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The Distributional and Fiscal Implications of Public Utility Pricing

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ABSTRACT: The setting of public utility prices involves balancing various competing government policy objectives, from equity concerns to ensuring the financial sustainability of providers and balancing public finances. In practice, public utility pricing often departs significantly from government objectives and tends to be characterized by unnecessarily complex price schedules, below cost-recovery tariff rates, and sectoral inefficiencies that contribute to large fiscal costs. Countries commonly embark on utility pricing reform in response to these heavy fiscal pressures. The paper discusses various reform options available to governments, with a focus on residential pricing schedules, highlighting their fiscal, financial, redistributive, and efficiency implications.

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WORKING PAPERS

The Distributional and Fiscal Implications of Public Utility Pricing

Prepared by David Coady, Samir Jahan, Fabiana Machado, and Mengfei Gu[1]

[1] The authors have benefited from comments received from colleagues on earlier versions of the paper at a Fiscal Affairs Department seminar and through the IMF departmental review process. All errors and omissions remain our own.

Contents

I. Introduction

The setting of public utility prices involves balancing various government policy objectives, both sector specific and national. Key objectives include promoting economic efficiency on both the demand and supply sides of the market, promoting the financial sustainability of suppliers, achieving equity objectives, and maintaining strong public finances. In general, these different policy objectives compete since achieving one policy objective typically involves a trade-off in terms of some other policy objective. For example, to promote economic efficiency, consumer prices need to reflect the marginal costs of service provision, and these costs can vary depending on the type of customer (high voltage industrial use vs. low-voltage residential use), time of use (peak vs. off peak hours), or location (remote, hard to reach areas vs. urban). Efficient prices, however, can go counter to equity concerns. For instance, providing service to low-income households in remote areas often involves higher supply costs than the same service offered to higher-income households in urban centers. Marginal cost pricing also falls short of covering a utility's costs in sectors characterized as natural monopolies, such as network industries, since average costs are higher than marginal costs. Addressing such revenue shortfalls through fixed access charges independent of consumption levels also has adverse equity implications. While average cost pricing can be an improvement from both equity and financing perspectives, it involves a departure from efficient pricing. And direct budget financing from general revenues adds to existing claims on scarce public funds possibly crowding out other priority public spending. The appropriate design of utility prices can therefore depend sensitively on how governments wish to balance these trade-offs.

In practice, public utility pricing often departs significantly from government objectives resulting in ample opportunities for welfare-improving reforms. For example, electricity pricing is often characterized by unnecessarily complex price schedules and below cost-recovery tariff rates, which can result in sectoral inefficiencies that contribute further to large fiscal costs. While price differentiation is widely used, it often departs from efficiency considerations and, together with underpricing, results in costly and poorly targeted mechanisms to help low-income households afford the service. The heavy fiscal burden is one of the main drivers of reform, which offers many options for countries to improve on the status quo.

This paper focuses primarily on the distributional and fiscal implications of public sector pricing and pricing reforms. Section II outlines the basic principles of public utility pricing and the trade-offs that arise in pursuing different policy objectives. Section III discusses the empirical evidence on public utility pricing schemes in practice, and highlights some of the main challenges to following the various price setting principles. It also emphasizes the importance of considering the full range of policy instruments available to governments for achieving underlying policy objectives. Based on this analysis, Section IV identifies potential avenues for reform, the types of empirical analysis that can inform such policy choices, and how the appropriate policy choices might vary across countries and over time. While the discussion focuses on the case of electricity pricing, most principles and examples also apply to a significant extent to other public utilities, including gas as well as water and sanitation services. That said, pricing in other sectors may also need to reflect additional sector-specific issues.

II. Principles of Utility Pricing

Among the most important policy objectives in public utility pricing are economic efficiency, financial sustainability, equity, and protecting the fiscal balance. Long-standing research has yielded a set of principles for pricing that can help understand, and thus better manage, the trade-offs involved in the simultaneous pursuit of these diverse, and often competing, policy goals.[1]

A. Economic efficiency

Efficient utility pricing is required to promote efficient decisions by consumers. This is achieved when consumer prices reflect the marginal cost of supplying the last unit of consumption, which in turn will maximize total consumer and producer surpluses. Prices above or below marginal cost can result in inefficient consumption and investment decisions.[2] For example, pricing above marginal cost may lead consumers (both households and firms) to over-invest in own-energy supply (such as own generation capacity, including solar panels), while pricing below marginal cost can promote wasteful consumption (such as unnecessarily leaving air conditioning running and lights on) resulting in excessive demand, supply shortages (inefficient load shedding), or excessive investment in new capacity.

The application of marginal cost pricing would require prices to vary according to levels of aggregate demand, levels of individual consumer demand, and consumer location. The marginal cost of supply will typically increase with the level of aggregate demand. For example, at any point in time, existing capacity in a country will usually involve supply from multiple sources with different marginal costs with higher marginal cost sources brought on board during peak consumption periods. Or higher demand may require higher short-term investment, including routine maintenance, to maintain capacity. Therefore, marginal cost is typically higher at peak demand times such as certain times of the day or months of the year. Charging higher “congestion (or peak load) prices” during peak times is a common policy recommendation to reduce demand to help avoid network overload and avoid inefficient service interruptions or rationing (load shedding).[3] The marginal cost of supply can also vary with the level of individual consumer demand—e.g., the marginal cost of electricity supply is typically higher for smaller consumers that require lower voltage (such as households and small businesses). Marginal cost can also be higher in harder-to-serve areas, such as remote rural areas.

The lumpiness of capital investments results in steep marginal cost fluctuations over time reflecting the infrequency of large investments. Long-term investment planning by countries usually involves scheduling new capacity and network extensions to come on stream as (peak) domestic demand approaches existing supply capacity or when marginal supply costs reach relatively high levels as generation plants age. The introduction of new capacity may result in a sharp drop in marginal supply costs associated with the closing down of high-

[1] For more detailed discussion of pricing in theory and practice, see Turvey (1976), Munasinghe and Warford (1982), Julius and Alicbusan (1998), Greer (2010), Huenteler and others (2017), and Foster and Witte (2020). Note that, in the context of power utilities, the extent and nature of government ownership and control can differ across the various stages of supply (i.e., generation, transmission, and distribution). This, in turn, can influence where the subsidies occur and how they are financed.

[2] We abstract from the issue of externality pricing given its complete absence in practice. For example, suppliers typically face prices for primary energy inputs well below the social cost of their (fossil fuel) consumption reflecting global and domestic environmental costs (Coady and others, 2015; Parry and others, 2021). In principle, (socially) efficient marginal cost pricing should reflect these higher input costs.

[3] For this reason, congestion or peak-load pricing is often referred to as “demand-side management”.

cost capacity and the higher efficiency of new capacity. Governments, however, typically try to avoid such sharp changes in consumer utility prices.[4]

The realization of efficiency gains from marginal cost pricing requires that consumers understand the relationship between their consumption levels and utility prices as well as having the ability to adjust or reallocate consumption to reduce consumption costs. Since such an understanding can be expected to decrease with the complexity of the utility pricing schedule, policy makers typically try to simplify the design of pricing schedules and undertake information campaigns to support consumer understanding. Consumers may also face credit or information constraints that act as a barrier to investing to increase their consumption efficiency. Or institutional arrangements may operate to reduce the ability of, or incentives for, individual consumers to manage their consumption levels (e.g., absence of meters, shared building utility costs, or capitalization of benefits in rented property prices). Such barriers often particularly constrain efficient responses by lower-income groups. To overcome such constraints, complementary investments and policies can be undertaken, such as installation of household-level smart meters and improving access to credit lines for the acquisition of more energy-efficient appliances[5].

B. Financial sustainability

In sectors characterized by economies of scale[6], average cost is higher than marginal cost so that marginal cost pricing results in financial losses (i.e., total costs less than total revenues). Reliance on public funds to finance these losses can be both detrimental to utility management and onerous for government finances. Public funds are also usually allocated on a short-term basis, which can hinder the long-term planning required to run utilities efficiently. In addition, dependency on public funds can leave utilities vulnerable to political whims. In many countries, insufficient funding has resulted in inadequate investment in maintenance and new capacity and an overall deterioration in operational efficiency. This, in turn, can result in increasing operational costs (e.g., technical network losses) and falling revenues (e.g., due to illegal consumption and poor billing practices). The end-result is often a utility that is not capable of delivering quality services (e.g., load shedding), customers that are reluctant to pay higher prices for such inadequate services, and both businesses and households needing to invest in more expensive (but also more reliable) own-supply sources.

Governments typically try to avoid such scenarios by charging utility prices that are more reflective of average costs. Cost-recovery pricing can enhance financial autonomy and promote more efficient management of

[4] In principle, when making energy-intensive consumption and investment decisions (such as investment in own capacity), efficiency would require consumers to consider how marginal cost varies over the long run. However, this would require, for example, knowledge of future demand levels, of demand-side pricing policies, and of technological change, which is typically seen as unrealistic.

[5] The nature and relevance of these measures would be context specific, varying across regions and according to level of development (Fowlie and Meeks, 2021; Sarkar and Singh, 2010). In emerging economies, for example, simple measures such as supporting the use of LED bulbs have been found to have significant effects, whereas in other countries low interest loans for buying expensive retrofit materials or energy efficient cooling and heating systems are more common (Schleich, Faure, and Meissner, 2021).

[6] The electricity sector is still mostly characterized by economies of scale, in particular at the transmission and possibly distribution stages. Average unit cost will therefore reflect both average fixed cost (which decreases with aggregate consumption) and variable costs, and thus decrease with consumption when marginal (variable) cost is below average cost. New technologies, however, could radically change this in the future by turning consumers into producers, i.e., into electricity generating units that can both buy and sell electricity. This change is reinforced by cheaper and efficient small-scale generation technologies, such as solar panels, the decreasing cost of batteries (to store the power generated), and digital platforms that allow small producers to trade in an open market.

utilities. In principle, efficient pricing and cost-recovery (or financial autonomy) can be simultaneously achieved with a "two-part" tariff structure (Coase, 1946; Greer, 2010) where fixed costs are recovered through a fixed charge independent of consumption level while variable costs are recovered through marginal cost pricing. However, if the fixed charge is uniform across consumers, then this may be prohibitive for low energy users, and while this effect can be abated by spreading the fixed charge over many years (e.g., the expected lifetime of plants), it cannot be avoided altogether. Another alternative that would minimize the efficiency cost of departing from marginal cost pricing is so-called "Ramsey pricing" whereby tariffs are set higher for consumers with relatively low demand elasticities.[7] However, since demand elasticities can be expected to vary across users and time in a complex manner, this alternative is seen as being too information intensive to be practical. These challenges have resulted in a greater emphasis on cost-recovery pricing whereby fixed costs are distributed uniformly across each unit of consumption (Box 1). But, compared to two-part tariffs, cost-recovery pricing means that large users face stronger incentives to reduce consumption through, for example, investing in own-generation, which would increase the average cost for other grid users as fixed costs would need to be spread over lower aggregate consumption from the grid.

Box. 1 Cost Recovery Components and Efficiency

The literature on cost-recovery pricing typically distinguishes between different cost measures, varying in their degree of comprehensiveness. These include:

- *Operational cost (OPEX) pricing*. To break even, public utilities need to recover operation and maintenance costs, which include day-to-day expenditures, payroll, maintenance costs, rent, and other general expenses.
- *Capital cost (CAPEX) pricing*. In addition to recovering operational costs, utilities may wish to cover part or all of the future investment costs required to replace current, or acquire additional, assets to meet future demand.
- *Return on capital pricing*. In addition to CAPEX, cost recovery may be based on the need to ensure that the utility receives an acceptable return on capital to pay interest to bondholders and return on equity to shareholders. This approach to cost-recovery pricing requires specifying the Regulatory Asset Base (RAB), which will define the assets to be remunerated and how they are valued, as well as the target rate of return (ROR) to be applied to this asset base.

To incentivize efficiency on the supply side, it is also important to base costs on efficient operations. In practice, high technical and non-technical losses during transmission unnecessarily increase operational costs. High technical losses may reflect poor maintenance resulting in a deterioration of infrastructure assets, which increases repair costs and infrastructure replacement costs or results in poor service quality. High non-technical losses, such as low bill-collection rates or lack of meters, can also result in high "implicit" costs as costs are spread over a lower consumption base (Fowlie and Meeks, 2021). Since passing these costs on to consumers risks institutionalizing supply-side inefficiencies, it is important that cost-recovery pricing implicitly assumes improvements in operational efficiencies over time, preferably mapped to an agreed reform plan to realize efficiency improvements.

