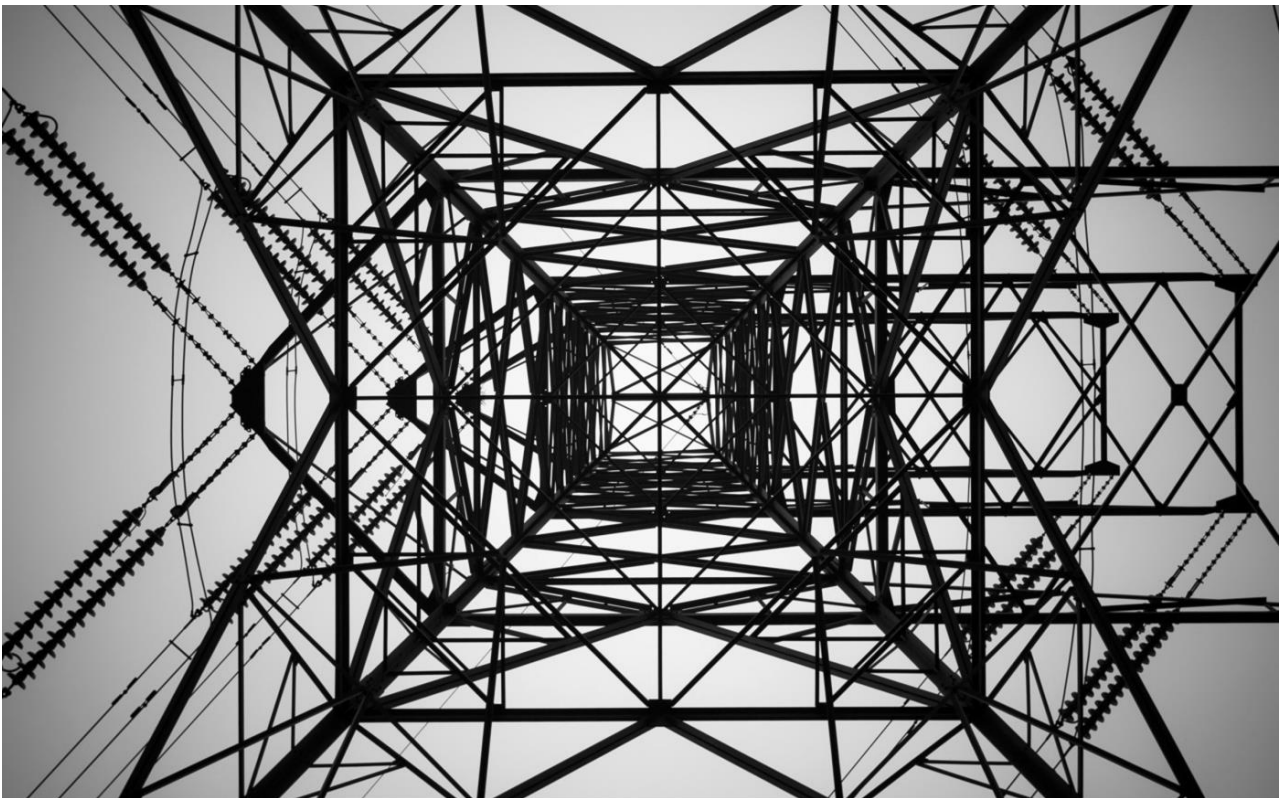


# Working Paper: A Review of Impacts of Electricity Tariff Reform in Africa

**In this review, we assess the literature on electricity tariff reform in Africa from 1987 to the present. The review is organised by type of reform, including tariff payment reform, tariff structure reform, and tariff rate reform. We further disaggregate our discussion by sector, where appropriate.**

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# A Review of Impacts of Electricity Tariff Reform in Africa

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## Abstract

Financially unviable power sectors require African governments to subsidise a large proportion of electricity generation and distribution costs. Yet despite such policies, African countries have low rates of grid electrification and high consumer prices relative to other countries in the Global South. Meanwhile, electricity subsidies and pricing regimes are often poorly targeted and regressive. Reducing the fiscal burdens of energy subsidies, expanding grid access, and improving affordability represent key but often conflicting priorities for decisionmakers undertaking electricity tariff reforms. Such reforms also have implications for the quality of electricity supply and the financial sustainability of providers. This review assesses the scientific literature on the impacts of electricity tariff reform in Africa. We identified over 6,000 papers through our search procedure, followed by two rounds of screening for relevancy, which yielded 82 relevant papers for inclusion in the final review. We organise our results according to three modalities of reform: tariff payment method; tariff structure; and tariff rate. The results are disaggregated by sector where appropriate, summarising impacts on households, firms and industries, utilities and governments, and economies at large. Such a framework allows for a comparison across countries and sectors, shedding light on the successes and shortcomings of various tariff reform efforts on the continent. The review concludes with a discussion of key evidence gaps in the literature to motivate future research.

**Key words:** electricity price, electricity subsidy, electricity demand, systematic review, Africa

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## 1. Introduction

An estimated 592 million people lack electricity access in Africa (IEA, 2020). Electrification rates on the continent are the lowest globally, with a mere 39% of the total population and 28% of the rural population electrified (IEA *et al.*, 2020). Among those connected to the grid, chronic unreliability and intermittency of supply limit economic growth and reinforce reliance on heavier polluting fuels (Herman *et al.*, 2017; Mensah, 2018). Meanwhile, the average cost of supplying 1 kWh in Sub-Saharan Africa is higher than in other low- and middle-income countries (LMICs), and residential tariffs in the region can be as high or higher as prices in Organisation for Economic Co-operation and Development countries (Eberhard and Shkaratan, 2012; Global Petrol Prices, 2021). The financial unviability of power sectors require many African governments to subsidise the costs of supply, yet households still face high prices and low reliability as governments shoulder growing quasi-fiscal deficits (Kojima and Trimble, 2016; Batinge *et al.*, 2019).

