-Use–Based Tariff Structures

As noted above, Time-of-Use Tariffs are a variation of volumetric charging that is present in less than half of the countries. The application of Time-of-Use tariffs is predicated on the installation of smart meters that are able to record the time of consumption. They have primarily been adopted in middle- and high-income countries for application to commercial and industrial customers, who may have greater flexibility to adjust their electricity consumption to time of day price signals, and whose higher consumption levels more readily justify the greater investment in smart meter infrastructure.

Time-of-Use tariffs operate essentially as linear tariffs where the volumetric price is differentiated according to the time of day when the electricity is consumed. Time-of-Use tariffs typically operate with either two time periods (usually an evening peak period and an off-peak) or three periods (usually an evening peak, daytime and nighttime).

It is interesting to examine the levels of prices that different categories of customers are facing between the peak period and the cheapest off-peak period (Figure 10). Overall, the ratio of Time-of-Use prices between the most expensive and cheapest time periods across countries is of the order of two. The highest gradient between peak and off-peak energy charges (2.7) is found in the residential customer class, followed by the industrial and agricultural groupings, which lie at 2.2 and 1.9 respectively. Several countries stand out for high differences between peak and non-peak volumetric prices, notably the Islamic Republic of Iran in the case of residential TOU charges, Morocco for commercial customers and the República Bolivariana de Venezuela for industrial users. (Figure 10).

Figure 10: Distribution of price gradients across Time-of-Use tariff structures by customer class

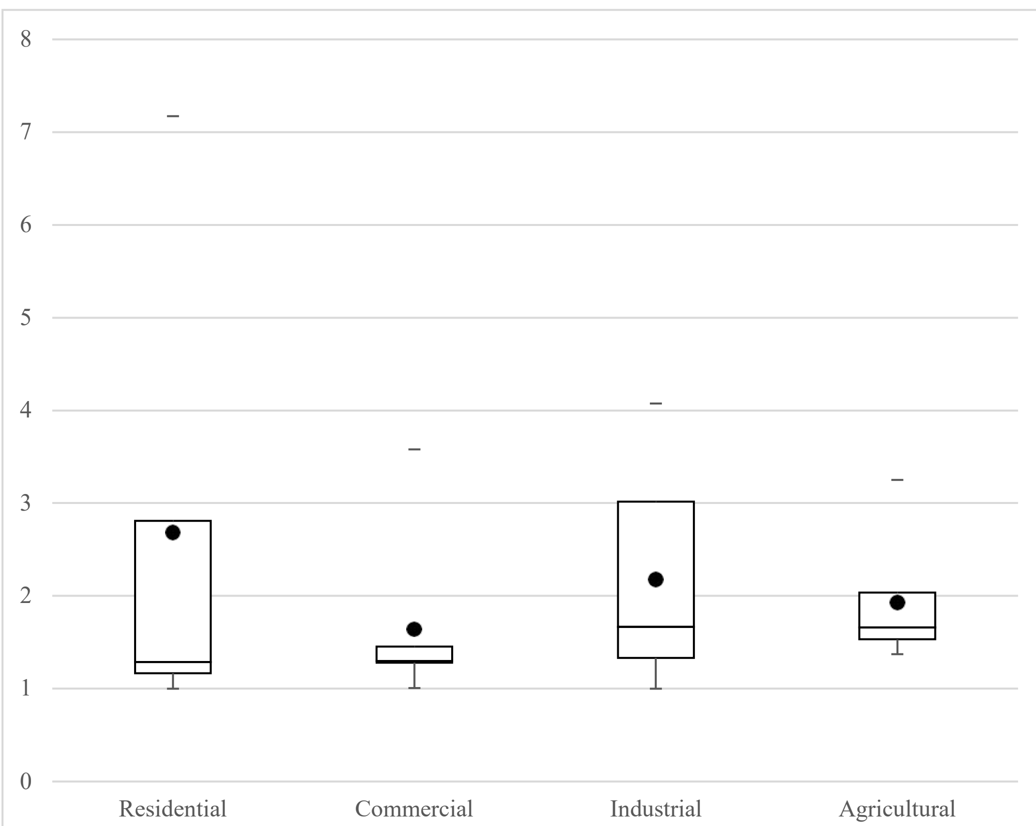


Figure notes: Bottom whisker cap = minimum; bottom box margin = 1st quartile; mid box bar = median; top box margin = 3rd quartile; top whisker cap = maximum.

Time-of-Use tariffs are expected to become increasingly important in the future, because they provide valuable information to consumers who are increasingly empowered by distributed energy technologies. Time-differentiated price signals are essential to incentivize economically efficient investments in rooftop solar and battery storage, as well as participation of demand-side response. Time-of-Use tariffs may also play an important role in the future by incentivizing the charging of electric vehicles during off-peak periods. The relatively low prevalence of such tariffs, as of 2015, indicates that there is still a long way to go before energy pricing fully supports decisions by decentralized actors.

4.3 Load-Based Tariff Structures

As noted above, a significant share of countries has introduced load-based elements to their tariff structures, sometimes known as demand charges, which are added on as additional fixed charges to the volumetric component of the power bill. The application of load-based charges is premised on a prior assessment of the maximum installed capacity for power consumption at the customer's premises. In some countries, banding is used to determine the charge falling on each customer. Typically, the bands fall along the following lines: In some cases, charges are linear on a per kilowatt basis, but additionally differentiated by low voltage, medium voltage and high voltage categories. In other cases, bands are further categorized by multiple kilovolt or kilowatt levels. Finally, the charge is often simply linear on a per kilowatt basis.

Figure 11: Distribution of load charges across customer groups (USD p. kW)

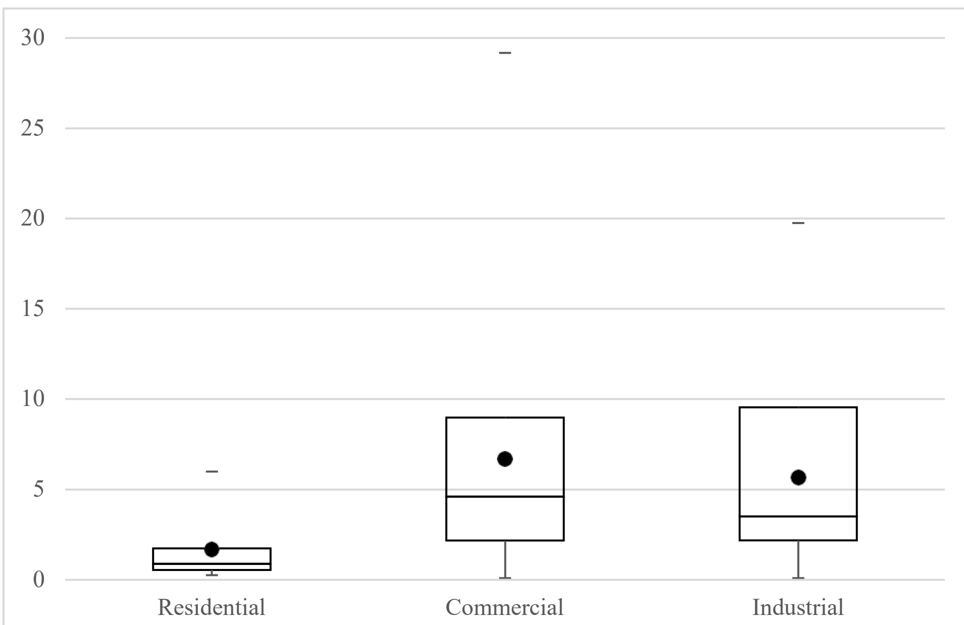


Figure notes: Bottom whisker cap = minimum; bottom box margin = 1st quartile; mid box bar = median; top box margin = 3rd quartile; top whisker cap = maximum.

The average load charge ranges from around $2 per kilowatt for residential customers, to $7-8 per kilowatt for commercial and industrial users. The dispersion of load charges practiced across countries is very much higher for non-residential customers. Where demand charges exist, they typically comprise about 25 percent of the monthly bill of an average customer, considering residential, commercial and industrial groupings.

Such charges are becoming increasingly important with the uptake of rooftop solar PV energy. When customers pay the electric utility solely on a volumetric basis, the savings that they make from the installation of rooftop solar may be quite large, even though they continue to depend heavily on the grid for back-up services. Going forward, a rebalancing of electricity bills from volumetric to load charges may better reflect the nature of the services that the grid provides to consumers, and ensure that adoption of rooftop solar is correctly incentivized.

4. Performance of Tariff Structures

The purpose of this section is to explore the performance of electricity tariff structures against three simple and widely used metrics. First, an examination of the ratio between average tariffs and average costs allows an assessment of whether pricing achieves cost recovery. Second, the affordability analysis looks at the ratio of average bills to the budget of the poorest and considers whether electricity bills are within the reach of poor households and hence are consistent with considerations of vertical equity. Third, the analysis of price differentiation examines the extent to which electricity pricing departs from a uniform price for all consumers and provides a first order indication of the efficiency of the tariff structure and the extent to which distortions and cross-subsidies are embodied therein.

4.1 Cost-Recovery

Underpricing of electricity can prejudice power utilities by preventing adequate maintenance expenditures, limiting their access to investment capital, and impacting debt sustainability (Huenteler et al., 2017). As noted above, operating and limited capital cost benchmarks will be used as a basis for assessing cost recovery. Cost benchmarks are calculated net of taxes, to see to what extent tariffs are aligned with underlying sector costs.