[7] Strictly speaking, Ramsey pricing is only efficient when consumption cross-price elasticities are zero (Coady and Drèze, 2002). More generally, if consumption and leisure are separable in utility and the government has access to sufficiently strong income distribution instruments (e.g., non-linear income tax schedules) then uniform consumption tax rates may be optimal. This is reinforced when there are high administrative costs associated with implementing differential tax rates across consumption categories.

C. Equity considerations

Governments also often depart from efficient pricing to achieve equity objectives. Fixed charges to cover common infrastructure costs, peak-load pricing, and higher tariffs in remote regions, can make it difficult for low-income households to cover basic utility needs[8] without undermining their ability to meet other basic needs such as food, health, and education. For instance, it is common practice to classify households with electricity expenditures exceeding 5 percent of total household consumption in tropical zones and 10 percent in temperate climates as "energy-poor" and therefore deserving of energy subsidies or income support (Huenteler et al., 2017; Komives et al., 2008). Low-income households are also more likely to be less responsive to prices due to already low levels of energy consumption and their inability to finance investments that enhance their energy efficiency.

While non-linear tariff structures are often motivated by such equity considerations, their effectiveness in this regard is typically exaggerated. This approach is premised on the belief that total household energy consumption is highly positively correlated with household income so that rising "block tariff" schedules are more progressive than flatter tariff schedules since, under the former, average tariffs increase with total household consumption. While tariffs set at above cost-recovery levels for households with the highest consumption levels can help achieve both distributional and efficiency objectives, there is a limit to how much can be achieved without generating excessive inefficiencies (e.g., over-investment in more costly own-supply systems). In addition, since household size is typically negatively correlated with household income (say due to the presence of children, multiple generation families, or second properties) this greatly weakens the correlation between total household (as opposed to per capita) household electricity consumption and household income.[9] This makes block tariff structures a very crude approach to achieving distributional objectives with a large share of low-income (high-income) households facing relatively high (low) average tariffs.[10]

A more effective approach to achieving distributional objectives would be the use of household energy discounts linked directly or indirectly to household income. Public financing of discounts would allow the structure of block tariffs to better reflect efficiency and financial autonomy considerations while containing the fiscal cost of such household support. Ideally a system of discounts would be directly based on household income information (i.e., means tested) and fully integrated within a comprehensive social safety net system. However, where access to reliable income information is prohibitively expensive (e.g., in developing countries with large informal sectors and limited administrative capacity), discounts could be linked to categorical variables that are highly correlated with household income (such as household size and composition, household physical and human capital, or location). Channeling ("targeting") a higher share of total income support to lower-income households and reducing leakage to higher-income households helps contain the fiscal cost of providing a given level of income support. Explicitly identifying discounts in utility bills can also enhance the understanding of households regarding the support provided by the government to protect them from high utility costs and help generate public support for tariff reforms that are more reflective of utility cost

[8] Basic utility needs are often motivated by the existence of negative social externalities linked to low levels of consumption, e.g., disease and poor health.

[9] Other common factors affecting the relationship between income and electricity consumption are lack of access to services by low-income households and the sharing of a single service connection among several households.

[10] From the perspective of income-support policies, this is undesirable on horizontal equity grounds since some low-income households are treated very differently than others.

structures. However, the limited administrative capacity in most developing countries may require significant investment in strengthening information and administrative systems before discount systems can be adopted.

D. Public finances

Governments also have general revenue requirements to finance other publicly provided goods and services, and consumption taxation makes a significant contribution to such financing needs in most countries. In general, efficiency considerations require that all consumption items should be subject to consumption taxation with higher tax rates on consumption with low price-elasticities (see footnote 7). Equity considerations, on the other hand, suggest higher rates when higher income groups account for a relatively high share of total consumption and income redistribution instruments are limited. In practice, administrative considerations argue for approximately uniform tax rates across all consumption goods, including energy. When combined with distributional considerations, this suggests that a positive tax rate on energy consumption is desirable in principle, possibly limited to higher consumption blocks. An inability to tax the economic profits of private energy-intensive firms would also reinforce the argument for energy taxation especially for firms involved in highly profitable and hard-to-tax sectors.

III. Utility Pricing in Practice

In practice, electricity pricing is often characterized by unnecessarily complex price schedules, average tariffs below cost-recovery, large fiscal costs, and sectoral inefficiencies. Despite the limited data on electricity pricing, regional and country studies consistently find that residential tariffs fail to cover the costs of service provision, in particular capital costs but in many cases even operational costs.[11] Where utilities absorb most of the revenue shortfall, underpricing often means that maintenance, repair, and investments needed to maintain and expand the network are postponed, leading to low levels of service reliability, operational efficiency, and service coverage (Huenteler et al. 2017, Komives et al. 2008, Trimble et al. 2016). This results in a high share of sectoral resources being wasted on inefficiencies, such as high technical and commercial losses. Where governments make up for the revenue shortfall, underpricing can represent a large drain on public resources or the accumulation of large contingent liabilities by the government. Underpricing also encourages inefficiently high levels of energy use and can make the adoption of energy efficiency measures less financially appealing.

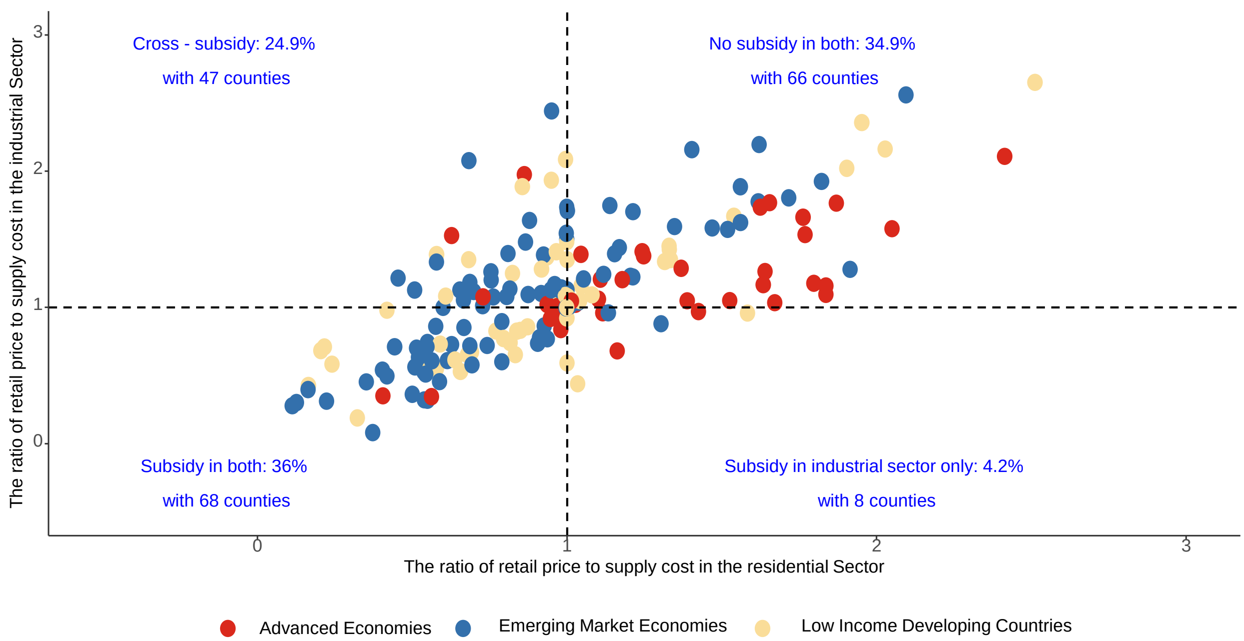
Price differentiation across and within consumer groups often runs counter to efficiency considerations. Price differentiation is desirable for sending the correct cost signals to consumers so they can respond accordingly. But, in practice, tariff schedules often send misleading signals. For example, efficient pricing would entail lower prices for higher voltage users, such as high-consuming industrial customers that are cheaper to serve, yet industrial customers are often charged considerably higher prices than residential (Figure 1) and other customers (Foster and Witte, 2020; Huenteler et al. 2020) to help cover the shortfall in revenue from underpricing of other consumers (Hernández Oré, 2017).[12] Such practices can harm the productivity and competitiveness of the industrial sector (Trimble et al. 2016; Hernández Ore et al., 2017) and generate strong incentives for these large customers to leave the network and self-provide (Huenteler et al. 2020; Komives et

[11] For more detailed discussion and evidence, see Briceno-Garmendia and Shkaratan, 2011; Foster and Witte, 2020; Huenteler et al., 2017; Hernández Ore et al., 2017; Huenteler et al., 2020; and Trimble et al., 2016.

[12] Note, however, that power subsidies are also often targeted at sectors such as fishing and agriculture reflecting social objectives.

al., 2008). Similarly, residential customers are rarely subject to time-of-use "peak" pricing (e.g., according to time of day or season), which could enhance demand management initiatives to encourage energy efficiency.[13] Price differentiation based on time-of-use is more prevalent among large industrial and commercial users whose levels of consumption more readily justify the costs of installing smart meters. But with consumers becoming "prosumers", net-metering and appropriate service charges (reflecting the value of being connected to the grid as a back-up) can ensure the right incentives for residential investment in self-generation.

Figure 1. Electricity Cost-recovery Rates in Industrial and Residential Sectors



Source: Authors' calculation based on IMF energy subsidies database (see Parry et al., 2021).
Note: The ratio of average retail price to supply cost is used as an index for cost recovery. If the ratio is larger than 1, it means the consumer price is at least large enough to cover the supply cost, while less than 1 suggests a subsidy. Top right: country with no electricity subsidies in either industrial or residential sector. Top left: country only subsidizes the residential sector. Bottom left: country has subsidies in both sectors. Bottom right: country only subsidizes industrial consumption.

Underpricing and widespread reliance on complex price differentiation often amount to costly and poorly targeted ways of helping low-income households afford electricity. Tariff subsidies (i.e., below cost-recovery tariffs) are widely used to keep prices low for residential users, financed either by raising prices for industrial and commercial customers or from general revenues. Within the group of residential users, it is also common to discriminate prices by household-level consumption (e.g., through increasing block tariffs) in an attempt to make electricity more affordable to low-income households (Foster and Witte, 2020, Hernández Ore et al., 2017, Komives et al. 2008).[14] Household-level electricity consumption, however, is a weak proxy indicator of income, making it a poor targeting mechanism (Hernández Ore et al., 2017, Komives et al. 2008). Reflecting

[13] According to Foster and Witte (2020), only 6 out of the 67 emerging and developing countries analyze differentiate tariffs by time-of-use.

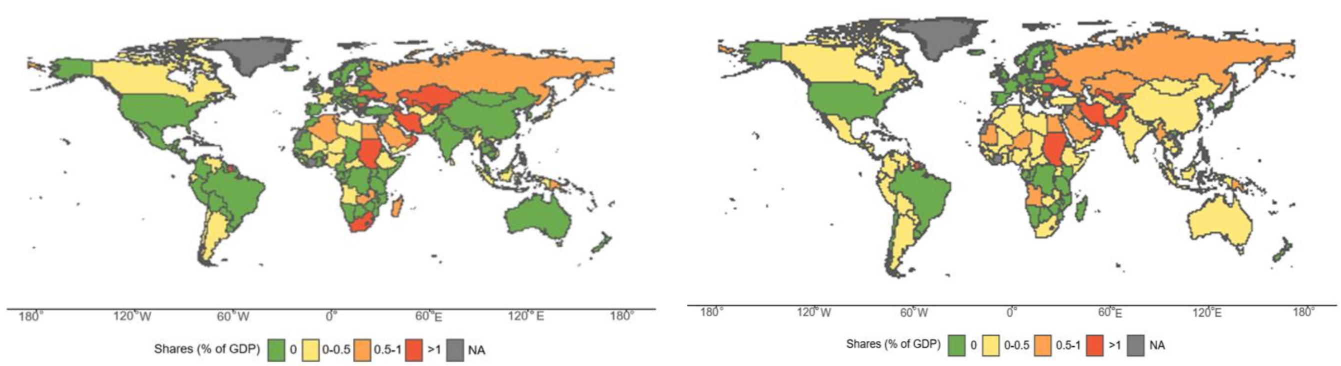
[14] According to Foster and Witte (2020), 48 out of 65 countries used increasing block tariff in the residential sector. Linear or decreasing block tariff structures are very uncommon.

the role of factors other than income (e.g., size and location of households) in determining total household electricity consumption, both low-income and high-income households are found in all consumption blocks. This, together with large electricity consumers benefitting from subsidies at lower consumption blocks, results in a high level of subsidy leakage to higher-income households (Komives et al., 2008; Foster and Witte, 2020; and Hernández Ore et al., 2017) and many lower-income households receiving low or no subsidy. Lack of universal access makes cross-subsidy schemes even more regressive, given that the poorest households are less likely to have access to electricity and benefit from these subsidy schemes and often need to rely on alternative and more expensive modes of energy, such as small diesel generators (Hernández Ore et al. 2017). Low-income households also often need to rely more on alternative energy sources, such as firewood, which result in adverse health and environmental costs (Köhlin et.al, 2011; UN-2021; WEO-2017).