There are numerous challenges that tariff reform aims to address. One key challenge is low electrification rates, particularly among rural households. Low connection rates limit the potential for revenue generation and grid expansion, inhibiting cost recovery for utilities (Kojima and Trimble, 2016). Affordability represents another challenge among those connected to the grid. Regressive pricing structures reduce the ability of low-income consumers to pay electricity bills and incentivise theft and illegal connections (Huenteler *et al.*, 2017; Yakubu *et al.*, 2018). Simultaneously, poor targeting of tariff subsidies may undercharge consumers with a higher ability to pay, decreasing opportunities for efficient use and dampening revenues (Independent Evaluation Group, 2016). Lastly, electricity sector subsidies create large fiscal burdens for state-owned or parastatal providers. Such subsidies drive significant budget deficits, inhibit cost recovery for utilities, disincentivise private sector investment, and crowd out scarce government resources (Blimpo, McRae, and Steinbuks, 2018; Cockburn, Robichaud, and Tiberti, 2018). Addressing all of these challenges creates trade-offs for governments, who must balance equity in access with financial viability.

Since the 1980s, African governments have implemented numerous reforms to reduce energy subsidies, liberalise electricity sectors, and institute more progressive tariff regimes. Reforms in the 1990s aimed to attract private investment and increase competition, though utilities still remain largely state-owned and regulated (Alleyne, 2013; Huenteler *et al.*, 2017). Tariff reform constitutes changes to tariff payment systems (e.g. prepayments vs. postpayments of bills), tariff structures (i.e. differential pricing of consumers based on consumption amount, consumer type, etc.), and tariff rates (i.e. increasing or decreasing electricity prices). Governments will often roll out a suite of reforms to address a range of objectives, including improving cost recovery, encouraging conservation or energy efficiency to alleviate strains on supply, investing in solutions that enhance reliability, and expanding access among low-income households. However, governments simultaneously face social distrust and resistance to tariff reforms (especially those involving rate increases), which can stall reforms or lead to their reversal (Kojima, Bacon, and Trimble, 2014).

Several countries have succeeded in improving cost recovery (such as Chad, Mozambique, Uganda, and Rwanda) but have struggled to achieve the social objectives of affordability and equity. Other countries (such as South Africa, the Democratic Republic of Congo, Tanzania, and Zambia) have prioritised affordability and equity objectives but have made limited progress on cost recovery. These cases highlight the trade-off between financial and social objectives; however, such an argument also neglects the fact that energy tariff subsidies are often highly regressive and fail to reach the consumers they aim to support (Alleyne, 2013). Electricity subsidies tend to benefit higher-income and more urban consumers who are more likely to have a grid electricity connection (Banerjee *et al.*, 2008). Poorly targeted tariff regimes can therefore exacerbate inequality by undercharging consumers with a higher willingness and ability to pay (Clements *et al.*, 2013; Ilskog *et al.*, 2005). As will be discussed in this review, reduction of electricity subsidies need not come at the expense of maintaining low prices and expanding connections for low-income consumers. Governments have a range of different reform options to reduce burdensome subsidies, improve targeting, and recover costs.

The rest of the paper is organised as follows. Section 2 describes the background, motivation, and scope of this review. Section 3 describes the material and methods used to conduct it. Section 4 summarises the main findings, organised by type of tariff reform (tariff payment reform, tariff structure reform, and tariff rate reform). Section 5 discusses the findings of the reform in the context of the literature and the need for further empirical evidence, and Section 6 concludes.

## 2. Background

This review focuses on studies of electricity tariff reform in Africa, to address the electricity access and affordability challenges faced by many countries on the continent. As previously discussed, power prices in Sub-Saharan Africa are among the highest across LMICs and electricity subsidies are poorly targeted. Despite higher prices, tariffs cover only about 70% of the average cost of power due to relatively high costs of production (Briceño-Garmendia and Shkaratan, 2011). Under-pricing of power creates financially insolvent utilities (often heavily subsidised by national governments), inhibits their ability to expand or maintain an adequate power supply, and encourages inefficient consumption (Independent Evaluation Group, 2016). High prices have also contributed to higher rates of non-technical losses and bill non-payment in the region (Godinho and Eberhard, 2019b; Yakubu, Babu, and Adjei, 2018).<sup>1</sup> A recent review on the impacts of energy interventions in LMICs by Jeuland *et al.* (2021) reveals that Sub-Saharan Africa as a region deviates from trends found in other regions, such as South Asia and Latin America, further motivating the need for a greater focus on literature pertaining to countries within this region.

The emphasis of this review is on grid utilities and tariffs, primarily because studies on the impacts of off-grid electricity pricing regimes remain scant. In addition, prices for off-grid electricity are often regulated at the community level, which makes comparison with grid electricity price impacts (often regulated at the national or regional level) difficult. Nonetheless, many African governments have set ambitious goals to achieve total or near-total rural electrification through a mix of grid and off-grid investments, and decentralised solutions such as solar home systems and mini-grids are an increasingly important solution to electricity access problems in Africa. Owing to the fact that the grid will not feasibly reach many dispersed rural communities within the next decade or two, reform of grid electricity tariffs alone will clearly be insufficient to achieve large-scale rural electrification, and there is a need to supplement this review with evidence pertaining to off-grid solutions.