Overall, residential tariffs are close to operating cost recovery, but are still a long way from recovering limited capital costs. Commercial tariffs are about 50 percent above the operating cost of service on average, and just about cover limited capital costs also (Figures 12a and 12b). Public tariffs barely cover half of operating costs, while no data are available for on the limited capital cost side. Looking across countries, residential tariffs only cover limited capital costs in 50 percent of countries, rising to 70 percent in the case of commercial tariffs. (Figure 13). This suggests that cost-recovery may indeed be more challenging an objective for politically-favored groups.

Unsurprisingly, the results on cost recovery vary across income groupings and according to the cost of electricity production. The average electricity tariff is plotted against the average limited capital cost of electricity production for some 16 countries that have financial statements for the distribution segment available. This analysis is undertaken for residential customers in Figure 13 and commercial customers in Figure 14. Each country is represented by a point in the scatter chart, with the color of the dot indicating the income group. Countries appearing towards the right-hand-side of the chart face higher costs of electricity production than those appearing towards the left. The 45-degree line separates those countries where tariffs exceed limited capital cost recovery, which lie above the line, from those whose tariffs fall short of limited capital cost recovery and lie below the line.

Results are more sensitive to income group in the case of residential customers than in the case of commercial customers. Some 66 percent of low-income countries fail to recover limited capital costs for residential users, compared with 25 percent of middle-income countries and a third of high-income countries (Figure 13). By contrast, only about 25 percent of low-income countries fail to cover limited capital costs, compared with around 20 percent of middle-income and two-thirds of high-income countries (Figure 14). Countries that stand out as exhibiting high limited capital costs and low electricity tariffs are Guinea, Austria and Sierra Leone.

Figure 12a. Average operating cost-recovery ratio, by customer class

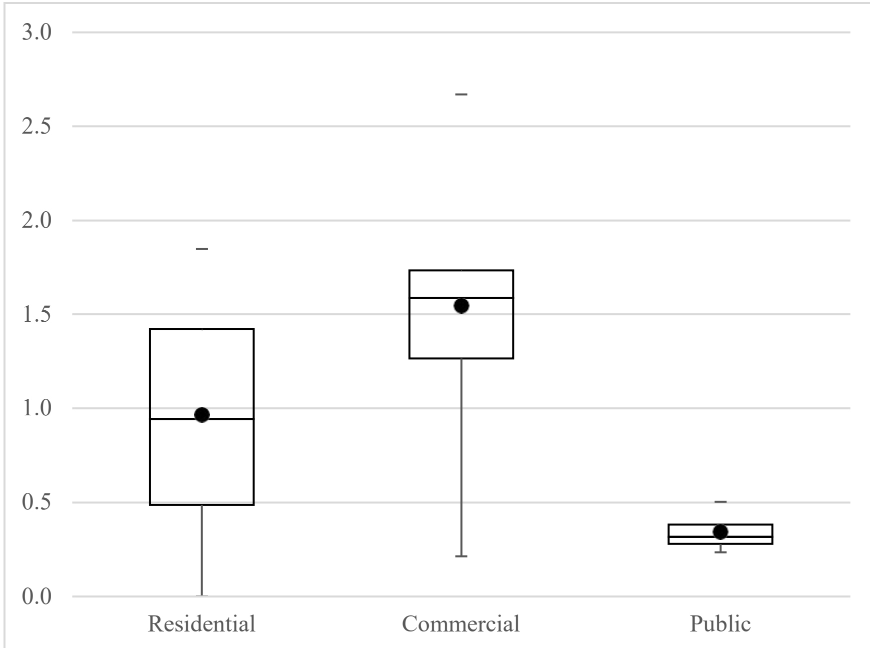


Figure notes: Bottom whisker cap = minimum; bottom box margin = 1st quartile; mid box bar = median; top box margin = 3rd quartile; top whisker cap = maximum.

Figure 12b. Average limited capital cost-recovery ratio, by customer class

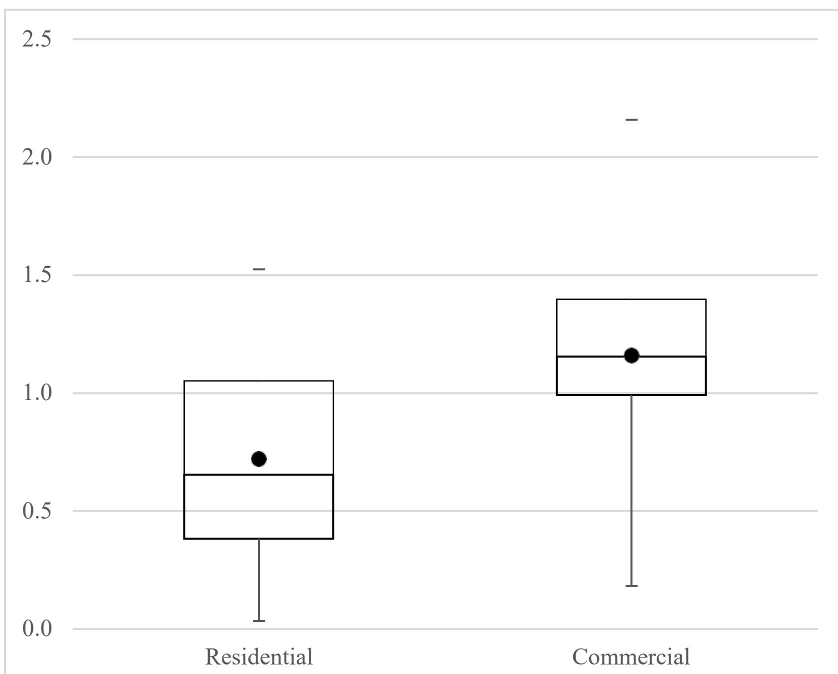
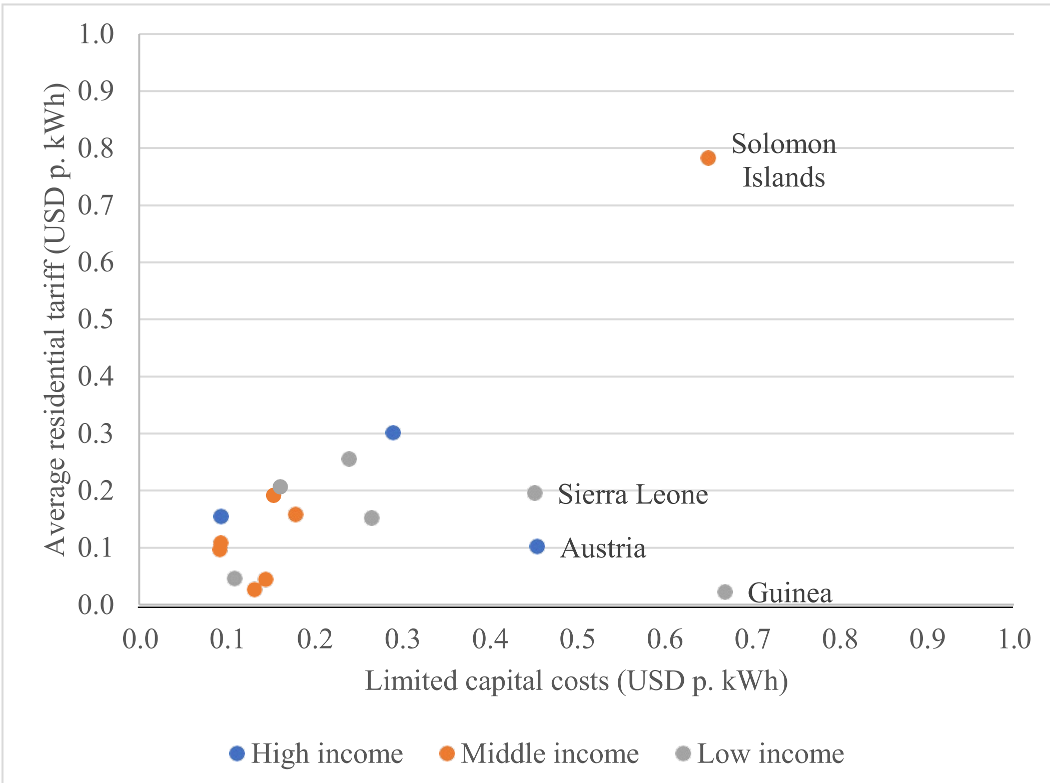


Figure notes: Bottom whisker cap = minimum; bottom box margin = 1st quartile; mid box bar = median; top box margin = 3rd quartile; top whisker cap = maximum.

Results are also sensitive to the absolute level of limited capital costs, with the ability to recover costs inversely related to the cost level. As far as cost of electricity production is concerned, it is instructive to compare the performance on cost recovery for countries with limited capital costs above and below US$0.20 per kilowatt-hour. For residential customers, only 40 percent of countries with limited capital costs above US$0.20 per kilowatt-hour are able to recover costs, compared to 55 percent of countries with lower costs of production (Figure 13). Results for commercial customers are starker: 50 percent of countries with limited capital costs above US$0.20 per kilowatt-hour are able to recover costs, compared to over 80 percent of countries with lower costs of production (Figure 14).