A ubiquitous consequence of public pricing in practice is a heavy fiscal burden on governments, which eventually requires reforms that promote higher efficiency and better subsidy targeting. Increasing demand, a decaying electricity infrastructure, and the need to close access gaps all call for significant new investments. Coupled with the need to supplement the revenue shortfall caused by underpricing, governments that in many cases are already cash-strapped end up in an unsustainable fiscal position (Figure 2). Reforms that help alleviate the fiscal pressure without penalizing low-income households are available in many cases (Hernández Ore et al, 2017). The appropriate design of such reform strategies depends on the context. Local economic and social conditions and characteristics of the sector, including prices and how much differentiation is warranted by actual costs, differ significantly across countries. The underlying process for evaluating local conditions and identifying viable reform strategies, however, follows a similar structure. To illustrate the common steps and issues that arise in this process, the next section presents an empirical evaluation of energy price subsidies and alternative reform options.

Figure 2. Fiscal Burden of Electricity Subsidies

Panel A. Industrial Sector **Panel B. Residential Sector**



Source: Author's calculation based on IMF energy subsidies database (see Parry et al. 2021)
Notes: The cut-off points for the subsidy groups in the heatmap are based on the empirical distribution of electricity subsidy shares. Green signifies no subsidies, yellow signifies low subsidies, orange signifies medium subsidies, and red signifies high subsidies.

IV. Utility Pricing Reform Strategies

Countries often embark on utility pricing reform in response to the heavy fiscal pressures that result from charging prices below cost-recovery levels and using general government financing to fill the utility's revenue gap. In addition to the fiscal burden it generates, this practice tends to negatively affect the utility's efficiency and financial sustainability, to disproportionately benefit higher-income households who consume more electricity, and to dilute incentives for energy efficiency. There are several reform options that can help address each of these issues to varying degrees. This section discusses various reform options with a focus on residential pricing schedules, highlighting their fiscal, financial, redistributive, and efficiency implications. Further details of the empirical analysis are presented in Annex II.

To evaluate alternative tariff reform strategies, we use as our baseline tariff structure an increasing block tariff (IBT) schedule, whereby the electricity tariff increases with the level of total household electricity consumption. As we saw above, such a schedule is typical of tariff schedules in many countries. An example of such a schedule is presented in Figure 3, with consumption falling in lower (higher) blocks being charged a tariff below (above) the cost-recovery tariff. Since all consumption below 400 kWh in the example is charged below cost-recovery prices, the overall average tariff for almost all households is also below the average cost-recovery tariff (Figure 3, Panels A and B). On average, households face average tariffs that are only 66 percent of the cost-recovery tariff (i.e., below $0.16 per KWh). Typically, such tariff schedules constitute a cross-subsidization mechanism, where higher consuming households and non-residential consumers pay average tariffs above the cost-recovery tariff to finance the subsidized price offered on lower consumption levels.

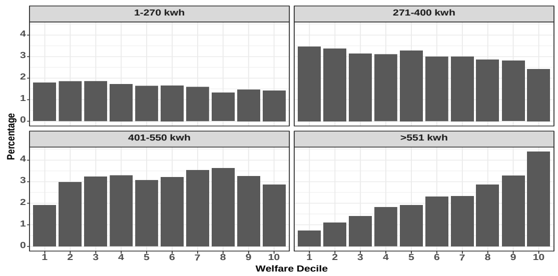
Such IBT schedules are typically used as a redistributive scheme, under the assumption that poorer households consume less electricity than richer households. In practice, however, the correlation between household income[15] (or welfare) and electricity consumption tends to be weak (Figure 3, Panel A). For example, a significant share of lower-income households has total household electricity consumption levels in blocks facing above cost-recovery tariffs, and similarly a significant share of higher-income households faces average tariffs below cost-recovery levels. This results in a significant leakage of subsidies (i.e., the difference between average prices paid and the cost-recovery tariff) to higher-income groups (Figure 3; Panel C) thus increasing the fiscal cost of protecting lower-income households. It also results in a significant share of lower-income households facing relatively high average tariffs. As a result, the share of total subsidies received does not vary much across welfare deciles (Figure 3, Panel C) reflecting average tariffs paid per kWh that vary little across welfare deciles (Panel B). Also, under this baseline IBT, the share of the household budget allocated to electricity consumption increases as household welfare decreases (Figure 3, Panel D).

[15] In the examples discussed in this section, household income (or welfare) is measured based on per capita food and non-food consumption expenditures. The terms income and welfare are used interchangeably. The term consumption is used to refer to electricity consumption.

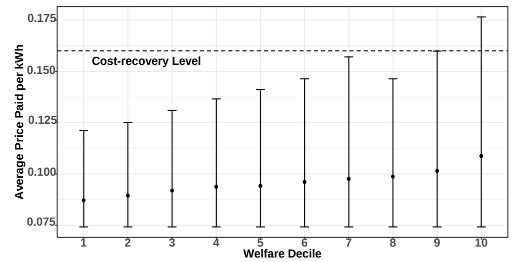
Figure 3. Baseline Tariff Schedule

(Baseline increasing block tariff schedule: From 1 – 270 kWh ($0.07), from 271 – 400 kWh ($0.11), from 401 – 550 kWh ($0/16), and above 551 kWh ($0.26))

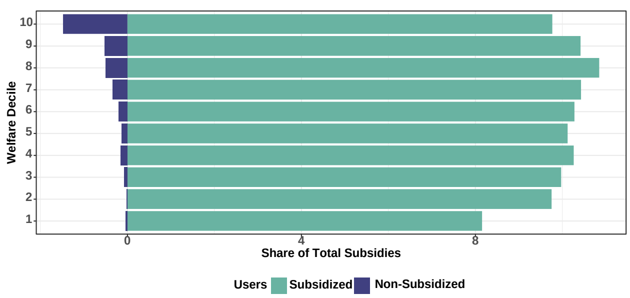
Panel A. Household Welfare and Electricity Consumption



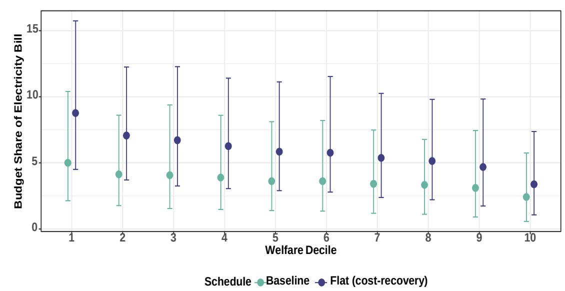
Panel B. Average Price Paid per kWh by Welfare Decile



Panel C. Share of Subsidies Accruing to each Welfare Decile



Panel D. Budget Share of Electricity Bill



Source: Authors estimations using household survey data.
Notes: Whiskers represent the 5th and 95th percentiles of the distribution. Panel A: Each panel corresponds to a consumption block in the tariff schedule and displays the percentage of total households that falls into that block and the corresponding welfare decile. Panel B: Average prices are calculated as total household expenditure on electricity divided by total household electricity consumption. Panel C**:** Subsidies are estimated as the difference between bill amount under the Scaled-Up IBT and a flat cost-recovery tariff. Subsidized (non-subsidized) households are those whose bill under the Scaled-Up IBT is below (above) their bill under a flat cost-recovery tariff. Total subsidies are the sum of subsidies received by all subsidized households. Green bars represent the share of total subsidies accruing to households in each welfare decile, and blue bars represent the share of subsidies collected from households paying above cost-recovery prices in each welfare decile. Further details are provided in Annex II.

A useful starting point in evaluating reform options is to consider the effects of charging cost-recovery tariffs to all residential users, i.e., eliminating all subsidies (*Baseline Reform*). Charging cost-recovery tariffs eliminates the need for government subsidies, increases incentives for energy efficiency, and contributes to the financial sustainability of the utility. However, a flat cost-recovery tariff level would come at a cost to virtually all households, including lower-income households (Figure 3, Panel D).[16] The resulting increase in expenditures on electricity, assuming no change in electricity consumption, would increase the budget share of electricity to levels substantially above the 5 percent "affordability" threshold for many of the lowest-income households.[17]

[16] In all reform simulations, we keep household electricity consumption levels fixed so that the welfare impact relates to the cost to a household of keeping consumption constant. A more comprehensive measure of the welfare impact would allow for the ability of households to reduce consumption, so that estimates of welfare losses in the paper should be interpreted as upper bounds.

[17] An important shortcoming of using the affordability criterion as a normative indicator can be seen from the fact that it is possible that these households could decrease the budget share below the 5 percent level by reducing electricity consumption even further with potentially very high welfare costs for these families.

The increase in the budget share can also be interpreted as the percentage decline in real income for the household, which is higher on average for lower-income households.

Governments have various reform options for addressing the fiscal burden and improving the targeting of subsidies, which vary in their information requirements and implementation complexity. A key barrier to designing well targeted subsidy schemes is information on the welfare of households consuming electricity. The more limited the information available, the greater the trade-off between the different policy objectives, i.e., fiscal cost, protection of low-income households, and consumption efficiency. Below we evaluate these trade-offs for a series of reform measures in order of their information requirements. The first set of reforms (Reforms 1-3) can typically be implemented by utility companies based on the information often readily available to them. Subsequent reform options (Reforms 4 and 5) would require significant expansion of the information directly available either to the utility or from other sources such as an integrated social beneficiary database. To ensure comparability across reforms, each of them have by design a common fiscal impact, i.e., eliminating the fiscal cost to the budget. The baseline against which all reforms are evaluated is the Baseline IBT set out in Figure 3, which has an average tariff across all household consumers of $0.105 per KWh (66 percent of the cost-recovery tariff of $0.16 per KWh) resulting in a fiscal cost to the budget equivalent to 0.7 percent of GDP. All the reforms involve equating the average tariff across all households to the cost-recovery tariff.

The following reforms are considered:

Reform 0 (Baseline Reform): Flat Cost-Recovery Tariff. This reform, evaluated above, replaces the Baseline IBT with a flat tariff equal to the cost-recovery tariff. This fully eliminates subsidies and their fiscal burden.

Reform 1: Scaling-up top IBT rates. This proportionally increases tariffs only for the top two electricity consumption blocks sufficient to raise the average tariff to the cost-recovery tariff. This essentially involves shifting the burden of financing the remaining subsidies to households with total electricity consumption falling into these blocks (i.e., cross subsidies).

Reform 2: Geographically targeted household lump-sum discounts. This reform targets lump-sum[18] discounts to households located in poorer geographical areas, while charging a flat above cost-recovery tariff to all users to finance these discounts. Household discounts decrease as the welfare of the geographical areas, proxied by the area's median per capita income, increases.

Reform 3: Geographically targeted per capita lump-sum discounts. This reform targets lump-sum discounts in per capita terms to households located in poorer geographical areas, while charging a flat above cost-recovery tariff to all users to finance the discounts. Per capita discounts decrease as the welfare of the geographical areas, proxied by the area's median income, increases.

Reform 4. Proxy-means tested lump-sum discounts at household level. This scheme targets lump-sum discounts to households that score low on a proxy-means test, while charging a flat above cost-recovery tariff to all users to finance these discounts. Discounts decrease as the household's proxy-means test score increases.