Further, our inclusion of North African countries and South Africa (whose economies and electricity sectors are comparatively more developed) highlights heterogeneity in the modalities and impacts of electricity tariff reform in economies at different levels of economic development. At the same time, the inclusion of these countries identifies commonalities among reform outcomes that appear unrelated to a country's gross domestic product and energy resources. As described later, despite larger energy endowments, North African countries encounter similar energy subsidy challenges as Sub-Saharan African countries, and the distributional inequalities from poorly targeted subsidies mirror those of other nations on the continent.

This review builds on the work of prior reviews of the African electricity sector, including the following papers. Alleyne (2013) offers perhaps the most comprehensive review of energy and subsidy reform on the continent, conducted by the International Monetary Fund via an observational study of 35 African countries. Huenteler *et al.* (2017) provides an in-depth, historical review of the cost recovery and financial viability of the power sector across LMICs, though it gives only a very limited perspective on the impacts of reforms on end-users. Rodriguez Pardina and Schiro (2018) review the impacts of regulatory reform on the electricity sector in LMICs, but do not discuss tariff impacts. Kojima *et al.* (2014) offer a political economy perspective of the barriers to reform facing African electricity sectors and the costs and benefits of subsidy reform. While reviews on the challenges facing African countries' electricity sectors are well covered in the literature, comparable reviews that holistically assess the impacts of different types of tariff reform are non-existent. The consideration of the various tariff reform types (i.e. payment, structure, and rate) allows for a more nuanced discussion and understanding of their benefits and disadvantages, as well as their interplay, which is important given that many governments and utilities undertake multiple types of reform simultaneously.

## 3. Methodology

This systematic review, conducted from 2019 to 2021, was implemented in three phases: 1) development of the search criteria; 2) systematic coding and organisation of the selected literature; and 3) analysis of the selected literature and synthesis of findings. The search was conducted in the Web of Science and EconLit databases in March 2020. The search yielded over 2,800 results from Web of Science and over 3,300 from EconLit, giving a total of 6,100 articles to screen. Two rounds of screening followed based on relevancy to the aims of our review; duplicate papers were removed, narrowing our search sample to 59 papers. We then supplemented this sample with 13 papers from members of the research team and 10 papers following

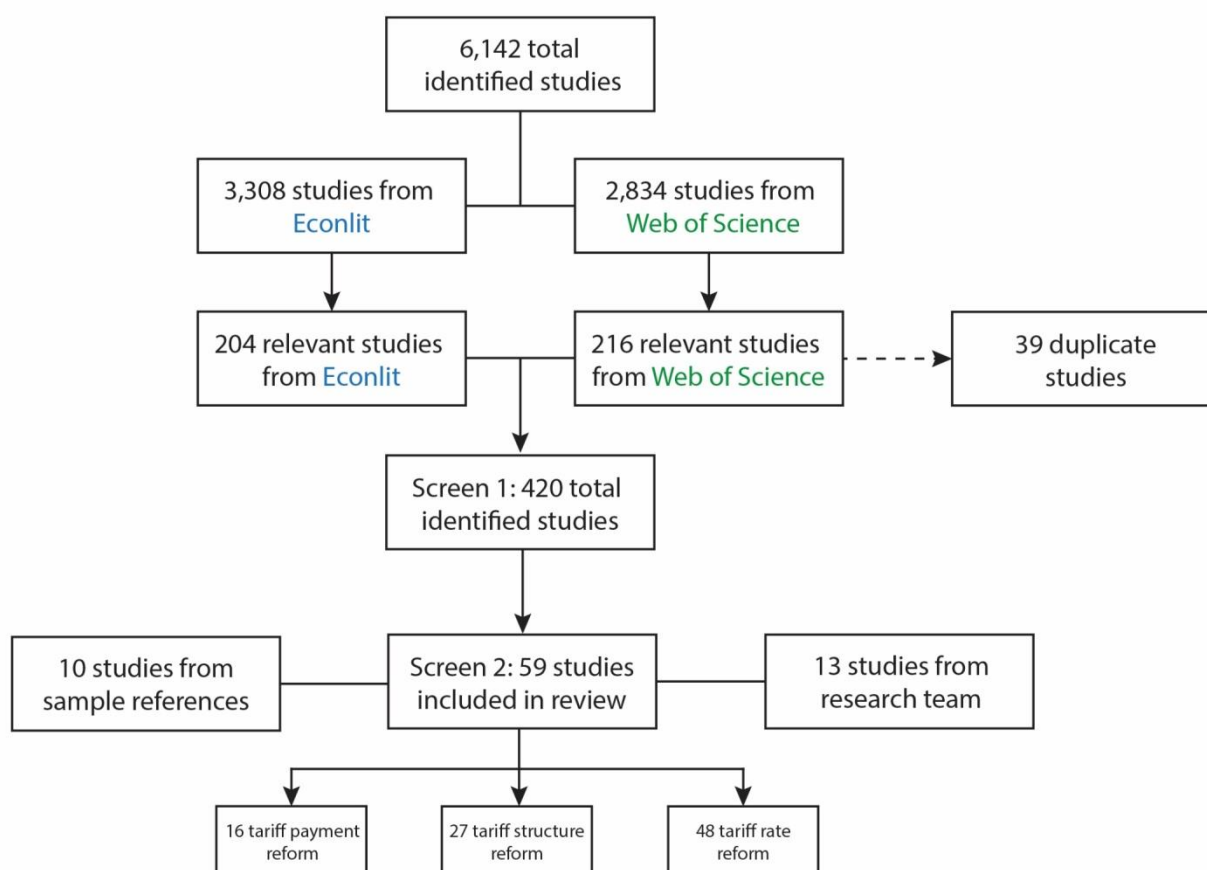
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<sup>1</sup>Non-technical losses refer to 'any electrical energy consumed and not invoiced. They may occur due to illegal connections, issues with energy meters such as delay in installation or reading errors, contaminated, defective or non-adapted measuring equipment, very low valid consumption estimates, faulty connections, and disregarded customers' (de Souza *et al.*, 2021, p. 1).

the screening of studies referenced in the original 59 papers, leading to inclusion of a total of 82 papers. Figure 1 presents a breakdown of our sample.