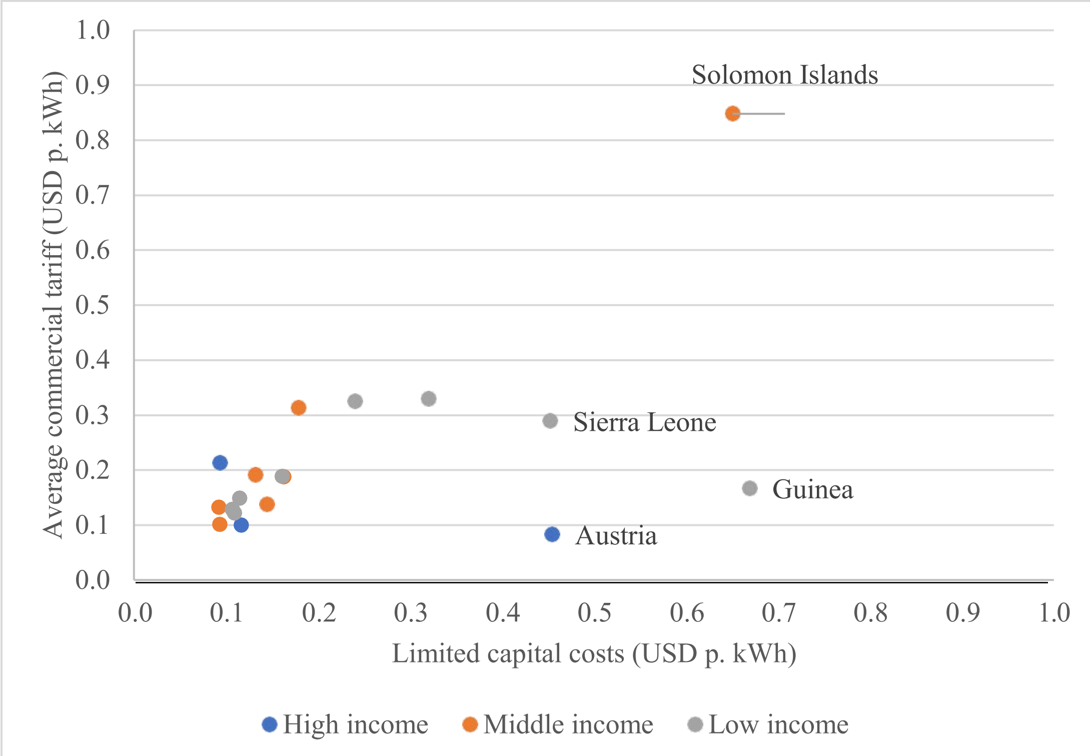
Figure 13. Limited Capital Costs against the Residential Tariff, by Income Group



Updated information on tariff structures for the same set of utilities in 2016 makes it possible to analyze the extent to which power tariffs kept up with general inflation levels in the country. Of the 25 residential tariff schedules in the panel data set, only 5 exhibit an increase in the average nominal tariff from 2015 to 2016, compared to 9 of the 19 commercial schedules and 7 of the 15 industrial schedules. An overwhelming majority of residential tariffs (80 percent) either fell or failed to increase in nominal terms.

Taking into account the inflation rate over this time period, only 16 percent of residential schedules kept up with changes in the consumer price index (CPI), compared to 42 percent of commercial tariffs and 46 percent of industrial electricity prices.

Figure 14. Limited Capital Costs against the Commercial Tariff, by Income Group

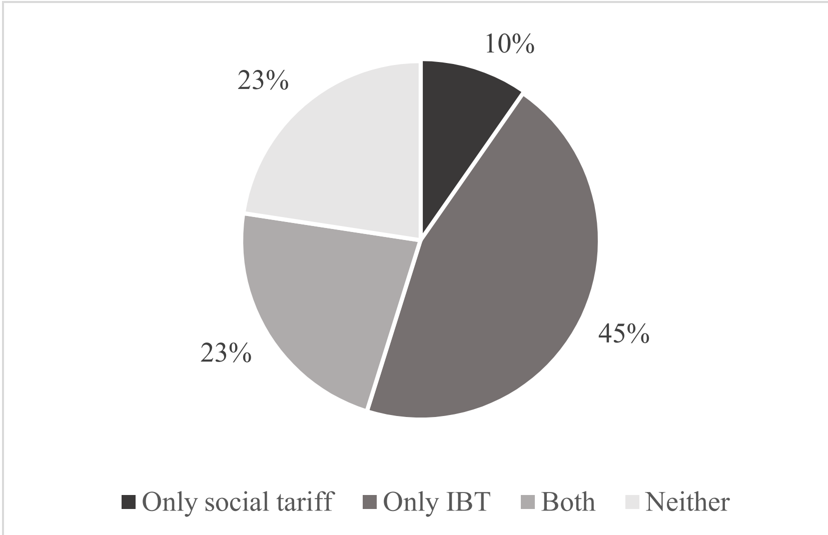


4.2 Affordability

In order to gauge whether electricity tariffs are affordable, the share of the monthly household budget of the bottom 40% of a country's income distribution that is spent on the representative electricity bill is calculated. Any taxation of electricity bills is included in the calculation, as it affects affordability for consumers. The rule of thumb in the literature is that a budget share under 5 percent is definitely affordable, a budget share between 5-10 percent starts to pose some affordability concerns, while a budget share over 10 percent is definitely beyond the bounds of affordability. More generally, the 5 percent threshold is often used to capture basic lighting and appliance usages of electricity typical of tropical countries, while the 10 percent threshold presupposes some thermal uses of electricity appropriate to colder climates.

Around three-quarters of countries have adopted some tariff design measures aimed at safeguarding affordability (Figure 15). About 45 percent of countries do so solely through the adoption of an IBT structure, while a further 23 percent offer multiple IBT structures, one of which is more oriented towards socially disadvantaged groups. Only 10 percent of countries offer just a social tariff structure without increasing block characteristics.

Figure 15. Share of countries that have adopted affordability measures



In the minority of countries that address social concerns solely through a social tariff, the evidence suggests that these tariffs are effective at improving affordability. Figure 16 compares the budget share spent on electricity for a representative household with average consumption depending on whether or not they are charged according to the social tariff. The results show that in almost 80 percent of countries the social tariff structure resulted in electricity consumption being affordable, and that this share would fall to 50 percent if poor consumers had to pay according to the regular tariff structure.

Figure 16. Share of countries with affordable electricity tariffs when social tariffs are in place

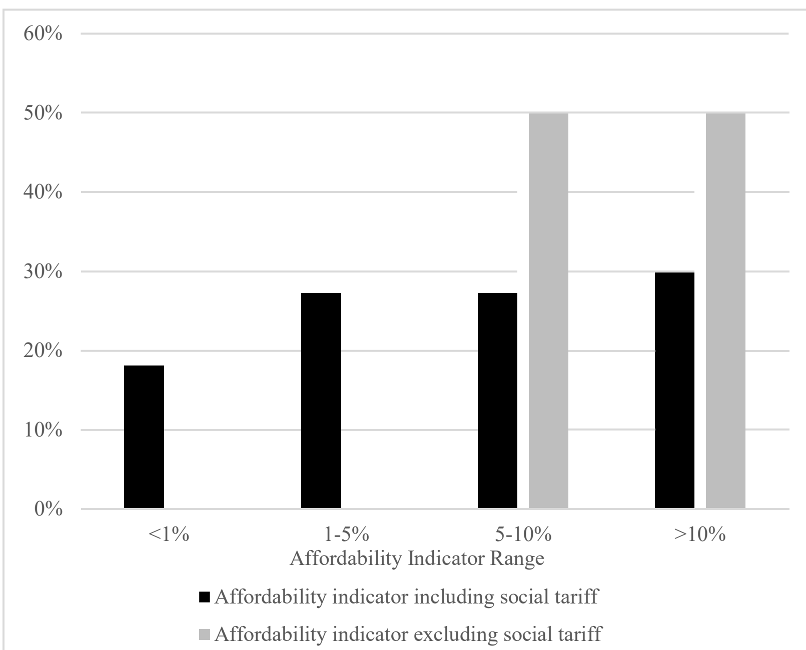
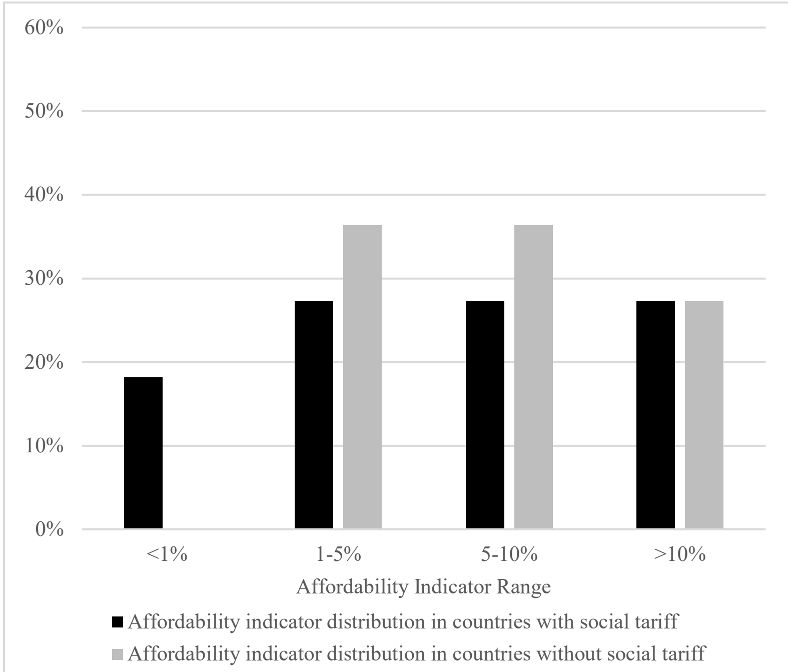


Figure 17. Share of countries with affordable electricity tariffs comparing those with and without social tariffs



Turning to the sample as a whole, countries with explicit social tariffs do somewhat better at safeguarding affordability for low income consumers than countries that lack such tariffs and handle affordability issues through a single IBT structure (Figure 17). While in both cases about one in four countries still faced affordability challenges on average, those countries with explicit social tariffs were much more likely to be able to keep the burden of electricity tariffs below 1 percent of the budget of the bottom 40 percent.