[18] We use the term "lump-sum" to highlight that the discount does not depend on electricity consumption levels but rather on proxies for household welfare.

Reform 5: Proxy-means tested lump-sum discounts at per capita level. This scheme targets lump-sum discounts in per capita terms to households that score low on a proxy-means test, while charging a flat above cost-recovery tariff to all users to finance these discounts. Per capita discounts decrease as the household's proxy-means test score increases.

Table 1. Summary of Reforms

	Reform 1	Reform 2	Reform 3	Reform 4	Reform 5
Targeting Mechanism	Electricity Consumption	Geographic	Geographic PC	Proxy-Means Test	Proxy-Means Test PC
Schedule	1 – 270 kWh $0.07 271 – 400 kWh $0.11 401-550 kWh $0.38 above 551 kWh $0.60	Flat tariff: $0.2/kWh	Flat tariff: $0.2/kWh	Flat tariff: $0.2/kWh	Flat tariff: $0.2/kWh
Average Tariff	$0.16/kWh	$0.2/kWh	$0.2/kWh	$0.2/kWh	$0.2/kWh
Monthly Discounts	Subsidized lower blocks	~$51/hh[1]	~$10/pc	~$51/hh	~$10/pc
Average Price	$0.16/kWh	$0.16/kWh	$0.16/kWh	$0.16/kWh	$0.16/kWh
Total Subsidies (%GDP)	0.45% GDP	0.27% GDP	0.27% GDP	0.27% GDP	0.27% GDP

Notes: PC indicates that monthly discounts are given at the individual rather than household level and thus ceteris paribus will increase with the number of individuals in a household.

In all reforms involving discounts (Reforms 2 to 5), the total bill for subsidies (i.e., household subsidies) is fixed. Subsidies are defined as the positive difference between electricity bill amounts under a flat cost-recovery tariff and the bill including discounts. Since all discount reforms eliminate the fiscal cost of subsidies to the budget, they are financed through a higher than cost-recovery flat tariff. The average tariff is therefore also above cost recovery levels. Households receiving discounts on their bills, however, pay an *average price* that is lower than the *average tariff*. Thus, average price refers to the price paid per kWh net of discounts, while average tariff refers to prices stipulated by the tariff structure without any discounts. All households paying an average price below cost recovery prices are subsidized, while all households paying average prices above cost recovery are contributing to financing these subsidies (i.e., taxed to finance the cross subsidy).

Reform 1. Scaling-up top IBT rates

The fiscal burden of the baseline tariff schedule can be eliminated by increasing the tariff paid for consumption in the top blocks. Restricting the increase to only the top consumption block would require an excessive increase in the top tariff level by almost 3.5 times, from $ 0.26 to $ 0.94 per kWh, which would involve an exorbitant welfare impact for a small share of households. Essentially, such a cross-subsidization scheme would involve financing the remaining subsidies through a very narrow "tax base" requiring a very high "tax rate" on this narrow base to achieve an average tariff rate equal to the cost-recovery tariff.[19] We therefore extend the tariff increase to the top two consumption blocks, which increase from $0.16 to $0.38 per kWh and from $0.26 to $0.60 per kWh. These new top block tariffs are 2.4 and 3.8 times the cost-recovery tariff, respectively.

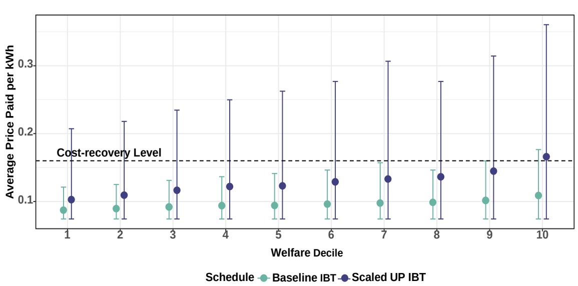
[19] Faced with such a high price, many households may reduce consumption significantly (including by going off-grid), which would require a steeper increase in price on remaining consumption (an even narrower tax base) to achieve the desired reduction in fiscal burden.

While this reform eliminates the fiscal burden of subsidies, many low-welfare households experience large increases in electricity bills and subsidies remain badly targeted with significant leakage to high-welfare households. Under the scaled-up IBT scheme, households with lower electricity consumption pay average tariffs (and prices)[20] below cost recovery, while households with higher consumption pay average tariffs above cost recovery. The former are therefore subsidized, while the latter fully fund these subsidies. Relative to the baseline IBT, even though average tariffs are higher across the board, the increase in the average tariff paid is smaller for lower-income households than for higher-income ones (Figure 4; Panel A). These differences in price levels translate into concomitant increases in the budget shares allocated to the electricity bill by households of all welfare levels (Figure 4; Panel B). The steep increase in tariff in the top consumption block, however, means a considerable share of households, in particular poor ones, would need to allocate substantially more than 5 percent of their budget towards electricity consumption.

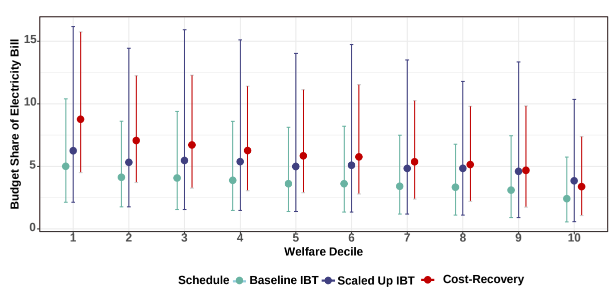
Since household-level electricity consumption is a poor proxy for income, all welfare deciles under this scheme contain both subsidized and non-subsidized households (Figure 4; Panel C). Indeed, the share of total subsidies accruing to the top one third of the welfare distribution is 28 percent. The burden of financing these subsidies is also spread across all welfare groups, although the burden share is higher for households in the top welfare decile. Some lower-welfare groups, however, are still financing subsidies accruing to higher-welfare groups (vertical inequality) and while many lower-welfare groups are receiving subsidies, many others are receiving lower subsidies or even financing these subsidies (horizontal inequality). Focusing the tariff increase on the top consumption blocks to eliminate the fiscal burden of subsidies, therefore, does not provide adequate protection to the vulnerable. While the proportion of households with high consumption is increasing in income, there is a non-negligible share of low-welfare households that are affected by the tariff increase. Within the bottom welfare deciles, some households incur welfare losses in excess of 10 percent (Figure 4; Panel D), although the share of households suffering these high losses is small. The share of vulnerable households in welfare deciles 2-4 that incur losses is also high and the average loss incurred is similar to that affecting higher welfare households (around 2-3 percent).

Figure 4. Scaled-up IBT

Panel A. Average Price Paid per kWh by Welfare Decile

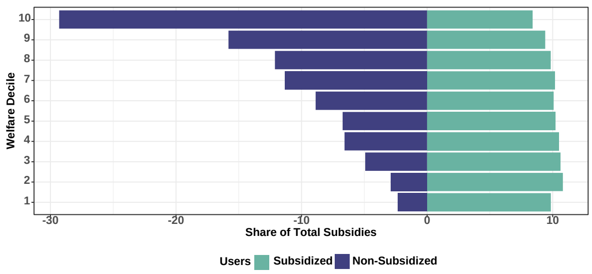


Panel B. Budget Share of Electricity Bill

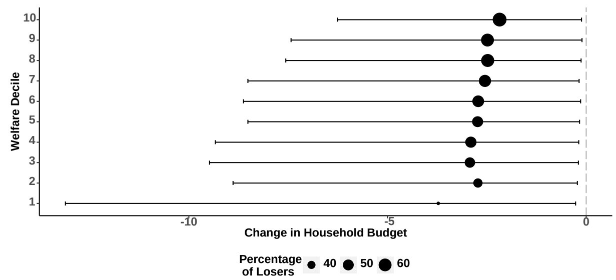


[20] We use the term “prices” to capture the combined cost of the tariff schedule and discounts.

Panel C. Share of Subsidies Accruing to each Welfare Decile



Pane D. Change in Household Budget from Baseline



Source: Authors' calculations using household survey data.
Notes: Whiskers represent the 5th and 95th percentiles of the distribution of the statistics shown. Panel A: Average prices are total bill amount divided by total electricity consumption. Panel C: Subsidies are estimated as the difference between bill amount under the Scaled-Up IBT and a flat cost-recovery tariff. Subsidized (non-subsidized) households are those whose bill under the Scaled-Up IBT is below (above) their bill under a flat cost-recovery tariff. Total subsidies are the sum of subsidies received by all subsidized households. Green bars represent the share of total subsidies accruing to households in each welfare decile, and blue bars represent the share of subsidies collected from households paying above cost recovery prices in each welfare decile. Panel D: Change in household budget reflects the increase in electricity bill resulting from higher prices at the top two consumption blocks. Dots represent average change in household budget. Dot sizes represent percentage of losers within each welfare decile. Further details are provided in Annex II.

Reform 2. Geographically Targeted Discounts

The targeting of subsidies can be improved by switching from differentiating tariffs by consumption blocks to a system of household discounts for poorer geographic areas. This type of targeting mechanism requires information on the location of the household, which is typically known by the utilities, and some welfare measure of neighborhoods (or other such administrative boundaries), that allows them to be ranked into ascending welfare order. This information can range from data on housing prices to more detailed estimations of the aggregate socio-economic status of households (e.g., poverty maps). In our example, localities (groupings of census tracts) were ranked based on the median per capita income and divided into "locality" deciles[21]. The targeting performance therefore depends on the quality and granularity of the data available and on the degree of homogeneity across households in any given location.

Under this reform, lump-sum discounts are distributed to households based on the ranking of their geographic area, with the generosity of the discount decreasing as the aggregate welfare of the locality increases. Several steps were followed to determine the level of the discounts in the various localities. First, a budget was fixed for the total amount of discounts to be awarded. This budget was set to reflect the cost of providing all households in the poorest half of the population with a basic electricity bundle of 110 kWh/month[22] at a flat cost-recovery tariff. This budget is equivalent to 0.27 of a percent of GDP and is considerably smaller than the total subsidies awarded under the baseline IBT scheme (about 0.45 of a percent of GDP). Second, more generous benefits are awarded to the poorest geographic areas, with geographical areas falling in the first 6 deciles of aggregate welfare receiving benefits decreasing in generosity, following the rule specified in Table 2. The final step

[21] Note that, given that the ranking is done by locality score (not household), each decile can contain a different number of households.

[22] There is debate about what quantity of electricity is deemed to satisfy basic needs. It can be as low as 50 kWh (100 kWh) per capita per year in rural (urban) areas up to 1,000 kWh per capita per year (including non-household electricity consumption) (Moss et al, 2020). In our example, we approximate the extended bundle of electricity consumption proposed in IEA, IRENA, UNSD, World Bank, WHO (2021), which is set to 1250 kWh per household per year.

involves solving for the reference benefit amount (B) given the discount budget and the desired relative generosity of benefits across locality welfare deciles. To finance these benefits, all users are charged a flat tariff 27 percent above the cost-recovery tariff (i.e., $0.2/kWh).

Table 2. Rule for Awarding Lump-sum Discounts to Households across Locality Welfare Deciles

Decile 1	Decile 2	Decile 3	Decile 4	Decile 5	Decile 6	>=Decile 7
B	*.9*B*	*.8*B*	*.7*B*	*.4*B*	*.2*B*	*B = 0*

Notes: B stands for Benefit for households in localities in the poorest welfare decile and is set to $51.1/month per household, which corresponds to a consumption of 260kWh/month. For Decile 1 households, where the median household size is 7, this amounts to 37 kWh/person.

The flat tariff charged, although above cost recovery, is lower than the tariffs for the top two blocks under the scaled-up IBT. This means that the average tariff is capped at lower levels relative to the scaled-up IBT, in particular for the higher welfare households (Figure 5, Panel A), while the lump-sum benefits bring the range of average prices down, especially for households in the lowest welfare deciles receiving higher discounts. A large majority of households in the bottom four welfare deciles are better off with the geographical rather than the consumption targeting in Reform 1.[23] The increase in average price (i.e., capturing the combined impact of a higher cost-recovery tariff and progressive discount system) is now mainly concentrated on higher welfare groups and this is reflected in a slightly more progressive welfare impact as captured by the change in budget share (Figure 5; Panel B).