The inclusion criteria for our review aimed to restrict our sample to studies of the impacts of electricity tariff reform in Africa. We did not consider studies on the drivers of reform, though these are relevant to the motivation and discussion of findings in this review; such studies are addressed to some extent in prior reviews, as discussed in the previous section. Our review includes studies of the impacts of electricity price reform on various types of stakeholders and institutions – including the end-users of electricity (e.g. households, firms, and industries), and the producers and regulators of electricity (e.g. utilities and governments) – and discussions of macroeconomic impacts (e.g. poverty, social welfare, inequality, etc.).

**Figure 1: Breakdown of studies included in this review (note that categories of reform are not mutually exclusive)**



A team of three graduate research assistants was trained and papers from the search results were randomly assigned to them for the two rounds of screening, as well as the coding of retained articles. The team received training to ensure consistency in screening and coding, and met regularly to resolve any issues or inconsistencies that arose. In the first round of screening, coders evaluated whether an article is relevant or not based on a reading of the paper's title and abstract. In the second round, coders examined the full article to determine relevance in line with the inclusion criteria described above. The inclusion/exclusion criteria were designed to restrict our sample to articles pertaining to tariff reform measures – namely, changes to electricity pricing rates, structures, and payment modalities. For example, a study examining the non-price determinants of electricity demand and the capacity of the grid to meet demand would be excluded. However, a study examining the impacts of electricity price on demand would be included.

For each study deemed relevant following the two screening rounds, the following information was recorded:

- A. study characteristics: setting and scale (e.g. regional, national, multi-country, etc.), methodology and sampling, level of analysis (e.g. residential, commercial, industrial, etc.), and a subjective assessment of study robustness;<sup>2</sup>
- B. reform type (e.g. tariff payment, tariff structure, tariff rate);
- C. impacts of reform on various outcomes (e.g. consumption, conservation behaviour, private sector investment, household welfare, poverty, employment, cost recovery, technology adoption, customer satisfaction, and non-technical losses); and
- D. direction and magnitude of impacts, where applicable (e.g. negative/positive and statistically significant, inconclusive or insignificant, etc.).

## 4. Results

This section presents the results of the review, organised by reform type. We first discuss changes in payment modalities or systems, such as moving to prepaid consumption from traditional postpayments of electricity bills. Tariff structure changes are then discussed, such as moving from block rates to constant variable rates or other structures.<sup>3</sup> Finally, we discuss changes in tariff rates (increases or decreases), which are by far the most frequently analysed reforms, as well as the effects on different economic sectors.

### 4.1 Impacts of tariff payment reform

Beginning with the least studied type of reform, we find a dearth of studies (especially quantitative and econometric studies) on tariff payment reform. The most common type of payment reform studied was shifting to prepaid metering, a reform that is undertaken almost exclusively in the residential power sector. This residential targeting is also reflected by the fact that this reform appears only in our sample of studies that consider impacts on households, though this could also reflect a lack of study of similar interventions in the commercial sector.

#### i) Effects of prepaid metering on electricity consumption

Several studies reveal a reduction in consumption associated with a switch to prepaid electricity meters. Aliu (2020) finds annual electricity use 47% lower among households with a prepaid meter compared to those with traditional postpaid meters in urban Nigeria. A similar study in urban Ethiopia also shows 18% lower consumption among prepaid metered households compared to postpaying customers (Beyene *et al.*, 2022). Two studies in South Africa examine the effects on customers prior to and following the switch to a prepaid meter. These studies, conducted in Cape Town and Soweto, demonstrate a reduction in consumption by 14% (over one year) and 48% (over seven years), respectively (Jack and Smith, 2020; Kambule *et al.*, 2019). In addition, meter tampering among customers in Ghana resulted in the replacement of tampered meters with prepaid meters, which led to a 13% self-reported increase in electricity consumption between 2014 and 2015. This positive effect was likely due to the reduction in unmetered consumption (Otchere-Appiah *et al.*, 2021). The impacts of prepayment on consumption must also be considered when assessing net effects on utility revenue (Jack and Smith, 2020; Otchere-Appiah *et al.*, 2021).

Decreases in electricity consumption following the installation of prepaid meters are mainly attributed to increased awareness of consumption and the discouragement of inefficient use. This behaviour was observed in Nigeria, where energy conservation measures were adopted more frequently by prepaying than by postpaying consumers (Akinyemi and Ajayi, 2015; Arawomo, 2017). In Nigeria and Mozambique, this effect was explained by prepayment requiring households to be more cognisant of the amount of electricity they consumed (Akinyemi and Ajayi, 2015; Baptista, 2015). In Ethiopia, prepaying customers were more likely to use energy-efficient lights (Beyene *et al.*, 2022). Studies from South Africa (a country with the longest experience of implementing prepaid meters) and Ghana (where power sector reforms, including prepaid meters, face more public

<sup>2</sup> Robustness was coded based on the subjective interpretation of the coder using the following criteria. For observational, experimental, and qualitative studies, robustness was assessed based on either: a) the strength and significance of results; b) whether results were found to be consistent with the wider population; c) whether multiple definitions of outcomes were tested and yielded consistent outcomes; or d) whether several sets of analyses confirmed the main findings. For modelling studies, robustness was assessed on the sensitivity of results to parameter assumptions (where described).