Overall, the various affordability measures result in a substantial discount over the regular electricity tariff for eligible consumers. Nearly 85 percent of the electricity tariffs with the social tariff discount applied are up to 60 percent cheaper than the non-discounted equivalent. However, this discount mostly affects tariff schedules that are already affordable. The difference between the affordability indicators including and excluding the social tariff is largest in countries where the standard electricity bill already takes up less than 5 percent of the income of the bottom 40 percent.

Most of the countries that have an affordability problem do so due to very low household income (Figure 18). Affordability problems are strikingly concentrated in low income countries. All countries with electricity bills absorbing over 10 percent of household incomes exhibit incomes per capita of less than $500. This is despite the fact that almost all of these countries have monthly electricity bills well below US$20. In higher income countries, much higher monthly electricity bills can remain affordable, due to the fact that even the poorest households enjoy higher absolute income levels.

The data suggest that higher levels of limited capital cost recovery are associated with larger affordability problems (Figure 19). The correlation coefficient between the cost-recovery measure and affordability indicator is 0.32, indicating a trade-off between reducing the burden of the monthly electricity bill for the poorest households and improving cost-recovery.

Figure 18. Average electricity bill against income per capita

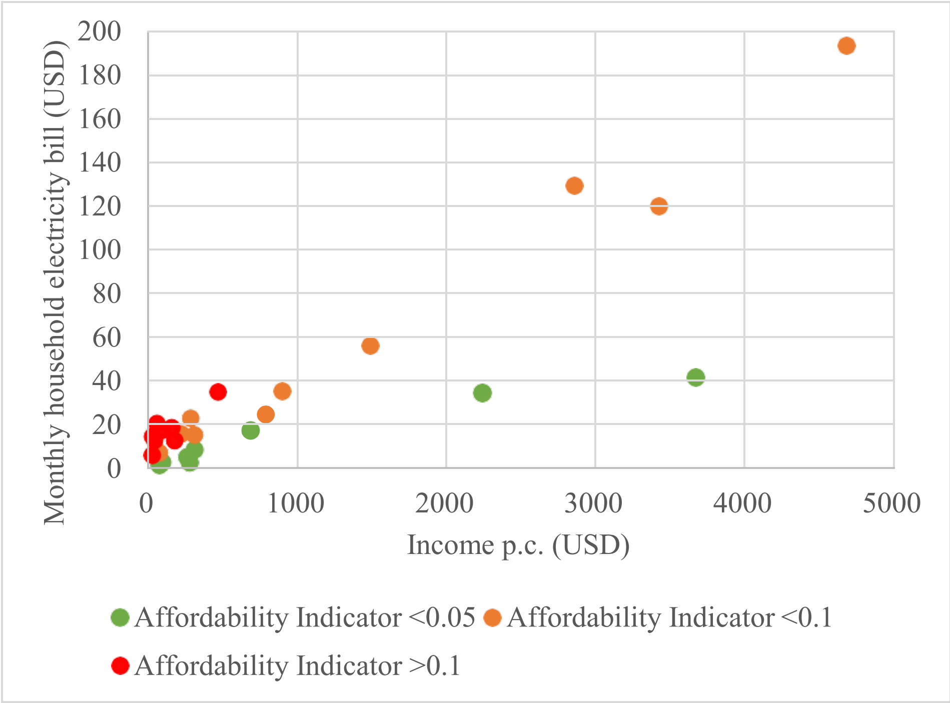
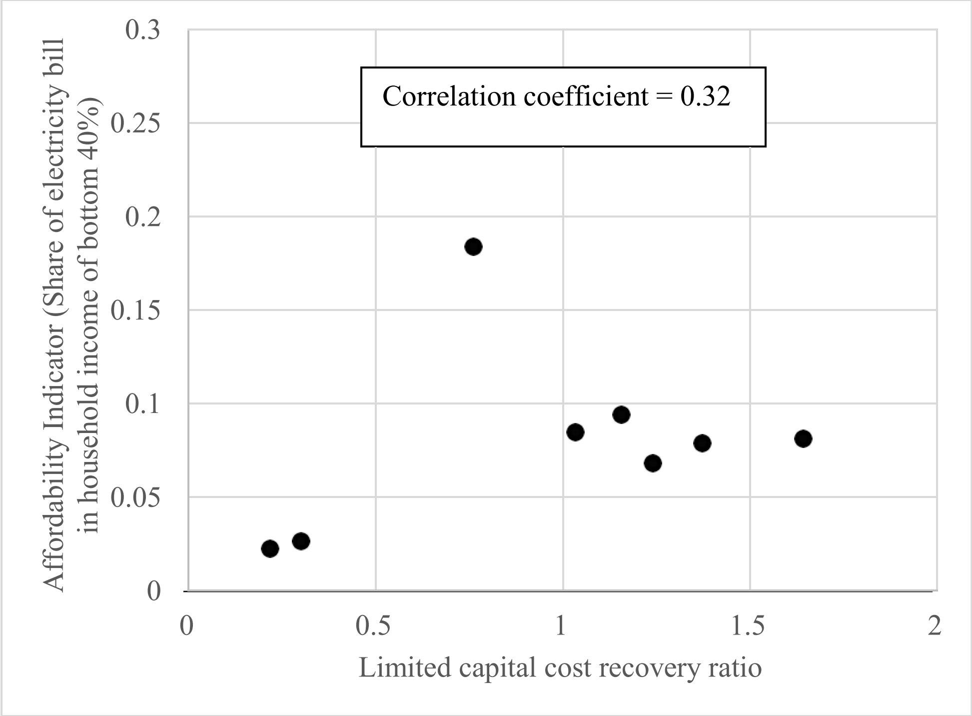


Figure 19. Affordability indicator against limited capital cost recovery ratio



4.3 Price Differentiation

Price differentiation captures the extent to which electricity prices for the same service vary across customer groups. Price differentiation poses immediate issues of fairness (or horizontal equity). It may also be used as a rule of thumb for evaluating the presence of cross-subsidies; even though – in strict economic and financial terms – this is not necessarily the case. Overall, price differentiation is widespread in the design of electricity tariff structures with residential and agricultural customers being the major beneficiaries.

In over 60 percent of the countries, industrial customers pay more than residential customers despite imposing likely lower costs on the system, while in almost 80 percent of the countries, commercial customers pay more than residential customers despite imposing similar costs on the utility (Figure 20a). These cross-subsidies are very large in magnitude: on average, commercial and industrial customers pay more than twice as much per unit of energy as residential customers.

Price differentiation in favor of agricultural customers is even greater. It is almost universal practice that industrial, commercial and residential customers pay more than agricultural customers, despite the fact that they do not cost any more to supply (Figure 20d). Moreover, the magnitudes of cross-subsidies in favor of agricultural customers are much larger than those in favor of residential customers: on average, non-agricultural customers pay five times as much for electricity as the tariff applied to agriculture.

Price differentiation in favor of public sector customers is much less common, practiced only in around one-third of the countries. Yet, when practiced, the price differential between public sector clients and other consumer groups excluding agricultural customers is relatively large compared to the other cases.