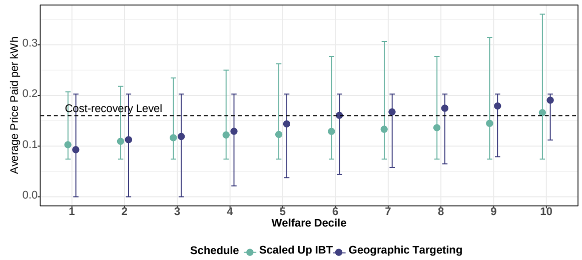
Geographically targeted discounts, financed by above-cost recovery tariffs, substantially enhance the overall progressivity of reform. The progressivity of financing (through an above cost-recovery tariff for all households) is now reinforced by a substantially more progressive discount scheme (Figure 5; Panel C).[24] The burden of financing these benefits also falls less heavily on the top welfare decile households, which can reduce incentives to opt out of the grid through self-generation. Eliminating the fiscal burden of subsidies through geographical targeting leads to some winners, despite the overall increase in tariff, relative to the baseline tariff. While geographically targeted discounts improve the overall progressivity of the reforms, it remains a crude approach to protecting lower welfare groups, resulting in substantial horizontal inequities in terms of gainers and losers within the lowest welfare groups (Figure 5; Panel D). Vulnerable households located in higher welfare localities are hit hard by the reform given the lower or complete absence of discounts in these areas, and the flat above cost-recovery tariff. Relative to the scaled-up IBT, however, the magnitude of the losses, especially among lowest welfare households, is reduced, although the number of households incurring these losses increases.

[23] The total subsidies awarded under the geographical targeting (equivalent to 0.27 percent of GDP) is considerably lower than under the previous reform (equivalent to 0.45 percent of GDP). While benefits can be made more generous, cross subsidization would imply an increase in the flat tariff needed to cover the higher costs. Vulnerable households who are excluded from the targeting would be particularly harmed, while the benefit given to included households would be overly generous. This trade-off between protecting vulnerable households that are included without harming those who are excluded can be reduced if subsidies are financed through the general budget, rather than through higher tariffs. An alternative solution would be to reduce the burden of the higher flat tariff on at least some of the excluded vulnerable households by incorporating some form of IBT. This would take advantage of the fact that very few low welfare households have very high consumption.

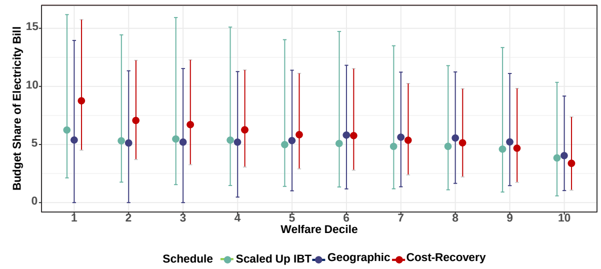
[24] The better targeting performance of discounts awarded by geographical area means higher benefits can be awarded to poorer households at a lower total benefit budget to be cross-subsidized. Even though the budget fixed for the total amount of discounts offered under this scheme is smaller than the total subsidies awarded in the IBT schemes, the most generous lump-sum discount applied to households in localities falling at the bottom welfare decile is considerably higher, at $50/month, compared to $16 under the baseline IBT. This benefit amount is adequate to procure 240kWh in a month.

Figure 5. Geographic Household Level Discount Scheme

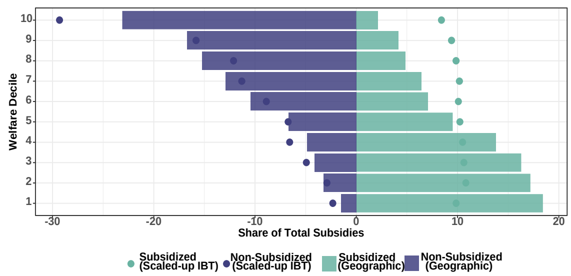
Panel A. Average Price Paid per kWh by Welfare Decile



Panel B. Budget Share of Electricity Bill



Panel C. Share of Subsidies Accruing to each Welfare Decile



Panel D. Change in Household Budget from Baseline

Source: Authors' calculations using household survey data. Notes: Whiskers represent the 5th and 95th percentiles of the distribution of the statistics shown. Panel A: Average prices are total bill amount divided by total electricity consumption. Panel C**:** Subsidies are estimated as the difference between bill amount under the Geographic household level discount scheme and a flat cost-recovery tariff. Subsidized (non-subsidized) households are those whose bill under the geographic scheme is below (above) their bill under a flat cost-recovery tariff. Total subsidies are the sum of subsidies received by all subsidized households. Green bars represent the share of total subsidies accruing to households in each welfare decile, and blue bars represent the share of subsidies collected from households paying above cost recovery prices in each welfare decile. Panel D: Change in household budget reflects the change in electricity bill resulting from the reform. Dots represent average change in household budget. Dot sizes represent percentage of losers and winners within each welfare decile. Further details are provided in Annex II.

Reform 3. Geographically Targeted Per Capita Lump-Sum Discounts

If utilities have information about household composition, this can be used to improve the targeting of geographically targeted discounts. Awarding discounts on a per capita, rather than household, basis achieves two things. First, it better compensates on average for big price increases since consumption is positively correlated with family size. Second, it improves progressivity since welfare is negatively correlated with family size. Awarding the same benefit to both small and large households can either be insufficient to protect large households or offer incentives for small households to increase consumption in cases where the discount is higher than the bill (i.e., some of the discount was previously unused) [25]. In this simulation, the discount budget and the flat charge per KWh remains the same as in Reform 2 (i.e., $0.20), but discounts are now awarded based on household size. The per capita benefit is set to $9.8[26] using the same decreasing benefit formula applied to the previous example, and spending on discounts is fully financed by cross-subsidization.

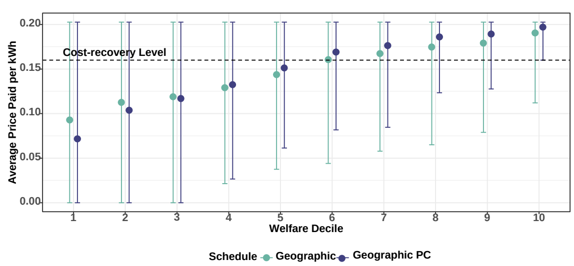
[25] In the simulations shown, only about 2% of households receive discounts that are higher than their reported bills.

[26] This corresponds to one-fifth of the benefit awarded in the previous example at the household level, which is consistent with the median household size of 5 in the sample.

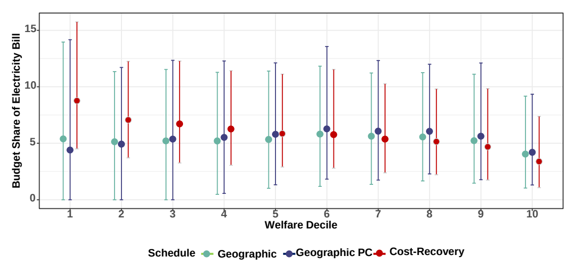
Households in the bottom third of the welfare distribution benefit the most from a change from household-level to per capita based discounts. Households that are excluded from discounts, and thus pay the flat above cost-recovery tariff, remain the same since the geographical allocation rule remains unchanged. Improved benefit incidence under per capita as opposed to household level discounts means households in the bottom third of the welfare distribution pay lower average prices, while those at the top half pay progressively more (Figure 6; Panel A). There is also a narrowing of the average prices paid by higher welfare households, while the cap at the flat above cost-recovery tariff also avoids strong incentives to go off-grid. The average welfare gain for the bottom welfare group is the largest (Figure 6; Panel B). Welfare losses are concentrated on the top half, who see an increase in the budget share allocated to electricity, assuming similar levels of consumption as in the baseline.

Figure 6. Geographic Per Capita Discount Scheme by Welfare Decile

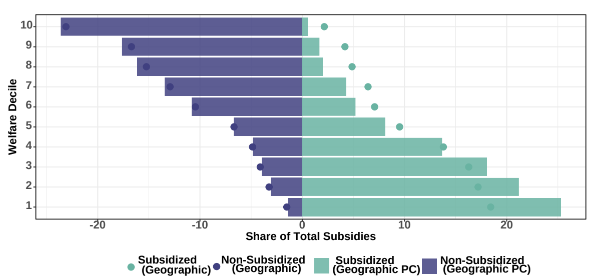
Panel A. Average Price Paid per kWh by Welfare Decile



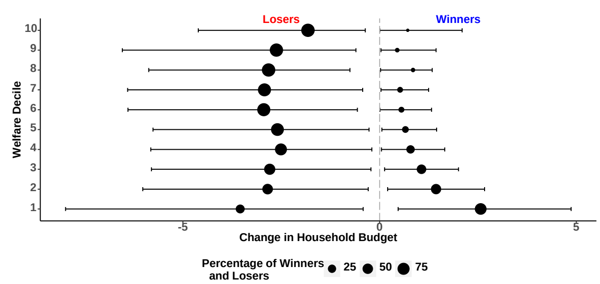
Panel B. Budget Share of Electricity Bill



Panel C. Share of Subsidies Accruing to each Welfare Decile



Panel D. Change in Household Budget from Baseline



Source: Authors' calculations using household survey data.
Notes: Whiskers represent the 5th and 95th percentiles of the distribution of the statistics shown. Panel A: Average prices are total bill amount divided by total electricity consumption. Panel C**:** Subsidies are estimated as the difference between bill amount under the geographic per capita level discount scheme and a flat cost-recovery tariff. Subsidized (non-subsidized) households are those whose bill under the geographic per capita scheme is below (above) their bill under a flat cost-recovery tariff. Total subsidies are the sum of subsidies received by all subsidized households. Green bars represent the share of total subsidies accruing to households in each welfare decile, and blue bars represent the share of subsidies collected from households paying above cost recovery prices in each welfare decile. Panel D: Change in household budget reflects the change in electricity bill resulting from the reform. Dots represent average change in household budget. Dot sizes represent percentage of losers and winners within each welfare decile. Further details are provided in Annex II.

Targeting benefits on a per capita basis greatly improves the progressivity of benefit incidence (Figure 6; Panel C). Relative to household-level geographic targeting, both benefit incidence and the burden of subsidy financing are more progressive, although the latter can only improve slightly because the targeting mechanism (i.e., which households are included and excluded) is the same as in the previous reform. Subsidized households in the bottom four welfare deciles receive a much larger share of the benefits, while those excluded from the benefit shoulder a smaller share of the financing burden. Improved benefit incidence through a per-capita allocation of discounts leads to less losers and higher average wins among households at the bottom welfare decile relative to the previous reform. The losses incurred, however, are higher in magnitude, decreasing slightly as welfare increases. Given the low elasticity of consumption among poorer households, these losses are difficult to avoid through lowering consumption.

Reform 4. Means-tested Household Lump-Sum Discounts

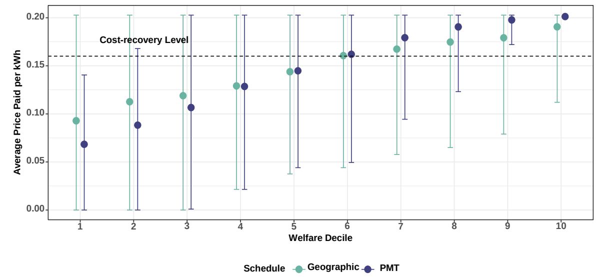
A better balance between fiscal, efficiency, and equity considerations can be achieved through charging above cost-recovery prices and improving the targeting of discounts towards lower welfare groups. However, improving the targeting of discounts requires more detailed information on household characteristics that are highly correlated with household welfare. One such approach is to use a “proxy means test” (PMT) which calculates a single poverty score for each household based on such household characteristics to allocate discount levels. This, of course, involves a heavier information burden than previous reforms since such characteristics would have to be collected from all households on a regular basis, which requires significant institutional capacity. In the illustration below, observable household characteristics, such as location, household size and composition, housing and other assets, and education levels, are used to compute a poverty (or welfare) score to categorize households into welfare deciles. To facilitate comparison, both the flat above cost-recovery tariff and the benefit allocation rule remain the same as in the previous reform (Table 1)[27]. Improvements in relation to previous reforms will result from greater protection for poor and vulnerable households due to the transfer of more of the budget to these households and the reduction of “errors of exclusion” (i.e., wrongly excluding poor and vulnerable households from discounts or giving them relatively low discounts).