<sup>3</sup> Block rates refer to a pricing structure where electricity price per kWh is constant over a range of kWh but changes (increases or decreases) with blocks involving higher or lower levels of consumption. Flat rates refer to a pricing structure where price per kWh does not change based on the amount consumed. Variable rates refer to a pricing structure where electricity price constantly fluctuates based on the market (Terza and Welch, 1982).

scrutiny) identify similar conservation behaviour among prepaying users (Boamah and Rothfuß, 2018; Jack and Smith, 2015; Tewari and Shah, 2003). In Rwanda, energy losses decreased by 8% between 2004 and 2009 partly due to the implementation of prepaid meters, which better enabled utilities to identify and penalise theft (Mwaura, 2012).

Overall, estimated responses to prepaid metering vary considerably across studies, and it is not clear what drives this heterogeneity. Still, as noted above, theories of why prepaid metering reduces electricity use tend to focus on consumers' greater attention to their energy use, which allows a reduction of inefficient consumption. Another possible explanation is that prepaid metering permits better management of liquidity constraints, allowing consumers to control their consumption when cash is limited, which in turn reduces billing debt accumulation. Thus, greater responses may be related to more severe problems of pre-reform inattention or the management of irregular cash flow. Some estimates may also be biased owing to inaccurate assessment of the counterfactual without prepaid metering. Another possible reason for heterogeneity is that most of the above studies sample townships within cities, which may not be representative of trends across these cities more broadly or across other urban populations in the study countries.

## ii) Effects across households

There exists some debate in the literature over whether the prepayment of electricity is beneficial for low-income households. On the one hand, the prepayment of electricity allows households to better plan and budget their energy consumption (Baptista, 2015; Tewari and Shah, 2003) and smooth household expenditures to income (Jack and Smith, 2015). In South Africa, prepayment facilitated greater flexibility in the frequency and quantity of electricity that low-income households could consume, and thereby enabled repayment of debt (Jack and Smith, 2015; Tewari and Shah, 2003). In addition to providing a mechanism for greater self-control of consumption, there is also limited evidence to suggest that prepayment may facilitate greater intra-household control (Jack and Smith, 2020). A study in urban Mozambique demonstrates this, observing that prepayment allowed women and younger males to purchase credits and control their own electricity consumption decisions (Baptista, 2015).

On the other hand, prepayment may entrench socioeconomic inequality among low-income households with high energy expenditure (Kambule *et al.*, 2019). Income uncertainty can impede the upfront purchase of electricity, as was found in South Africa and Tanzania, reducing consumption among low-income users (Jacome and Ray, 2018; Makonese *et al.*, 2012). In Tanzania, such users generally preferred prepaid meters to avoid the risk of debt accrual from postpayment, preferring a system that rendered non-payment obsolete. However, studies also found that among the lowest energy users, postpayment offered more security of connection than prepaid meters, as disconnection may not always occur after the first missed payment (Jacome and Ray, 2018). Prepaid systems also change the terms by which customers interact with service provision, which may require more careful accounting of energy expenditures and more frequent purchases of electricity, which may add time burdens to households if credits must be purchased via vendors (Boamah and Rothfuß, 2018; Tewari and Shah, 2003). Lastly, there is a risk that prepaid meters can undermine the goals of Sustainable Development Goal 7 (access to affordable, reliable, and clean energy for all) if prepaid meters create new barriers to access electricity and cause households to shift to biomass fuels to meet their energy needs (Jacome and Ray, 2018).

## iii) Impacts of prepaid metering on customer satisfaction and revenue collection

The greater flexibility in electricity purchasing and consumption afforded by prepaid meters led to greater satisfaction with service delivery among some households in Mozambique and South Africa (Baptista, 2015; Jack and Smith, 2015). In South Africa, the elimination of postpaid meters reduced consumer disconnection and reconnection costs after non-payment (Tewari and Shah, 2003). Residents with prepaid meters generally display greater satisfaction, though perhaps not when electricity service provision is highly politicised, i.e. where prepaid meters are perceived to be a tool for greater control by the government or when roll-out coincides with unpopular rate increases (Boamah and Rothfuß, 2018; Tewari and Shah, 2003; Yakubu, Babu, and Adjei, 2018).

Switching customers to prepaid meters in Ghana coincided with increased rates of electricity theft, though this reform occurred in parallel with tariff price increases and without immediate improvements in reliability, sparking a public outcry (Yakubu, Babu, and Adjei, 2018). Yakubu *et al.* (2018) also identified public dissatisfaction with high costs, rather than poverty, as the primary motivation for electricity theft. In contrast, prepayment in Namibia and South Africa generally reduced electricity theft and non-payment, though aggregate losses remained high in the latter case (Azimoh *et al.*, 2017; Tewari and Shah, 2003). In Rwanda, prepaid meters aided utilities in the identification of electricity theft and roll-out

coincided with deterrent penalties (Mwaura 2012). Jack and Smith (2020) highlight that failure to address non-technical losses can undo the cost recovery benefits of prepaid meters (explored below).

Prepaid meters transferred some transaction costs from the utility to consumers (including meter reading and billing), improving cost recovery and cash flows from upfront payment (Azimoh *et al.*, 2017; Jack and Smith, 2020; Tewari and Shah, 2003). In South Africa, improved revenues from prepayment offset the higher fixed costs of meters within a year (Jack and Smith, 2020). Prepaid meters were also easier to install, though unexpected maintenance issues did not eliminate staffing requirements altogether. Notably, prepaid meters were widely implemented in South Africa's electrification of dispersed rural communities, and helped improve cost recovery for the electric utility, Eskom (*ibid*). The success of prepaid metering in South Africa can be attributed to good planning and marketing of the reform to the public, which emerge as key elements for determining the success of other reforms (mentioned below).