Figure 20a. Cross-subsidies between residential and other customer groups

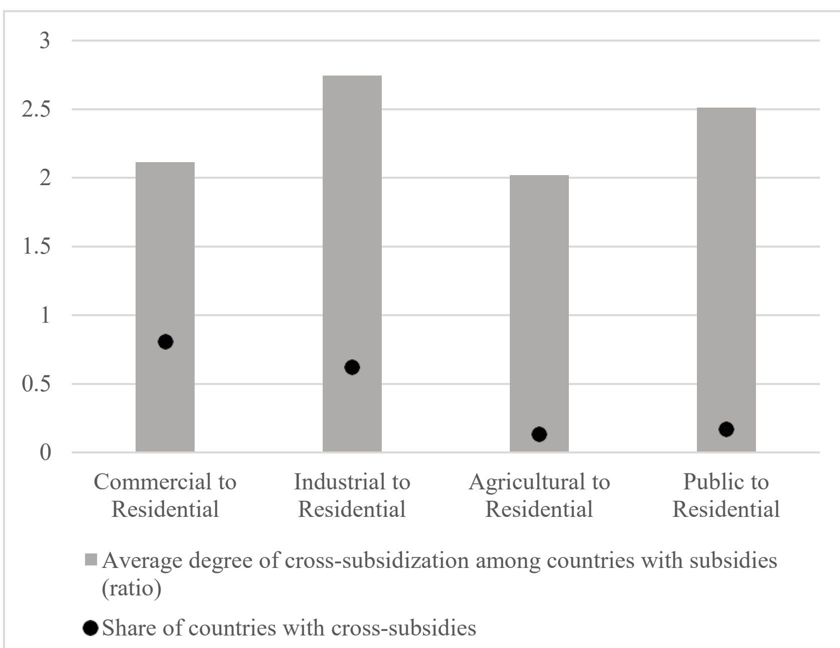


Figure 20b. Cross-subsidies between commercial and other customer groups

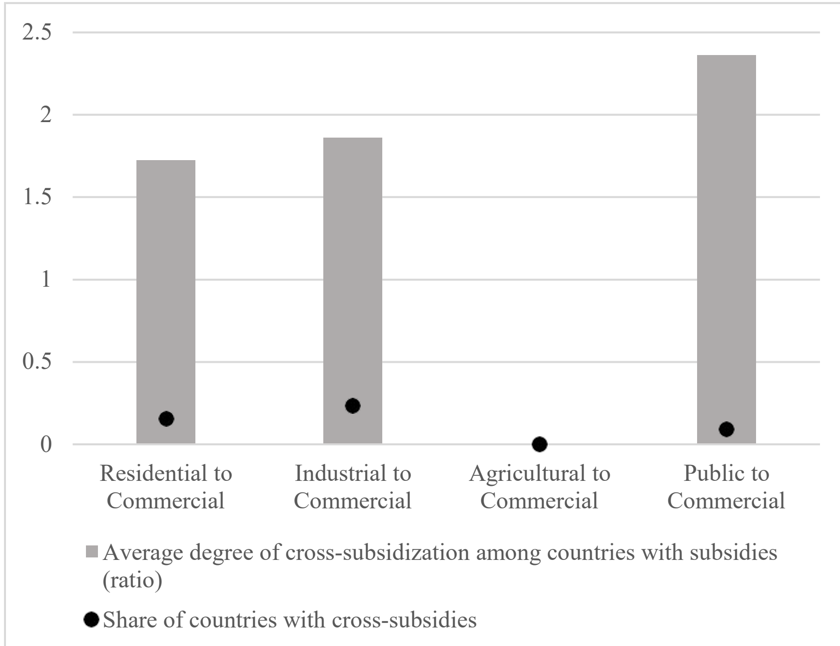


Figure 20c. Cross-subsidies between industrial and other customer groups

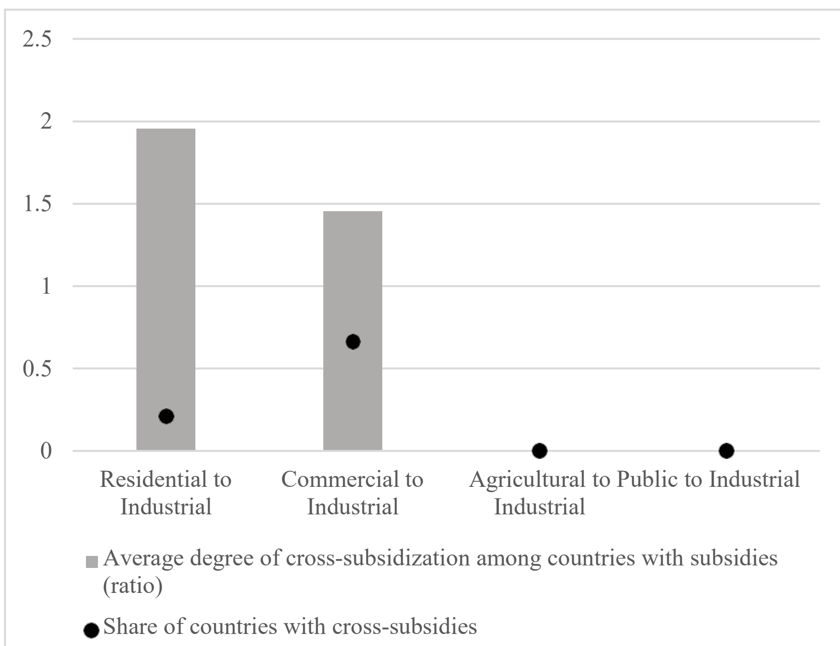
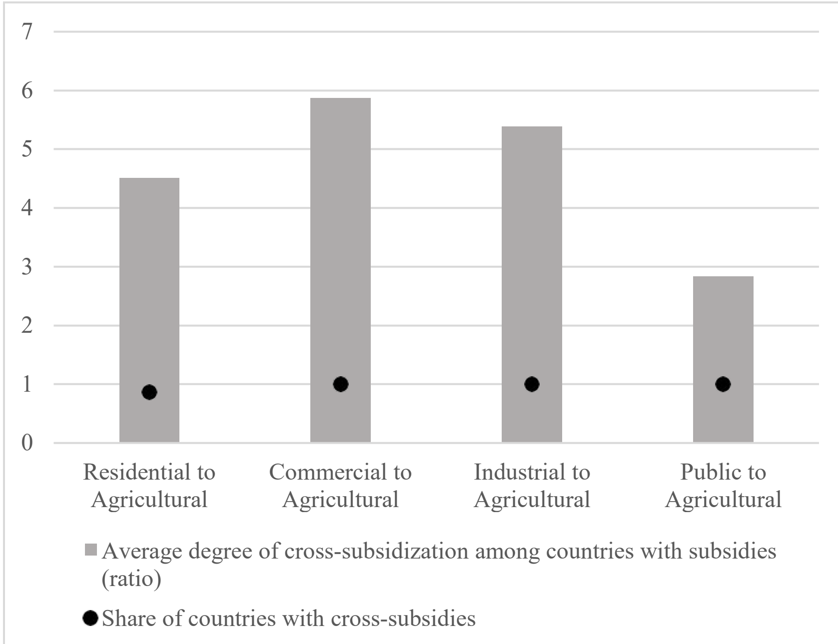


Figure 20d. Cross-subsidies between agricultural and other customer groups



6 Conclusion

In summary, this paper has provided a comprehensive survey of electricity pricing practices and tariff structure designs across more than 60 countries around the world. The results show that, on average, electricity prices stand at around \$0.13 per kilowatt-hour across all countries and customer categories. However, this average conceals huge variations, with the highest prices observed at around \$0.80 per kilowatt-hour, about 40 times higher than the lowest prices observed, at around \$0.02 per kilowatt-hour. Where separate agricultural tariffs exist, these tend to be the lowest at \$0.06 per kilowatt-hour on average. Prices are somewhat higher for public sector consumers (\$0.07 per kilowatt-hour on average), and considerably higher for residential customers (\$0.14 per kilowatt-hour on average) and particularly commercial and industrial customers (at close to \$0.20 per kilowatt-hour on average).

Electricity tariffs clearly reflect underlying cost drivers. Prices are particularly high for Small Island Developing States (SIDS): at \$0.26 per kilowatt-hour on average compared with \$0.16 per kilowatt-hour elsewhere. Countries with substantial domestic energy resources tend to enjoy relatively low tariffs, such as \$0.12 per kilowatt-hour for countries with hydro-power, and \$0.15 per kilowatt-hour for fossil fuel exporters. Consumers in high income countries generally face higher tariffs, at \$0.24 per kilowatt-hour on average, than those in low and middle-income countries, at \$0.15 per kilowatt-hour on average.

The results indicate that price differentiation is widespread. The vast majority of countries enforce tariff structures that benefit residential and agricultural consumption at the expense of commercial and industrial users. Residential tariffs are typically about half the level of industrial and commercial tariffs, while agricultural users tend to pay only about a fifth of what other user categories are charged.

Volumetric pricing remains the mainstay of electricity tariff structures. In the case of residential customers, 65 percent of the countries apply Increasing Block Tariffs (IBTs). For commercial and industrial customers, linear charges are more widely applied, and increasingly modified by Time-of-Use factors and complemented with load-related fixed charges, particularly in middle-income and high-income countries. Where Time-of-Use factors exist, they entail unit charges that are twice as high during peak as during off-peak periods. Where load-related charges exist, they typically entail fixed costs of around \$4.6 per kilowatt across residential, commercial and industrial customer groups.

Residential IBTs typically incorporate close to four consumption blocks. The first block is around 80 kilowatt-hours per month on average, or twice the average residential consumption, while the highest block amounts to some 470 kilowatt-hours per month and is closer to the average residential consumption level. The first block is typically priced at around \$0.09 per kilowatt-hour and covers 57 percent of operating costs, while in the final block the price typically rises to around \$0.18 and more than fully covers average operating costs. Overall, there is evidence that first blocks are set well below average consumption and that cost recovery improves at higher consumption blocks.

On average, residential electricity tariffs are not very far from recovering operating costs but have not yet achieved limited capital cost recovery. Commercial tariffs on the other hand just about cover limited capital costs. Performance on residential cost recovery is weakest for countries in the low-income bracket in the residential segment, and/or those facing relatively high costs of service provision in excess of US\$0.20 per kilowatt-hour. Over the period 2015-16, an overwhelming majority of residential tariffs either fell or failed to increase even in nominal terms, while almost half of commercial and industrial tariff schedules increased in line with or in excess of the inflation rate.