Improved targeting results in lower average prices paid by households in the bottom welfare deciles. Households in the bottom half of the welfare distribution pay on average prices that are below cost recovery, while the top half pays average prices that are above cost recovery and increasing in welfare (Figure 7; Panel A). Lower exclusion errors bring down the entire range of average prices paid by the bottom two deciles. Conversely, lower errors of inclusion mean average prices paid by higher welfare households lie around or above the cost-recovery tariff. The scheme also brings the average budget allocated to electricity for the bottom three deciles to levels at or below 5 percent (Figure 7; Panel B). Both the average prices per kWh paid by the bottom three welfare deciles and the share of the budget they allocate to electricity consumption are the lowest across all reforms considered thus far.

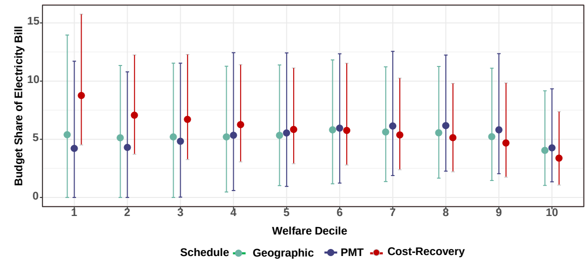
[27] Targeting by household, rather than geographic area, leads to slightly less beneficiaries at the bottom categories and, as a result, a somewhat lower subsidy budget. This is because geographic areas with lower aggregate welfare tend to have a slightly higher number of households (about 2% more).

Figure 7. Proxy-means Test Discount Scheme

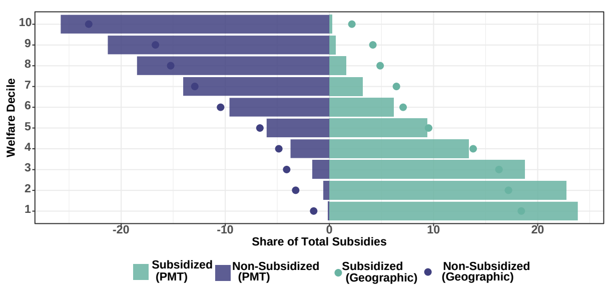
Panel A. Average Price Paid per kWh by Welfare Decile



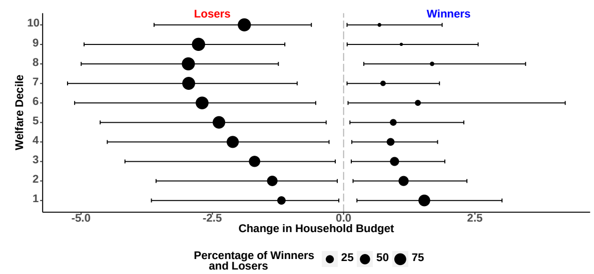
Panel B. Budget Share of Electricity Bill



Panel C. Share of Subsidies Accruing to each Welfare Decile



Panel D. Change in Household Budget from Baseline



Source: Authors' calculations using household survey data. Notes: Whiskers represent the 5th and 95th percentiles of the distribution of the statistics shown. Panel A: Average prices are total bill amount divided by total electricity consumption. Panel C**:** Subsidies are estimated as the difference between bill amount under the PMT household level discount scheme and a flat cost-recovery tariff. Subsidized (non-subsidized) households are those whose bill under the PMT scheme is below (above) their bill under a flat cost-recovery tariff. Total subsidies are the sum of subsidies received by all subsidized households. Green bars represent the share of total subsidies accruing to households in each welfare decile, and blue bars represent the share of subsidies collected from households paying above cost recovery prices in each welfare decile. Panel D: Change in household budget reflects the change in electricity bill resulting from the reform. Dots represent average change in household budget. Dot sizes represent percentage of losers and winners within each welfare decile. Further details are provided in Annex II.

Replacing the baseline IBT with a fully cross-subsidized PMT lump-sum discount scheme leads to less losers and lower losses among lower welfare households. The incidence of the discount formula is progressive, while benefits are recovered mostly from wealthier households (Figure 7; Panel C). Even though the baseline IBT is heavily subsidized, there is a good share of lower welfare households that benefit from the change to the PMT scheme. Conversely, very few higher welfare households are made better-off with the switch, although a few large gains are reaped by mid- to high-welfare households. These are explained by a combination of errors of inclusion and the generous household level discount that disproportionally benefits smaller households. These errors of inclusion (and exclusion) can potentially be reduced using more detailed data and analysis and the generosity of aggregate discounts can be reduced by allocating benefits on a per capita basis, as shown in the next example.

Reform 5. Means-tested Per Capita Lump-Sum Discounts

Moving from household to per capita discounts can further enhance the progressivity of reforms. Under this reform the discount received by households is linked to the number of household members, with per capita discount levels decreasing across welfare groups as determined by the same proxy-means test. Since lower welfare households tend to have a larger household size, and electricity consumption increases with household size, this will enhance the progressivity of discounts and further reduce the number of lower welfare households with large losses. The improved targeting, relative to the geographical scheme (see Figure 7), means a higher proportion of larger households receive the benefit.

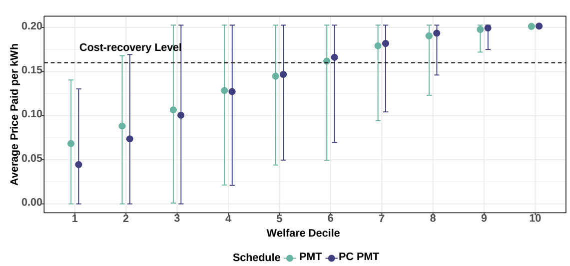
Under this discount scheme, households in the bottom three deciles pay the lowest average prices per kWh (and budget shares) across all reforms (Figure 8, Panels A and B). The range of average prices paid remains large for lower welfare deciles, reflecting the horizontal inequities that arise from errors of exclusion, where excluded vulnerable households pay close to the above cost-recovery tariff. Given the progressivity of discounts, the range is much smaller for higher welfare households, who are mostly excluded from the discount.

Subsidy incidence is further improved through the per capita, rather than household, level benefit allocation. The bottom two deciles receive higher shares of the subsidy, while the middle half receives lower shares. A switch from the baseline IBT to the per capita PMT results in higher gains to winners in bottom deciles, but losses can be higher among losers, especially for large households now receiving lower discounts (Figure 8; Panel D). Compared to a flat cost-recovery schedule, the per capita PMT scheme results in the lowest losses among vulnerable households and the largest wins across all reforms considered (Appendix Figure 2).

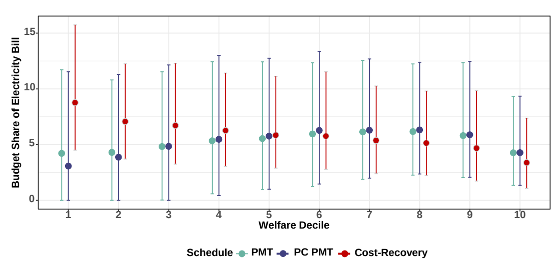
Additional eligibility rules for discounts could be employed to further improve on the fiscal and distributional implications of reform. For example, if reliable direct information on incomes is available for high-income individuals, then it may be possible to exclude more of these from discounts. Similarly, if households need to select-in to the discount scheme, e.g., by providing the information on household characteristics required to calculate the proxy-means score, then this may encourage high-income households not to apply (i.e., to self-select out of the discount scheme). However, care should be taken to ensure that such an application process does not disadvantage low and middle welfare household in applying (e.g., if access to the internet is required to apply). Finally, if thought desirable, e.g., if the focus is on “compensation” as opposed to “redistribution”, it may also be possible to reduce large net gains to some households by capping the maximum total discount a household can receive.

Figure 8. PMT Per Capita Discount Scheme

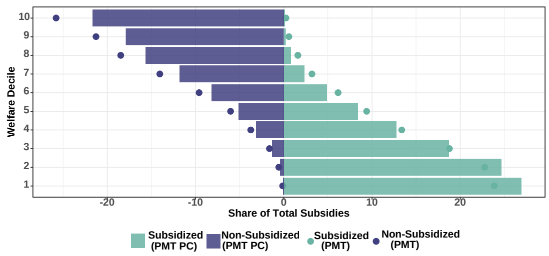
Panel A. Average Price Paid per kWh by Welfare Decile



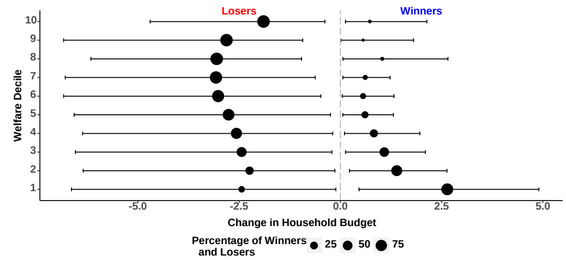
Panel B. Budget Share of Electricity Bill



Panel C. Share of Subsidies Accruing to each Welfare Decile



Panel D. Change in Household Budget from Baseline



Source: Authors' calculations using household survey data. Notes: Whiskers represent the 5th and 95th percentiles of the distribution of the statistics shown. Panel A: Average prices are total bill amount divided by total electricity consumption. Panel C**:** Subsidies are estimated as the difference between bill amount under the PMT per capita level discount scheme and a flat cost-recovery tariff. Subsidized (non-subsidized) households are those whose bill under the PMT per capita scheme is below (above) their bill under a flat cost-recovery tariff. Total subsidies are the sum of subsidies received by all subsidized households. Green bars represent the share of total subsidies accruing to households in each welfare decile, and blue bars represent the share of subsidies collected from households paying above cost recovery prices in each welfare decile. Panel D: Change in household budget reflects the change in electricity bill resulting from the reform. Dots represent average change in household budget. Dot sizes represent percentage of losers and winners within each welfare decile. Further details are provided in Annex II.

V. Conclusion

The setting of public energy utility prices involves balancing various government sector-specific and national policy objectives. Key objectives include promoting economic efficiency on both the demand and supply sides of the market, promoting the financial sustainability of suppliers, achieving equity objectives, and maintaining strong public finances. In general, these different policy objectives compete since achieving one policy objective typically involves a trade-off in terms of another. The appropriate design of energy prices can therefore depend sensitively on how governments wish to balance these trade-offs.

This paper begins by discussing the policy trade-offs that can emerge when formulating public utility pricing policies, before turning to the issue of pricing reform. Since actual pricing policies often deviate significantly from stated policy objectives, this can leave ample room for reforms that better achieve underlying policy objectives. In practice, the most common motivation for reforms is the need to address large fiscal subsidies arising from pricing below cost recovery. The paper therefore uses this scenario as its point of departure, looking at issues that arise when designing reforms to address these fiscal pressures. While the discussion focuses on the case of electricity pricing for residential consumers, many of the insights from the analysis also apply to gas as well as water and sanitation utility services.

The analysis in the paper starts from the existence of an increasing block tariff (IBT) schedule with an average tariff set below the cost-recovery tariff, generating significant fiscal costs. Such a scenario is often motivated by a desire to protect low-income households from unaffordable electricity bills. While moving to a flat cost-recovery tariff for all households can eliminate the fiscal cost of subsidies, it results in a very large increase in electricity bills for lower-income households, which is typically seen as undesirable. The analysis therefore discusses alternative reform options that can better protect these households from increasing electricity bills while still achieving the underlying fiscal objective of eliminating the fiscal burden of electricity subsidies. The reform options are discussed in the order of the amount of information needed by the utility (or the government) to improve the trade-off between fiscal and distributional objectives, which can also avoid inefficient incentives for large consumers to go off-grid.

The empirical analysis of alternative reform options helps to bring out the advantages and disadvantages of each reform. In general, however, the better the information available on household welfare levels, the greater the potential for addressing fiscal pressures arising from energy subsidies while providing adequate protection to lower-income households.