## 4.2 Impacts of tariff structure reform

Given the heterogeneity in the end-uses of electricity by various actors – and the different benefits that energy services provide to households, industries, and economies – tariff structure reform allows prices to be changed in complex ways to meet a range of different criteria. Such criteria can differentiate prices based on the type of consumer, the amount of electricity consumed, the type of use, the time of day of consumption, and others.

### i) Pricing differentiated by consumer type

Many African utilities have implemented different pricing schemes depending on the type or class of electricity consumer (Clements *et al.*, 2013). Across industry types, differential pricing can also act as a tool of 'pricing resources used in the production of different commodities differentially' (Thopil and Pouris, 2013 p. 3). Governments and utilities sometimes leverage such pricing schemes to restrict energy-intensive industries and promote the expansion of less energy-intensive industries (*ibid*), or to achieve equity goals. Industries and businesses (the largest per capita consumers of electricity) often pay different rates per kWh than households or small firms. This is the case in South Africa, which offers over 320 different tariff pricing schemes for businesses (Kelly and Geyer, 2018). Kohler (2014) discusses the application of differential pricing for various South African industrial sectors, which are among the least energy-efficient in the world. Charging higher prices for certain sectors would, in theory, raise the cost of energy inefficiency and drive out the least efficient industries in the long term. Kohler (2014) suggested that the construction, paper, pulp and print, and iron and steel sectors would be ideal targets for higher pricing due to their sharp negative responses to price changes. Such effects need to be weighed against the effects on industrial production, as discussed in Section 4.3.3.

Industries in Egypt, South Africa, Nigeria, Cameroon, Uganda, Cabo Verde, Tanzania, and Senegal actually pay less per kWh for electricity than households, which can result in households cross-subsidising electricity costs for industry (Ajodhia, Mulder, and Slot, 2012; Clements *et al.*, 2013; Griffin, Laursen, and Robertson, 2016; Marwah, 2017; Thopil and Pouris, 2013). Where cross-subsidisation is reversed (as in Kenya), there exists the risk of negative economic consequences as high electricity prices have been a major driver of firm closure and relocation (Godinho and Eberhard, 2019a; Mpholo *et al.*, 2020). There also exist less widely implemented targeting approaches not based on consumption, including fixed standard charges, geographic targeting, and means-tested discounts, which may address some of the targeting challenges presented in the next section (Alleyne, 2013; Maboshe, 2020; Vagliasindi, 2012).

### ii) Increasing block tariffs

Increasing (or inverted) block tariffs (IBTs) are the most commonly implemented quantity-differentiated pricing mechanisms for electricity in Africa. IBTs price electricity based on kWh consumed each month. Consumers that use electricity above certain thresholds must then pay more for every kWh consumed above that threshold. Thus, low consumers (typically low-income households) pay a low, heavily subsidised rate per kWh, and high consumers (often wealthier households or firms) pay a higher rate. IBTs are often designed based on the idea that high-tier consumers help cross-subsidise costs for lower-tier consumers. In addition, higher prices are thought to serve as a price signal to indicate the importance of conserving power as consumption increases (Cardenas and Whittington, 2019).

IBTs are heavily scrutinised in the literature as poorly targeted to meet equity objectives and as inhibiting cost recovery for providers (Alleyne, 2013; Kelly and Geyer, 2018; Wodon, 2012). Low-income households often share electricity connections or meters, which may place such households in a higher tariff block and undermine the tariff objective (Cardenas and



Whittington, 2019; Huenteler *et al.*, 2017; Vagliasindi, 2012). There is evidence that IBTs may reduce demand in the residential sector (Imi *et al.*, 2019). However, recent work from Ethiopia shows that low prevailing prices overall and low billing awareness may mitigate the incentive to conserve as consumers are more likely to respond to average rather than marginal prices. Consumer response to average rather than marginal prices may also reflect a lack of price signalling from poorly structured IBT tariff regimes (Cardenas and Whittington, 2019). In South Africa, poorly designed IBTs mainly subsidise consumption for low-income households at the expense of utility revenues (rather than achieving cross-subsidisation from higher-tier consumers), though this pricing structure did insulate these consumers from price hikes in 2007 (Kelly and Geyer, 2018). The failures of South Africa's IBT schemes have been attributed to the relatively small pool of high-tier consumers. Insufficient revenue capture from these consumers can also result from blocks that increase too gradually, which compromises cost recovery objectives (Alleyne, 2013). This evidence supports the claim that IBTs are more efficient in the presence of larger customer bases, since high-tier consumers can cross-subsidise the costs of less profitable, lower-tier consumers (Huenteler *et al.*, 2017).

### iii) Volume differentiated tariffs

Volume differentiated tariffs (VDTs) are designed to address some of the targeting challenges of IBTs but remain relatively understudied (Alleyne, 2013; Vagliasindi, 2012). VDTs charge consumers a single marginal price for all of their consumption, but that price is higher if the consumer exceeds a certain threshold, rather than applying only to consumption above an IBT-type threshold. This reduces the fraction of subsidy benefits incurred by higher-tier consumers of electricity, may help to create a more progressive pricing system when meter sharing is limited, and tends to improve cost recovery due to the higher overall revenue obtained from those with more electricity consumption.

Several countries have adopted forms of VDTs, including Cameroon, Cabo Verde, Benin, Ghana, Ethiopia, and Togo. Tunisia implemented a hybrid IBT/VDT structure, with volume differentiated pricing for those consuming less than 200 kWh per month and increasing block pricing for those consuming above 200 kWh per month. The wealthiest quintile, more often priced on an IBT schedule, still captured 25% of electricity subsidy benefits (Cuesta, El Lahga, and Lara Ibarra, 2017). In Cabo Verde, simulations of VDTs found an increase in targeting performance, though subsidies remained largely regressive (Angel-Urdinola and Wodon, 2007). It is worth noting that prepayment of electricity may complicate volume differentiated pricing since the total volume consumed over a given period is undetermined at the time of purchase (Mpholo *et al.*, 2020).