Affordability remains a widespread concern, with three-quarters of countries adopting either IBTs and/or separate social tariff schedules with a view to safeguarding affordability for low income customers. These measures do deliver substantial discounts to customers that benefit from them and have a material effect on affordability. Despite this, only one-third of countries are able to keep average electricity bills within 5 percent of household income. Affordability challenges are particularly large for countries with per capita income below US$500 per year and/or average monthly electricity bills over US$20 per month. There are evident trade-offs between cost recovery and affordability with countries that do well on one dimension often suffering on the other: the correlation coefficient between the affordability indicator and limited capital cost-recovery lies at 0.8.

Finally, the current wave of technological disruption in the power sector, and the entry of prosumers and other new players into the sector, makes it particularly critical that countries adopt tariff structures that truly reflect the cost of providing grid electricity and communicate clear economic price signals to consumers that may be considering decisions to install rooftop solar or battery storage capacity, switch to electric vehicles, or participate in demand response schemes. These new challenges can be better addressed with electricity tariff design that better captures load-related costs through fixed charges, provides time of use price signals, and recovers volumetric costs through undifferentiated linear tariff schedules. The results of this survey indicate that this is a far cry from current electricity pricing practices around the world.

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Annex 1A: Overview of Tariff Structure Design for Residential Customers, 2015

Country	Tariff schedule organized by	Type of volumetric tariff structure	Nr of blocks	Block sizes (kWh)	Block charges (USD/kWh)	Power con-sumption (kWh/mo.)	Operating, limited capital costs (USD/kWh)	Average unit tariff for 2015 and 2016 (USD/kWh)	Monthly electricity bill (USD/mo)
Algeria	Class	IBT	-	-	-	257.9	0.16, 0.27	0.04	9.82
Angola	Voltage, Class	kV-dependent	-	-	-	190.9	0.39, 0.45	0.03	5.32
Armenia	Voltage	kV-dependent	-	-	-	187.7	0.11, 0.11	0.11, 0.08	20.36
Australia	Class, product	DBT	3	333, 583	0.26, 0.26, 0.26	531.5	0.29, 0.35	0.34	182.74
Austria	Class, product	Linear/Multiple	1	-	0.10	360.5	0.23, 0.19	0.10	36.76
Bangladesh	Class & Voltage	IBT	6	75, 200, 300, 400, 600	0.04, 0.06, 0.06, 0.06, 0.1, 0.12	55.9	0.11, -	0.05, 0.05	2.58
Benin	Voltage, Class	IBT	3	20, 250	0.16, 0.22, 0.23	38.9	-	0.20	7.65
Bolivia	Demand & Voltage	IBT/Multiple	5	20, 50, 300, 500	0, 0.07, 0.08, 0.08, 0.09	91.5	-	0.06	5.48
Burkina Faso	Voltage, Class, Ampere	IBT	3	75, 100	0.15, 0.16, 0.26	60	0.08, 0.1	0.26	15.33
Burundi	Class	IBT	3	100, 300	0.04, 0.08, 0.16	60	-	0.04	2.64
Cambodia	Class & Voltage	IBT	2	50	0.15, 0.18	130.4	-	0.17	21.53
Cameroon	Voltage, Class	IBT	4	110, 400, 800	0.1, 0.15, 0.18, 0.19	36.1	-	0.10, 0.08	3.50
Chile	Voltage	Linear	1	-	0.34	150	0.11, 0.12	0.34	50.89
China	Class, Voltage	IBT/voltage-dependent	3	240, 400	0.08, 0.09, 0.13	200[6]	-	0.08	15.55

[6] Based on assumption due to missing data.

Country	Tariff schedule organized by	Type of volumetric tariff structure	Nr of blocks	Block sizes (kWh)	Block charges (USD/kWh)	Power con-sumption (kWh/mo.)	Operating, limited capital costs (USD/kWh)	Average unit tariff for 2015 and 2016 (USD/kWh)	Monthly electricity bill (USD/mo)
Congo, Dem. Rep.	Voltage, Class	Linear/Multiple	1	0.04	-	88.8	-	0.04, 0.04	3.46
Côte d'Ivoire	Voltage, class	IBT	Differs by kVA	200	0.07, 0.15	62.2	-	0.09, 0.29	5.77
Egypt, Arab Rep.	Class & Voltage	IBT	7	50, 100, 200, 350, 650, 1000	0.01, 0.02, 0.02, 0.03, 0.05, 0.08, 0.1	150	0.14, 0.18	0.02	2.56
Ethiopia	Class & Voltage	IBT	7	50, 100, 200, 300, 400, 500	0.01, 0.01, 0.02, 0.02, 0.02, 0.02, 0.03	37	0.12, 0.15	0.01	0.51
Germany	Class	Linear	1	-	0.43	262.6	-	0.43, 0.39	111.90
Ghana	Class & Voltage	IBT	3	50, 300	0.08, 0.17, 0.24	35	0.22, 0.67	0.16, 0.08	5.55
Greece	Class	IBT	2	2000	0.14, 0.14	310.6	-	0.15	48.02
Guatemala	Voltage	Linear/TOU	1	-	0.16	92.6	-	0.16	14.41
Guinea	Class	IBT	3	60, 330	0.01, 0.01, 0.03	60	-	0.02, 0.02	1.37
Haiti	Class	IBT	3	30, 200	0.11, 0.16, 0.28	16.6	0.09, 0.14	0.31	5.10
Honduras	Class	IBT	5	100, 150, 300, 500	0.07, 0.12, 0.12, 0.15, 0.16	137.7	-	0.08	11.13
India	Voltage, Class	IBT	4	100, 300, 500	0.04, 0.06, 0.09, 0.12	85.8	0.22, 0.29	0.13	10.90
Indonesia	kVA, Consumption	IBT/Multiple	3	30, 60	0.02, 0.03, 0.04	113.9	-	0.04, 0.04	5.04
Iran, Islamic Rep.	Class & Capacity	IBT/TOU	7	100, 200, 300, 400, 500, 600	0.02, 0.02, 0.05, 0.08, 0.1, 0.12, 0.13	150	-	0.02	2.91

Country	Tariff schedule organized by	Type of volumetric tariff structure	Nr of blocks	Block sizes (kWh)	Block charges (USD/kWh)	Power con-sumption (kWh/mo.)	Operating, limited capital costs (USD/kWh)	Average unit tariff for 2015 and 2016 (USD/kWh)	Monthly electricity bill (USD/mo)
Japan	Class	IBT	3	120, 300	0.21, 0.27, 0.32	408.7	-	0.30, 0.26	123.35
Jordan	Class	IBT	7	160, 300, 500, 600, 750, 1000	0.06, 0.1, 0.12, 0.15, 0.21, 0.25, 0.36	335.4	-	0.06, 0.07	20.44
Kenya	Class & Voltage	IBT	3	50, 1500	0.03, 0.14, 0.22	38.8	-	0.07, 0.06	2.69
Korea, Rep.	Class, voltage	IBT	6	100, 200, 300, 400, 500	0.06, 0.11, 0.17, 0.26, 0.38, 0.65	281.4	0.29, 0.35	0.12	32.45
Kyrgyz Republic	Class & IBT	IBT/Multiple	2	700	0.01, 0.03	435.9	0.04, 0.05	0.01, 0.01	6.38
Lebanon	Voltage, Class	IBT	6	100, 200, 300, 400, 500	0.02, 0.04, 0.04, 0.05, 0.08, 0.13	486.3	-	0.03	16.25
Madagascar	Voltage, Class	IBT	2	25	0.06, 0.29	150	0.3, -	0.26	38.53
Malawi	Class, Voltage	Linear/Multiple	1	-	0.08	150	-	0.08, 0.03	12.30
Malaysia	Voltage, Class	IBT	5	200, 300, 600, 900	0.07, 0.1, 0.16, 0.17, 0.18	335.2	-	0.09, 0.07	30.60
Mali	Voltage	IBT	2	200	0.21, 0.24	150	-	0.21	31.41
Mongolia	Class	IBT/TOU	2	150	0.05, 0.06	164.2	-	0.05	7.94
Morocco	Class	IBT	6	100, 150, 200, 300, 500	0.11, 0.12, 0.12, 0.13, 0.15, 0.18	130.6	0.07, 0.11	0.11	14.19
Mozambique	Voltage, Class	IBT	4	100, 300, 500	0.03, 0.08, 0.12, 0.12	76	-	0.07	5.44
Myanmar	Class	IBT	3	100, 200	0.04, 0.04, 0.06	39.4	0.19, 0.27	0.04	1.53

Country	Tariff schedule organized by	Type of volumetric tariff structure	Nr of blocks	Block sizes (kWh)	Block charges (USD/kWh)	Power consumption (kWh/mo.)	Operating, limited capital costs (USD/kWh)	Average unit tariff for 2015 and 2016 (USD/kWh)	Monthly electricity bill (USD/mo)
Nepal	Class, Voltage	VDT/Multiple	5	20, 50, 150, 250[7]	-	27.6	-	0.41	11.34
Nicaragua	Class	Non-linear block tariff	7	25, 50, 100, 150, 500, 1000	0.09, 0.19, 0.2, 0.27, 0.25, 0.39, 0.44	97.9	0.13, 0.14	0.17	16.70
Niger	Class, short/long use	Linear	1	-	0.15	150	0.14, 0.15	0.15, 0.12	22.83
Nigeria	Class	Linear/voltage dependent	1	-	0.16	61.7	-	0.16	10.11
Pakistan	Class, kW	IBT/TOU	5	100, 200, 300, 700	0.02, 0.06, 0.08, 0.15, 0.17	135.7	0.26, -	0.03, 0.04	3.64
Philippines	Class, Voltage	IBT	8	20, 50, 70, 100, 200, 300, 400	0.18, 0.18, 0.18, 0.18, 0.18, 0.19, 0.2, 0.21	98.3	0.31, 0.45	0.15	15.19
Rwanda	Class/Voltage	Linear	1	-	0.20	150	0.65, 0.33	0.20	29.94
Senegal	Voltage, Class	IBT	3	150, 250	0.21, 0.23, 0.23	83.7	0.02, 0.06	0.21	17.81
Sierra Leone	Class	IBT	3	30, 150	0.13, 0.18, 0.24	150	-	0.20, 0.13	29.38
Solomon Islands	Class	Linear	1	-	0.78	150	-	0.78, 0.74	117.39
Sri Lanka	Class	VDT	2	60	-	84.3	-	0.07	5.91
Tanzania	Class/Voltage	IBT	2	75	0.06, 0.21	97.2	-	0.13, 0.07	12.33
Thailand	Class, Voltage	VDT/TOU	2	150[8]	-	182.2		0.18	31.97

[7] Refers to VDT blocks
[8] Refers to VDT blocks.