- *Use of IBT with consumer cross subsidization.* The fiscal cost of subsidies can be eliminated by increasing the tariff levels only for households falling into high electricity consumption blocks. This brings the overall average tariff above cost recovery for these households who then finance the remaining subsidies for households in lower consumption blocks. However, the low correlation between total household electricity consumption and household welfare means that many low-income households with high consumption levels falling in the top consumption blocks are even worse off than they would be under a flat cost-recovery tariff scheme. While the overall progressivity of subsidies is improved (i.e., leakage of subsidies to higher-income households is reduced), this reform gives rise to significant horizontal inequity with many lower-income households paying for subsidies to other lower-income households (as well as for subsidies to some higher-income households, i.e., vertical inequality).
- *Use of household discounts.* While the use of flat tariff schedules and household discounts can address many of the above challenges, the ability to do so depends on the quality of the information used to target discounts towards lower-income households. For instance, while targeting discounts to households in “poorer” localities can improve the progressivity of subsidies and reduce the magnitude of the losses for low-income households in these localities, this also comes at the cost of a larger number of excluded low-income households. However, improving the targeting of discounts by using more detailed information on household characteristics strongly correlated with household welfare can greatly improve the targeting of discounts to lower-income households as well as the coverage of these households thus providing significantly greater protection to most low-income households. In this sense, improving the targeting and coverage of discounts can greatly improve the trade-off between vertical and horizontal equity objectives.

The analysis in the paper helps to bring out the ineffectiveness of using IBT tariff schedules in protecting low-income households from high electricity bills. This arises primarily because of the very weak correlation between household consumption levels and household welfare. A much more effective approach is to use household discounts and base eligibility for discounts on detailed information on household characteristics strongly correlated with household welfare, i.e., delinking subsidies from electricity consumption levels. This approach helps to better balance the trade-off between fiscal and distributional objectives and to avoid very large tariffs for households in large consumption blocks that can incentivize them to leave the electricity grid and rely on less efficient energy sources, thus also increasing the cost-recovery level for those still using the grid. The need for detailed information on household welfare also highlights the importance of integrating the design of energy subsidy schemes with the design of the broader social protection system which relies on similar information.

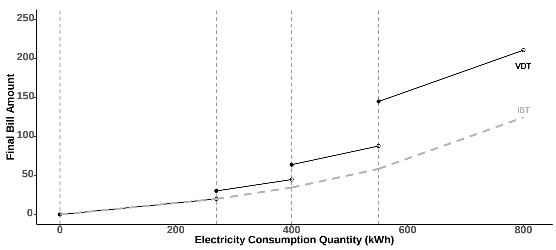
Box 2. Cliffhanger Effects Under Volume Differentiated Tariffs

Volume differentiated tariffs (VDT), whereby users in each consumption block pay a single flat tariff rate on all consumption and the tariff rate increases as consumption increases, are often observed in practice or discussed as policy options. However, an important shortcoming of such an approach to tariff setting is that households with very similar levels of consumption can face substantially different electricity bills. In addition, it can exacerbate horizontal inequities where lower welfare households with different consumption levels (e.g., reflecting different household size) are treated very differently.

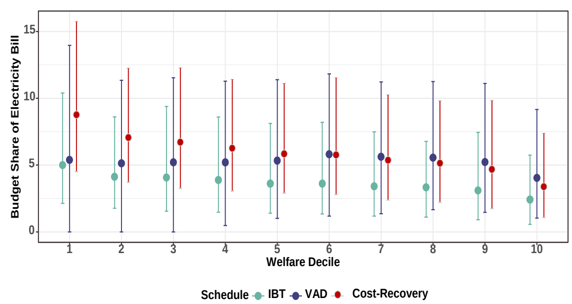
This can be seen by comparing the baseline IBT with a similar tariff schedule applied as a VDT scheme (Figure). The VDT results in a higher average tariff at higher consumption levels since the higher tariff is applied to all consumption and not just consumption falling within that tariff block. This in turn increases household electricity bills (Panel A). For instance, households with consumption just above the maximum in the third consumption block could see their electricity bill increase by 65 percent. Such “cliff edge” effects can be particularly problematic for lower welfare households. Panel B shows the distribution of budget shares by welfare decile for both tariff schedules. The range of budget shares within any given welfare decile is a lot larger, reflecting the fact that households in every decile have consumption that falls into every block.

Figure. Volume Differentiated Tariffs

Panel A. Relationship Between Consumption and Final Bill



Panel B. Budget Share of Electricity Bill



Source: Authors’ calculations using household survey data. Notes: Final bills corresponding to the VDT were calculated based on the same blocks and prices as the baseline IBT. Panel A: dotted line represents final bill amount as a function of quantity consumed under the baseline IBT and solid lines correspond to the VDT. Panel B: Dots represent the average budget share corresponding to the electricity bill among households within each welfare decile. Bars represent the 5th and 95th percentiles of the distribution of budget shares within each welfare decile.

Appendix I. Utility Pricing and Regulation

The framework for setting utility prices can play a crucial role in determining the effectiveness of regulators in promoting the delivery of high-quality services at the lowest possible cost. Tariff setting is a critical instrument for achieving this objective, not only through decisions about tariff levels and structure but also through the design of tariff regimes, i.e., the process by which tariffs are set and updated to provide incentives for utilities to maintain and enhance production efficiency. The effectiveness of such incentives will depend on three factors. First is the frequency of tariff adjustments. For instance, when tariffs are adjusted too frequently there is less incentive for the utility to increase its efficiency and reduce its costs since any gains are quickly passed on to consumers in the form of lower tariffs. Second is the extent to which prices can be delinked from observed utility costs. If this link is too strong, then the utility will have less incentive to increase efficiency since lower costs will be reflected in lower consumer prices rather than higher profitability. Third is the level of financial motivation of the utility, e.g., whether utilities face a “soft” or “hard” budget constraint. Utilities facing a soft budget constraint will assume that any losses will be covered automatically by the public budget (e.g., through budget transfers or the accumulation of government-guaranteed debt) and therefore have less incentive to enhance operational and investment efficiency.

Conceptually, there are two main types of regulatory regimes: (i) cost-of-service (rate-of-return) regulation and (i) incentive-based regulation. While incentive-based regulation aims to address the weak incentives for enhancing efficiency in the cost-of-service or rate-of-return regulation, good practice often involves balancing the implications for different dimensions of efficiency.

Under Rate of Return Regulation (ROR regulation), tariffs are set to reflect the utilities observed cost (e.g., based on the previous period average costs, including covering the opportunity cost (or desired return) on assets—when costs reflect only operational costs this becomes “cost-of-service”, or CS, regulation). Existing tariffs remain in effect until a tariff review is requested by key stakeholders (including the utility, consumers, and the government) prompted, for example, by actual or projected supply shortages or fiscal pressures. This type of regime has two main downsides (Lyon, 1994). The first is the potential incentive of the utility to over-invest in capital to increase earnings by expanding the capital base on which the rate of return is calculated (the “Averch-Johnson” effect). The second, alluded to earlier, is the incentive of the utility to increase sales rather than to reduce costs since any reduction in costs is quickly passed onto consumers in the form of lower tariffs while increasing sales (and over-investing in capacity) may increase funds available for increasing compensation or in-kind benefits. It has also been pointed out that the frequency of tariff reviews and the level of regulatory oversight required by this type of regulation has very high administrative costs (Sappington and Weisman, 2016).

Incentive-based regulation attempts to circumvent (or contain) the downsides of ROR regulation. While there are several variants of incentive-based regimes, the main ones are price-cap/revenue-cap, sliding scale, and yardstick/benchmark regulation (Lyon, 1994). In price-cap regulation the permissible price increase is capped at a ceiling based on two factors: price index—usually the consumer price index, and a (downward) adjustment linked to the differential between the expected gain in productivity in the sector and in the economy as a whole (called the X-factor[28]). In some cases, a third adjustment is included, the Z-factor, that allows increases in price due to extraordinary events that have a significant impact on the utility’s costs but are not reflected in the

[28] Usually set based on historical TFP estimates (Sappington and Weisman, 2016).

consumer price index[29]. The period between tariff adjustments is typically 4 to 6 years, allowing the utility time to reap the benefits from efficiency gains. Given that the costs used to set tariff levels are the average costs of the utility over the entire period, rather than just the period before review as in ROR regulation, the utility's incentive to engage in cost padding right before the review is lowered.

There are two main downsides to price-cap regulation. First, costs and demand shocks can threaten both allocative efficiency and the financial viability of the utility. Under imperfect information, prices are unlikely to adequately reflect these changes, which sends the wrong signals to consumers and utilities, and, in the case of negative shocks to the utility, can mean significantly lower revenues than required (Lyon, 1994). The other downside refers to the fixed review dates, which means incentives to reduce costs are decreasing in time (i.e., as the next review date approaches). One way to bypass this last issue is the UK's *rolling cap* scheme, which allows utilities to keep profits from efficiency gains for 4 to 5 years following the improvements. A variant of price-cap is *revenue-cap* regulation whereby, instead of imposing a limit to the prices in a service basket, the limit is imposed on the utility's revenue.

Sliding scale regulation adds limits to how much profit a utility can retain or lose under a price-cap regulation before profit sharing with customers take place. These are called “zones of reasonableness” or “deadbands” (Lyon, 1996). Relative to price-caps, this reduces the occurrence of large gaps between prices and costs, while not completely removing the utility's incentives for cost reduction (Lyon, 1994). Simulations show that it is optimal to let the utility keep more of the profits from cost reduction and have consumers absorb more of the losses from increases in cost (Lyon, 1996). The intuition is that the initial price cap is set below current prices and cost reduction will likely bring prices very close to the caps. The small difference between costs and prices in favor of the utility are unlikely to affect allocative efficiency, while the opposite is true in cases where the utility's cost increases, and such discrepancies can be quite large. Simulations also show that price caps tend to lead to larger profits for the utility, whereas sliding scale leads to higher rates of profit sharing with customers.

In yardstick or benchmark regulation there is a decoupling of utility's costs and prices. Rather than set prices or caps using the utilities reported costs, this type of regulation uses estimated costs based on the performance of other utilities in the sector or using a “model utility” simulation based on engineering models and expert opinion. The price estimates can be disaggregated by cost component or activity or be computed as total costs. The latter affords the utility more flexibility and generate higher incentives for efficiency gains in operations rather than from large investments in capital. While benchmarking accounts for shocks that are common to all the utilities, the resulting price estimates might not be appropriate to the individual utility given differences in context across utilities in the sample (demand levels and characteristics, geography, and so on). This means the model needs to include controls for all these factors, which increases the level of complexity of estimations and the data requirements.

In developing countries, the choice of regulatory regime will likely involve important trade-offs (Pardina and Schiro, 2018). The first has to do with the level of information required to achieve the best possible outcome in each case. From this perspective, price caps are the least demanding, followed by cost-of-service (requiring detailed information on utility accounting) and yardstick (requiring both information on utility accounting but also all of the controls required to make comparisons appropriate). The second has to do with the congruence in objectives between the regulatory regime and the local sector needs. In mature markets, such as the UK, it is

[29] Some examples are extreme weather events that cause sizeable damage, or significant changes in regulation or tax rates.

reasonable to choose a regulatory regime, such as a price cap, that prioritizes efficiency gains. In less developed markets, however, large capital investments to extend the network, increase service quality, and keep up with increasing demand takes precedence. Incentives for overinvestment in capital, seen as a downside of ROR regulation in developed countries, is not an issue where this type of investment is needed.

Governance Issues

In the same way that regulatory substance—the content of regulation—depends on context, so too does regulatory governance, i.e., the legal, institutional and procedural aspects of regulation. Several options exist to structure regulation, from leaving it fully in the hands of the government (regulation by government) to regulating by contract by outsourcing regulatory functions to experts and setting up an independent regulator (Eberhard, 2007). While the creation of an independent regulator is something to aspire to, it might not be the right place to start for three reasons (Brown et al., 2006). First, the required capacity, commitment, and institutional strength might not exist. Second, an independent regulator might be incompatible with national laws and the constitution. Third is the risk involved in going for the ideal too soon. Any perceived or actual failure in its workings can discourage the government from continuing with the necessary reforms. In these cases, a transitional solution that could involve hybrid versions of the available options is advisable.

The appropriate design depends on the country's political, institutional, and legal arrangements but also on the government's level of "regulatory commitment", the strength of its institutions, and the availability of qualified personnel (Eberhard, 2007). The first group of factors calls for clarity in the definition of regulatory roles, responsibilities, and procedures to avoid inconsistencies with existing laws and practices, such as overlapping jurisdiction over decisions. "Regulatory commitment" refers to how willing and able the government is to transfer regulatory responsibilities to an independent regulator, expert panels, or contracts and to de-politicize regulatory decisions (Eberhard, 2007).