### iv) Lifeline tariffs

To promote affordability for low-income households, governments may offer lifeline tariffs or free basic electricity, fully or heavily subsidising electricity costs for low consumers. Lifeline tariffs can be incorporated as the first (and sometimes second) block in an IBT scheme and can be set to align with the levels of consumption needed to obtain the energy services to which governments wish to guarantee access. For example, if regulators want to encourage the use of electricity for cooking, then a lifeline tariff of 100 kWh per month may be set (as in Tunisia). If regulators want to subsidise less energy-intensive services, such as lighting, then a lifeline rate of 50 kWh per month may be established (as in Ghana and Ethiopia) (Van Den Broek and Lemmens, 1997). By promoting affordability, lifeline tariffs may also encourage switching to electricity for energy needs, particularly among low-income households (Hosier and Kipondya 1993).

While lifeline tariffs are designed to reduce the costs of consumption for low-income consumers, they often encounter the same targeting problems as IBTs. In Tunisia, the poor are not even the majority beneficiaries of the lifeline tariff block (Cuesta, El Lahga, and Lara Ibarra, 2017). In Ghana, only 8% of the subsidy for the lifeline tariff reaches the poor. Set relatively low at 50 kWh per month, this tariff did not benefit low-income consumers living in compound housing and disadvantaged those living just above the poverty line (Vagliasindi, 2012). Among South African households eligible for free basic electricity, use of the programme was low and 91% were unaware of the existence of the programme altogether, which may reflect communication failures of the policy itself, and emphasises the importance of public education and consumer consultation (Bekker *et al.*, 2008; Masekameni *et al.*, 2018; Mpholo *et al.*, 2020). Across countries in Africa, the lowest-income households are not likely to be grid connected, reducing the effectiveness of lifeline (and IBT) targeting in meeting equity objectives (Makonese *et al.*, 2012). Thus, greater emphasis has shifted to connection subsidies, discussed further in Section 5, which may better target low-income, unconnected households (Alleyne, 2013; Wodon, 2012).

### v) **Dynamic electricity pricing**

The final tariff structure scheme considered in our review is dynamic or time-of-use (TOU) pricing, which remains relatively underexplored in Africa, largely because it requires advanced metering technology that is less common in the region. Dynamic pricing is a particularly useful mechanism for utilities and regulators to smooth consumption across times of peak and low demand, and its application is mostly limited to larger consumers such as large firms and industries, as opposed to households. In 2004, the South African utility, Eskom, implemented various TOU pricing schemes for industrial consumers in its Nightsave and Megaflex schemes. Based on the predictability, time and amount of demand, firms can choose between various TOU structures and simultaneously optimise their own cost savings (Hamer, Kgwetiane, and Vosloo, 2014).

A case study of a South African processing plant demonstrated that a switch to Megaflex TOU pricing yielded a potential cost savings of 4–11% (Hamer, Kgwetiane, and Vosloo, 2014). Another study modelling the impacts of real-time pricing on South African industries found that non-chemical industries can benefit the most from a TOU pricing scheme. This is because these firms have considerable flexibility in the time of day when they choose to use electricity, allowing them to align production with low demand periods at relatively low cost (Pretorius and Delpont, 1998). In one study, municipal service providers in South Africa preferred TOU pricing schemes as they smoothed consumption across peak and low demand times (Kelly and Geyer, 2018). At least one study examines the impact of a smart prepaid metering system among Ghanaian households, finding that these meters reduce non-technical losses by deterring tampering or theft (Otchere-Appiah *et al.*, 2021).

## 4.3 **Impacts of tariff rate reform**

The most common reform type studied in our review is tariff rate reform. We first present macroeconomic impacts of tariff rate changes on country economies, then organise the following sub-sections by end-users, given that changes in electricity prices impact consumers differentially. End-users in this section include households, firms and industries. The last sub-section describes impacts of electricity price changes on providers and regulators of electricity.

### 4.3.1 **Aggregate impacts of tariff rate reform**

#### i) **Direct effects on poverty**

Computable General Equilibrium modelling is commonly used to estimate the macroeconomic impacts of tariff reform, and to clarify its distributional consequences. Tariff rate increases on their own are typically found to increase poverty and exacerbate socioeconomic inequality. In Tunisia, a 10% uniform increase in tariffs resulted in a 2.5 percentage point increase in the short-term poverty rate<sup>4</sup> (Cuesta, El Lahga, and Lara Ibarra, 2017). A 75% uniform increase in the tariff rate in Zambia – where less than one third of the population has access to electricity and access outside urban areas is extremely low – produced only a 0.5 percentage point increase in extreme poverty<sup>5</sup> (Maboshe, Kabechani, and Chelwa, 2019). Low electrification rates among poor households meant tariff increases in Mali and Senegal led to marginal increases in poverty rates, though low-income groups experienced the greatest welfare losses via indirect effects (see Section 4.3.2) (Boccanfuso, Estache, and Savard, 2009a, 2009b). It is worth noting that tariff increases can lead to a reduction in poverty when coupled with an expansion of grid connections (Mbanda and Bonga-Bonga, 2018).