Country	Tariff schedule organized by	Type of volumetric tariff structure	Nr of blocks	Block sizes (kWh)	Block charges (USD/kWh)	Power con-sumption (kWh/mo.)	Operating, limited capital costs (USD/kWh)	Average unit tariff for 2015 and 2016 (USD/kWh)	Monthly electricity bill (USD/mo)
Togo	Voltage, Class	IBT/Multiple	4	40, 200, 350	0.13, 0.17, 0.23, 0.24	67.4	0.13, 0.16	0.18, 0.15	12.07
Tunisia	Voltage, Class	VDT	2	200[9]	-	137.5	-	0.07	9.14
Turkey	Voltage, Class	Linear/TOU	1	-	0.15	209.1	-	0.15	30.88
Uganda	Class	Linear	1	-	0.21	150	-	0.21, 0.17	31.04
Vanuatu	Class	IBT	-	-	-	150	-	0.16	24.26
Venezuela, RB	Class & Voltage	VDT	2	150[10]	-	150	-	0.11	16.74
Yemen, Rep.	Class	IBT/Multiple	4	200, 350, 700	0.03, 0.04, 0.06, 0.09	64.3	-	0.03	1.80
Zambia	Class	IBT	2	200	0.03, 0.09	295.5	0.11, -	0.06	16.28
Zimbabwe	Class	IBT	3	50, 300	0.02, 0.11, 0.15	143	-	0.13, 0.08	18.27

[9] Refers to VDT blocks.
[10] Refers to VDT blocks.

Annex 1B: Overview of Tariff Structure Design for Commercial Customers, 2015[11]

Country	Tariff schedule organized by	Type of volumetric tariff structure	Demand charge (USD/kW)	TOU charges (USD/ kWh)	Monthly electricity bill (USD/mo)	Operating, limited capital costs (USD/kWh)	Average unit tariff for 2015 and 2016 (USD/kWh)
Algeria	Class	Linear	-	-	52.8	0.16, 0.27	0.05
Armenia	Voltage	kV-dependent/TOU	-	0.09, 0.11	101.3	0.11, 0.11	0.10
Australia	Class, product	DBT	-	0.18, 0.32, 0.32	372	-	0.37
Austria	Class, product	Linear/Multiple	6.93	-	82.9	0.23, 0.19	0.08
Bangladesh	Class & Voltage	Linear/TOU	0.3	0.1, 0.14	122.3	0.11, -	0.12, 0.07
Benin	Voltage, Class	Linear	-	-	222.1	-	0.22
Bolivia	Demand & Voltage	IBT	-	-	93.1	-	0.09
Burkina Faso	Voltage, Class, Ampere	Linear/TOU	1.7	0.13, 0.28	325	0.08, 0.1	0.32
Burundi	Class	Product-dependent	-	-	149	-	0.14
Cambodia	Class & Voltage	Linear	8.89	-	4.8	-	0.00
Cameroon	Tension, Class	IBT/TOU	-	0.14, 0.16	132.8	0.16, -	0.13
Chile	Tension	Linear	9.33	-	99.9	-	0.09
China	Class, Voltage	kV-dependent/TOU	-	0.06, 0.14, 0.22, 0.24	135.7	-	0.14
Congo, Dem. Rep.	Voltage, Class	Linear/Multiple	-	-	75	-	0.07
Côte d'Ivoire	Voltage, class	Linear/Multiple/TOU	-	0.07, 0.08, 0.1	188.2	-	0.18, 0.43
Egypt, Arab Rep.	Class & Voltage	Linear/Multiple	-	-	106.2	0.14, 0.18	0.10
Ethiopia	Class & Voltage	IBT/Multiple	11.75	-	17.1	0.12, 0.15	0.01
Germany	Class	Linear	4.21	-	390.8	-	0.39
Ghana	Class & Voltage	IBT	-	-	313.4	0.22, 0.67	0.31, 0.32
Greece	Class	Linear	-	-	212.9	-	0.21
Guatemala	Tension	Linear/Multiple	1.15	-	215.7	-	0.21
Guinea	Class	Linear	-	-	166.8	-	0.16

[11] Monthly electricity consumption is set to 1000 kWh per month.

Country	Tariff schedule organized by	Type of volumetric tariff structure	Demand charge (USD/kW)	TOU charges (USD/ kWh)	Monthly electricity bill (USD/mo)	Operating, limited capital costs (USD/kWh)	Average unit tariff for 2015 and 2016 (USD/kWh)
Haiti	Class	IBT	2.22	-	314	0.09, 0.14	0.31
Honduras	Class	IBT	-	-	351.7	-	0.35
India	Voltage, Class	kW-dependent/TOU	1.34	0, 0, 0.01, 0.02	186.6	0.22, 0.29	0.18
Indonesia	kVA, consumption	IBT	-	-	137.8	-	0.13
Iran, Islamic Rep.	Class & Capacity	Linear/Multiple/TOU	-	0.04, 0.07, 0.15	92	-	0.09
Jordan	Class	IBT	4.99	-	174.8	-	0.17
Kenya	Class & Voltage	Linear/Multiple	-	-	195.9	-	0.19, 0.12
Korea, Rep.	Class, voltage	Linear/Multiple/TOU	-	-	177.1	0.29, 0.35	0.17
Kyrgyz Republic	Class & IBT	Linear	9.27	-	42.6	0.04, 0.05	0.04, 0.03
Lebanon	Voltage, Class	Linear/Multiple	-	-	91.9	-	0.09
Madagascar	Voltage, Class	Linear/Multiple	0.09	-	379.3	0.3, -	0.37
Malawi	Class, voltage	Linear/Multiple	-	-	107.2	-	0.10, 0.05
Malaysia	Voltage, Class	Linear/TOU	6.7	0.07, 0.11	116.5	-	0.11, 0.07
Mali	Voltage	Linear/TOU	-	0.1, 0.15, 0.21	329.9	-	0.32
Mongolia	Class	Linear/TOU	-	0.05, 0.08, 0.13	95.5	-	0.09
Morocco	Class	IBT/Multiple	2.33	-	171.2	0.07, 0.11	0.17
Mozambique	Voltage, Class	IBT/Multiple	-	-	113.5	-	0.11
Myanmar	Class	Non-linear IBT	-	-	97.4	0.19, 0.27	0.09
Nepal	Class, voltage	Linear/Multiple	2.63	-	128.5	-	0.12, 0.14
Nicaragua	Class	Linear/Multiple	22.85	-	403.2	0.13, 0.14	0.40
Nigeria	Class, unknown	Linear/voltage dependent	-	-	124.8	-	0.12
Pakistan	Class, kW	Linear/Multiple/TOU	-	0.12, 0.18	191.6	0.26, -	0.19, 0.19
Philippines	Class, voltage	IBT	3.89	-	457.7	0.31, 0.45	0.45
Rwanda	Class/Voltage	Linear	10.76	-	187.7	0.65, 0.33	0.18
Sierra Leone	Class	IBT	-	-	289.7	-	0.28

Country	Tariff schedule organized by	Type of volumetric tariff structure	Demand charge (USD/kW)	TOU charges (USD/ kWh)	Monthly electricity bill (USD/mo)	Operating, limited capital costs (USD/kWh)	Average unit tariff for 2015 and 2016 (USD/kWh)
Solomon Islands	Class	Linear	-	-	848.1	-	0.84, 0.75
Tanzania	Class/Voltage	Linear/Multiple	-	-	188.9	-	0.18
Thailand	Class, voltage	IBT/Multiple	-	-	118.2	-	0.11
Togo	Voltage, Class	IBT	6.89	-	190.0	0.13, 0.16	0.19, 0.20
Tunisia	Voltage, Class	Linear/TOU	-	0.07, 0.13, 0.14	130	-	0.12
Turkey	Voltage, Class	Linear/TOU	0.9	0.08, 0.13, 0.21	149.9	-	0.14
Uganda	Class	Linear	-	-	188.5	-	0.18
Vanuatu	Class	Linear	2.66	-	513.9	-	0.51
Venezuela, RB	Class & Voltage	Linear/Multiple	-	-	128.6	-	0.12
Yemen, Rep.	Class	Linear	8.37	-	162.9	-	0.16
Zambia	Class	Linear	3.96	-	365.1	0.11, -	0.36
Zimbabwe	Class	Linear/TOU	-	0.05, 0.08, 0.16	156.7	-	0.15, 0.12