The goal of regulation is to provide the right incentives for efficient and reliable provision of services, while ensuring the financial viability or utilities. Achieving these goals through regulation by government can be difficult, especially if utilities are state owned. A conflict of interest arises between short-term political interests, such as offering low-cost or free services to constituencies, and long-term policy goals, such as ensuring the financial viability of utilities and future investments in the sector (Pardina and Schiro, 2018). It is often the case that effective regulation is obtained by separating government roles and functions (Eberhard, 2007). The best solution would therefore be a combination of regulation by contract, outsourcing to expert panels, and an independent regulator.

The most common challenges faced by regulation in developing countries are weak regulatory commitment, institutional fragility, lack of transparency, and lack of capacity. To overcome these challenges, it is recommended to proceed in steps. In countries characterized by weak regulatory commitment and capacity, both institutional and in human capital, regulation by contract can be a good place to start (Eberhard, 2007). Capacity can then be strengthened over time though the creation of an expert panel to provide advice, performance reviews, and technical assistance, and through investments in training. Coupled with demand-side incentives for participation and accountability, legitimacy and transparency can also be built from the ground up. Other recommendations include starting with less complex regulation and lower discretionary powers granted to a new regulatory body, and, on the utility side, to commercialize state-owned enterprises so they are responsive to regulatory incentives.

Future Issues

Climate change and disruptive new technologies bring new challenges to regulation. Climate change has prompted many countries to make strict pledges to reduce emissions. This means incorporating more renewables into the energy matrix and engaging in demand management to encourage lower electricity demand. Both require sizeable investments and changes in behavior and preferences. Most regulatory regimes, however, primarily aim at generating incentives for reducing costs and prices, which could lead to higher rather than lower consumption. Incentives to engage in demand management might also be lacking as under many regimes, lower sales mean lower revenues. Moreover, climate change calls for additional investments in increasing resilience to extreme weather events and mitigating its effects.

New technologies, in turn, "will substantially affect both the pattern of demand for electricity, as well as the structure of costs; both of which are fundamental inputs to tariff regulation" (Pardina and Schiro, 2018). Two challenges are particularly relevant. The first is how to generate the incentives for the adoption of risky new technologies. For example, the UK's new revenue-cap regulation—RIIO (Revenues = Incentives + Innovation + Outputs) —creates an innovation fund to help offset the risks. The second challenge is how to regulate the expansion of distributed generation, including the rise of "prosumers" —consumers who self-provide and are allowed to sell extra generation back to the grid. Rapid improvements in self generation, such as solar PV systems and storage technologies, are likely to increase the number of prosumers and encourage many of them to drop off the grid. Given the cost of such technologies, the biggest and highest income consumers are likely to find exit profitable, compromising the financial sustainability of the network operation as (fixed costs will then need to be spread over a much smaller consumer base.

Appendix II. Data and Analysis

This appendix provides details about the data and analysis performed in Sections III (Utility Pricing in Practice) and IV (Utility Pricing Reform Strategies) of the paper.

Utility Pricing in Practice

Data of all figures are from IMF energy subsidies database (see Parry et al (2021)).

In Figure 1, the ratios of electricity retail price to the supply cost are calculated for the residential and industrial sectors for the year 2020. It's defined as a cost-recovery index to examine the electricity subsidy practices in both sectors.

The electricity subsidy maps in Figure 2 use 2020 electricity subsidy shares (as a percentage of GDP) to evaluate the fiscal burden of each country. The subsidy shares are divided into 4 categories as 0% (no subsidies), 0-0.5% (low subsidies), 0.5-1% (medium subsidies) and above 1% (high subsidies). The cut-off rule is based the distribution of subsidy shares shown below:

Appendix Table 1. Break-down Used to Create Maps in Figure 2

(The quantiles of subsidy shares as a percentage of GDP are as followings)

Quantiles	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
Industry	0	0	0	0	0	0	0.13	0.46	1.05	3.54
Resident	0	0	0	0	0	0.11	0.28	0.55	0.98	5.61

Utility Pricing Reform Strategies

All simulations were done using pre-processed household survey data, that is, data that already contained estimations of income and food and non-food items consumption at the household level. The data was collected in 2017-18 and contains 15,999 households. The following new variables were created for the analysis:

GDP. The GDP variable used was obtained from the World Bank WDI database and corresponds to the year 2018.

***Welfare Deciles*.** Taking into account the survey design strategy and weights, households were partitioned into deciles based on per capita household consumption, with consumption including food and non-food items.

***Electricity Consumption*.** Estimated based on reported electricity bill and the tariff structure in place at the time of the survey. The tariff structure was an IBT, which allows for a one-to-one mapping of final bill to consumption.

Reform simulations consist of the application of the different tariff schedules, as described in the text, to the estimated electricity consumption. In the case of reforms 2-5 the following steps were followed to target discounts to households:

Reform 2 and 3. Geographical Targeting

The dataset contains a variable called *cluster* that groups households belonging to the same geographical area. There is a total of 2,500 clusters, which were divided into deciles based on the median per capita consumption of households in each cluster.

Reform 4 and 5. Proxy-means Test Targeting

To allocate discounts to households based on the PMT method the following steps were followed:

1. A linear regression was estimated of per capita consumption on the following household characteristics:
    a. Household size
    b. Urban or Rural
    c. Province
    d. Age of household members. Three variables were used: number of household members below 5 years of age, between 6 and 10 years-old, and older than 66.
    e. Type of dwelling
    f. Area of dwelling
    g. Wall material
    h. Rent value
    i. Total number of rooms
    j. Assets. Eleven variables: number of refrigerators, TVs, computers, private cars, washers, freezers, ovens, microwaves, dishwashers, vacuum cleaners, and tablets;
2. Based on the regression model results, a predicted value of per capita consumption was estimated for each household;
3. Households were categorized into deciles based on the predicted value of per capita consumption;
4. Discounts were awarded according to the rule in Table 1.

Appendix Figure 1. Performance of Proxy-means Test in Correctly Classifying Households into Welfare Deciles

Notes: Figure displays the transition matrix comparing actual per capita household income with predicted per capita income, with households allocated into welfare deciles according to each criterion. Values represent percentage of households falling in each cell. Welfare is based on household food and non-food consumption.

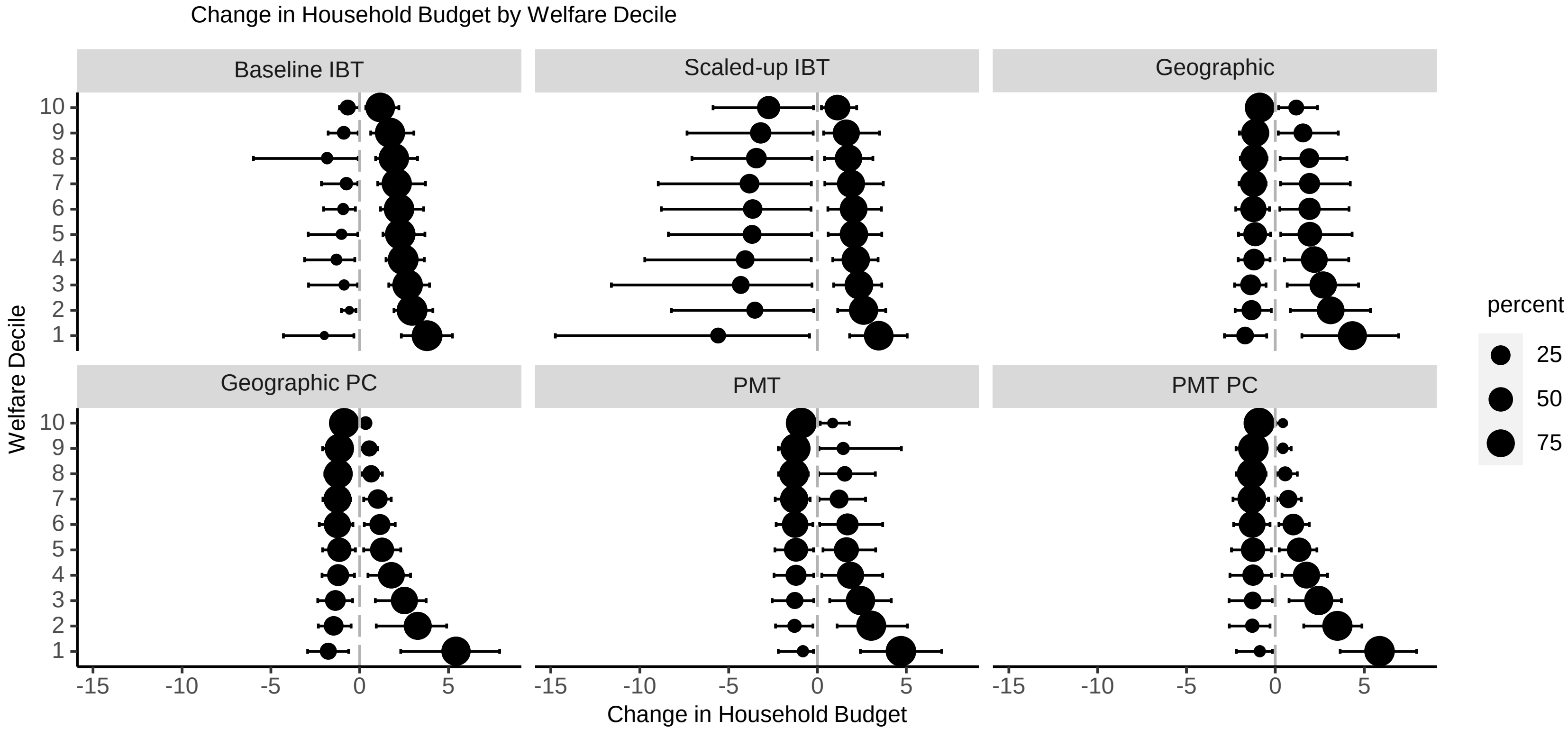
Appendix III. Additional Tables and Figures

Appendix Table 2. Targeting Accuracy of Geographical and PMT Targeting Mechanism

	Bottom 30% targeted by Reform				Middle 30% Targeted by Reform				Top 40% Targeted by Reform			
	% of HH		Average HH size		% of HH		Average HH size		% of HH		Average HH size	
	Geographic	**PMT**	**Geographic**	**PMT**	**Geographic**	**PMT**	**Geographic**	**PMT**	**Geographic**	**PMT**	**Geographic**	**PMT**
Deciles												
1	68%	90%	6.8	6.87	23%	10%	6.53	5.79	9%	0%	6.98	5.45
2	55%	72%	5.94	6.29	28%	26%	6.19	5.9	17%	2%	6.73	4.33
3	52%	55%	5.5	5.76	29%	40%	5.7	5.55	19%	5%	5.85	4.76
4	40%	37%	5.06	5.61	40%	51%	5.32	5.35	20%	12%	5.9	4.45
5	22%	22%	4.75	5.28	53%	57%	5.01	5.24	25%	21%	5.33	4.24
6	18%	14%	4.36	4.74	42%	49%	4.6	5.1	41%	37%	4.85	4.04
7	17%	6%	4.18	4.67	28%	36%	4.16	4.98	55%	57%	4.52	3.94
8	12%	3%	3.35	3.99	26%	20%	3.45	4.68	62%	77%	4.2	3.7
9	12%	1%	3.28	3.44	20%	10%	3.29	4.59	68%	89%	3.71	3.46
10	6%	0%	2.6	1.56	11%	2%	2.81	4.67	83%	98%	3.09	3

Note: For “% of HH”, each cell in the table displays the percentage of households belonging to both the corresponding welfare decile (rows) and the targeted deciles (columns). Targeted deciles in Geographic targeting are based on the estimated welfare of the areas where households are located. Targeted deciles in the PMT targeting are based on the household-level predicted values of a proxy-means-test, as explained in the text and in Annex II.

Appendix Figure 2. Winners and Losers from a Switch from Flat-cost Recovery Schedule to Corresponding Reform



Notes: Change in household budget reflects the change in electricity bill resulting from the reform. Dots represent average change in household budget. Dot sizes represent percentage of losers and winners within each welfare decile. Further details are provided in Annex II.

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