Annex 1C: Overview of Tariff Structure Design for Industrial Customers, 2015[12]

Country	Tariff schedule organized by	Type of volumetric tariff structure	Demand charge (USD/kW)	Low to high TOU charges (USD/ kWh)	Operating, limited capital costs (USD/kWh)	Monthly electricity bill (USD/mo)	Average unit tariff for 2015 and 2016 (USD/kWh)
Algeria	Class	Linear	-	-	0.16, 0.27	263.8	0.05
Armenia	Voltage	kV-dependent	-	0.08, 0.09	0.11, 0.11	474.8	0.09
Bangladesh	Class & Voltage	kV-dependent/TOU	0.48	0.08, 0.11	0.11, -	456.1	0.09, 0.10
Benin	Voltage, Class	Linear	-	-	-	780.3	0.15
Bolivia	Demand & Voltage	Linear	7.38	-	-	617.1	0.12
Burkina Faso	Voltage, Class, Ampere	Linear/TOU	10.86	0.13, 0.24	0.08, 0.1	1438	0.28
Cambodia	Class & Voltage	Linear	-	-	-	24.1	-
Chile	Tension	Linear	1.15	-	-	728.2	0.14
China	Voltage, Class	kV-dependent/TOU	7.64	0.06, 0.15, 0.17, 0.1	-	518.4	0.10
Congo, Dem. Rep.	Voltage, Class, Customer group	Linear/TOU	-	-	-	284.5	0.05
Côte d'Ivoire	Voltage, class	Multiple/TOU	11.75	0.07, 0.08, 0.1	-	927.5	0.18, 0.06
Egypt, Arab Rep.	Class & Voltage	Linear/Multiple	2.81	-	0.14, 0.18	402.1	0.08
Ethiopia	Class & Voltage	Linear/Multiple	-	-	0.12, 0.15	85.3	0.01
Ghana	Class & Voltage	Linear	11.09	-	0.22, 0.67	1570.1	0.31, 0.32
Guinea	Class	Linear	-	-	-	830.8	0.16
Haiti	Class	Linear	2.22	-	0.09, 0.14	1654.8	0.33
India	Voltage, Class	Linear/TOU	-	0, 0, 0.01, 0.02	0.22, 0.29	941.9	-
Iran, Islamic Rep.	Class & Capacity	Linear/TOU	2.14	-	-	228.4	0.04
Jordan	Class	Linear/TOU	4.04	0.15, 0.18	-	1748.8	0.34
Kenya	Class & Voltage	Linear/Multiple	2.59	-	-	623.5	0.12, 0.17

[12] Monthly electricity consumption is set to 5000 kWh per month.

Country	Tariff schedule organized by	Type of volumetric tariff structure	Demand charge (USD/kW)	Low to high TOU charges (USD/ kWh)	Operating, limited capital costs (USD/kWh)	Monthly electricity bill (USD/mo)	Average unit tariff for 2015 and 2016 (USD/kWh)
Kyrgyz Republic	Class & IBT	Linear	-	-	0.04, 0.05	212.9	0.04, 0.03
Lebanon	Voltage, Class	Linear/TOU	-	0.05, 0.05, 0.07, 0.07, 0.21	-	377.5	0.07
Madagascar	Voltage, Class	Linear/TOU	14.16	0.02, 0.04, 0.19	0.3, -	1017.2	0.20
Malawi	Class, voltage	Linear/Multiple & TOU	6.73	0.1, 0.03	-	779.8	0.15, 0.04
Malaysia	Voltage, Class	Linear/TOU	11.06	0.06, 0.1	-	1118.7	0.22, 0.07
Mongolia	Class	Linear/TOU	-	0.05, 0.1, 0.17	-	477.5	0.09
Morocco	Class	Linear/TOU	3.55	0.07, 0.11, 0.15	0.07, 0.11	4915.1	0.15
Mozambique	Voltage, Class	Linear	5.14	-	-	476.9	0.09
Myanmar	Class	Non-linear IBT	-	-	0.19, 0.27	417.3	0.08
Nepal	Class, voltage	Linear	2.03	0.04, 0.07, 0.09	-	449.3	0.08, 0.10
Nicaragua	Class	Multiple/TOU	19.75	-	0.13, 0.14	1811.3	0.36
Niger	Class, short/long use	Linear/Multiple/TOU	3	0.09, 0.09, 0.26	0.14, 0.15	1178.6	0.23
Nigeria	Class, unknown	Linear/voltage dependent	-	-	-	1972.3	0.39
Pakistan	Class, kW	Linear/Multiple	3.5	-	0.26, -	927.2	0.18, 0.18
Philippines	Class, voltage	Linear/Multiple	11.61	-	0.31, 0.45	855.4	-
Rwanda	Class/Voltage	Linear	0.18	-	0.65, 0.33	962.4	0.19
Senegal	Voltage, Class	Linear/TOU	8.04	0.12, 0.17	0.02, 0.06	1526.1	0.30
Sierra Leone	Class	Linear	0.49	-	-	1663.8	0.3
Solomon Islands	Class	Linear	-	-	-	4118.1	0.82, 0.67
Tanzania	Class/Voltage	Linear	8.63	-	-	987.5	0.19
Thailand	Class, voltage	IBT (voltage) /Multiple	2.67	-	-	550.1	0.11
Togo	Voltage, Class	IBT	2.66	-	0.13, 0.16	1352.7	0.27
Turkey	Voltage, Class	Linear/TOU	0.09	0.04, 0.09, 0.09, 0.16	-	466	-

Country	Tariff schedule organized by	Type of volumetric tariff structure	Demand charge (USD/kW)	Low to high TOU charges (USD/ kWh)	Operating, limited capital costs (USD/kWh)	Monthly electricity bill (USD/mo)	Average unit tariff for 2015 and 2016 (USD/kWh)
Uganda	Class	Linear/Multiple	-	-	-	608.6	0.12
Vanuatu	Class	Linear	10.46	-	-	2361.7	0.47
Venezuela, RB	Class & Voltage	Linear	3.39	-	-	380.9	0.07
Yemen, Rep.	Class	Linear	-	-	-	814.4	0.16
Zambia	Class	Linear/Multiple/TOU	1.81	0.03, 0.04	0.11, -	275.9	0.05
Zimbabwe	Class	Linear	-	0.05, 0.08, 0.16	-	338.6	0.06, 0.12

Annex 1D: Overview of Tariff Structure Design for Public Customers, 2015

Country	Tariff schedule organized by	Type of volumetric tariff structure	Demand charge (USD/kW)	Monthly electricity bill (USD/mo)	Average unit tariff (USD/kWh)
Algeria	Class	Linear	-	15.8	0.01
Burundi	Class	Linear	-	26.9	0.02
Cambodia	Class & Voltage	Linear	-	55.7	0.06
Chile	Voltage	Linear	1.15	53.3	0.05
Côte d'Ivoire	Voltage, Class	Linear	-	47.4	0.05
Guinea	Class	Linear	-	73.4	0.07
Haiti	Class	Linear	-	94.1	0.09
Kenya	Class & Voltage	Linear	-	38.1	0.04
Lao PDR	Voltage, Class	Linear	0.00	30.6	0.10
Lebanon	Voltage, Class	Linear	-	27.5	0.03
Morocco	Class	Linear	-	62.6	0.06
Nigeria	Class, unknown	Linear	-	294.8	0.30
Thailand	Class, Voltage	IBT/TOU	-	26.1	0.02

Annex 1E: Overview of Tariff Structure Design for Agricultural Customers, 2015

Country	Tariff schedule organized by	Type of volumetric tariff structure	Demand charge (USD/kW)	Low to high TOU charges (USD/ kWh)	Monthly electricity bill (USD/mo)	Average unit tariff (USD/kWh)
Bangladesh	Class & Voltage	Linear	0.47	-. -	-	-
China	Class, Voltage	Linear/Multiple/TOU	-	0.05, 0.14	97.9	0..09
India	Voltage, Class	Linear	-	-. -	16.4	0.01
Iran, Islamic Rep.	Class, Voltage	Linear/Multiple/TOU	-	-. -	-	-
Jordan	Class	Linear/TOU	5.13	0.08, 0.17	120.7	0.12
Kyrgyz Republic	Class	Linear	-	-. -	12.7	0.01
Lebanon	Voltage, Class	Linear	-	-. -	25.6	0.02
Malaysia	Voltage, Class	kV-dependent	-	-. -	32.8	0.03
Morocco	Class	Linear/Multiple/TOU	-	-, -	49.9	0.04
Mozambique	Voltage, Class	IBT	-	-. -	29.0	0.02
Nicaragua	Class	Linear/Multiple/TOU	16.72	0.14, 0.19	351.0	0.35
Nigeria	Class, unknown	Linear/kV-dependent	-	-. -	38.6	0.03
Thailand	Class, Voltage	IBT/TOU	-	0.07, 0.11	18.7	0.01
Tunisia	Voltage, Class	Linear/TOU	-	0.05, 0.08	19.6	0.01
Turkey	Voltage, Class	Linear/TOU	-	-. -	39.8	0.03
Venezuela, RB	Class, Voltage	Linear/TOU	0.01	0.05, 0.08	61.5	0.06
Zimbabwe	Class	Linear/Multiple/TOU	-	0.04, 0.13	36.1	0.03