#### ii) **Aggregate elasticities of demand**

Price elasticities of demand vary across studies, though electricity demand appears consistently price inelastic (see Table 1). Some of the highest consumer price elasticities estimated were -0.681 for Tunisia from 1990 to 2007 (Gam and Rejeb, 2012). In Namibia, price elasticity was -0.30 in the long run from 1980 to 2002 (De Vita, Endresen, and Hunt, 2006) and was similarly inelastic estimate of -0.15 in Lesotho from 1995 to 2012 (Thamae, Thamae, and Thamae, 2015) and South Africa at -0.55 from 2008 to 2011 (Inglesi 2010). Amusa *et al.* (2009) document price elasticity estimates to be insignificant in South Africa between 1960 and 2007. Inglesi-Lotz (2011) calculates consumer price elasticity of demand in South Africa between 1980 and 2005, finding that periods of higher prices created higher sensitivities to price fluctuations among consumers. One of

<sup>4</sup>The poverty rate is defined as the percentage of individuals in a population living below the poverty line, which is typically set at half the median income of a population. A short-term increase refers to the immediate change in the poverty rate, independent of behavioral responses from consumers.

<sup>5</sup>Extreme poverty is defined as the inability of a household to meet the cost of basic food basket, according to the 2015 Zambian Living Conditions Monitoring Survey Report.

the earliest price elasticity studies on the continent examined price elasticity from 1950 to 1983 in South Africa, calculating a long-run, own-price elasticity of -0.90. This was during a period when industry was the primary consumer of electricity; thus, this value may be less reflective of effects across non-industrial consumers (Pouris, 1987).

**Table 1: Studies of aggregate electricity demand**

Authors	Period	Country	Sector	Price elasticity
Gam and Ben Rejeb (2012)	1990–2007	Tunisia	Aggregate	-0.681
De Vita <i>et al.</i> (2006)	1980–2002	Namibia	Aggregate	-0.30
Thamae <i>et al.</i> (2015)	1995–2012	Lesotho	Aggregate	-0.15
Inglesi-Lotz (2010)	2008–2011	South Africa	Aggregate	-0.55
Amusa <i>et al.</i> (2009)	1960–2007	South Africa	Aggregate	Statistically insignificant
Inglesi-Lotz (2011)	1980–2005	South Africa	Aggregate	From -1 in 1980s to ~0 in mid 2000s
Pouris (1987)	1950–1983	South Africa	Aggregate	Long run: -0.90

### iii) Substitutability of electricity

Low consumer price elasticities indicate that consumer demand is relatively insensitive to price changes, both in the short and long run. This finding suggests that many consumers may not want to replace electricity with other fuels (such as kerosene or gas) or may not be able to do so, or these other fuels provide energy services that are different, either substantively (e.g. household cooking) or in terms of their quality (e.g. for lighting). In Namibia, South Africa, and Senegal, consumers appeared relatively ‘locked in’ to appliances or equipment used for electricity services, implying minimal substitutability of non-electric fuels (Boccanfuso, Estache, and Savard, 2009a; Inglesi, 2010; De Vita, Endresen, and Hunt, 2006). From 1960 to 2007, electricity prices were found to be insignificant in determining aggregate demand due to low prevailing prices and the lack of close substitutes for electricity (Amusa, Amusa, and Mabugu, 2009). In Nigeria (and similarly in Ethiopia), from 1970 to 2007, the price of substitute fuels had little effect on the price elasticity of electricity due to low ownership of alternative power systems (Babatunde and Shuaibu, 2009; Guta *et al.*, 2015). Thus, low substitutability may reflect a reliance on electricity for certain services and technological limitations that hinder substitution.

#### 4.3.2 Impacts of tariff rate reform on the residential sector

##### i) Effects on residential sector electricity demand

Few studies calculate price elasticities of residential demand for electricity. In line with price elasticities of aggregate demand, residential price elasticities for electricity are typically negative and inelastic (see Table 2). However, electricity price was cited as a major determinant of demand (Boccanfuso, Estache, and Savard, 2009a; Landis and Timilsina, 2014; Talbi and Nguyen, 2014; Ye, Koch, and Zhang, 2018). Long-run price elasticities among South African households, where electricity prices are among the lowest globally, ranged from -0.04 and insignificant (Ziramba, 2008) to -0.89 (Ye, Koch, and Zhang, 2018). The former finding can be partially explained by low prevailing tariffs and low connection rates. Tunisia, another country with relatively low residential electricity tariffs, was estimated to have a price elasticity of -0.30 between 1980 and 2004 (Talbi and Nguyen, 2014). A study of Ethiopian residential electricity demand from 1970 to 2011 revealed a comparable price elasticity of -0.238 (Guta *et al.*, 2015). Similarly, Babatunde and Shuaibu (2009) found a slightly positive, though insignificant, elasticity of demand among Nigerian households from 1970 to 2007; this was attributed to low prices, high rates of theft and non-payment, and unreliable supply. Low and decreasing elasticities of demand over time reflect trends in the larger global literature and may be attributed in part to technological improvements in energy efficiency (Labandeira, Labeaga, and López-Otero, 2017).

**Table 2: Studies of residential electricity demand**

Authors	Period	Country	Sector	Price elasticity
Ziramba (2008)	1978–2005	South Africa	Residential	-0.04, statistically insignificant
Ye <i>et al.</i> (2018)	2010–2011	South Africa	Residential	-0.89
Talbi and Nguyen (2014)	1980–2004	Tunisia	Residential	-0.30
Guta <i>et al.</i> (2015)	1970–2011	Ethiopia	Residential	-0.238
Babatunde and Shuaibu (2009)	1970–2007	Nigeria	Residential	Long run: 0.121 Short run: 0.091 (both insignificant)

### ii) Effects on conservation behaviour and technologies

Despite the relatively inelastic demand for electricity, there is evidence that price increases can induce energy conservation. In Ghana, a 100% tariff increase in 2000 led to an increase in conservation activities among households (low-income households in particular) and greater investment in back-up power sources (Adom, 2017; Boamah and Rothfuß, 2018). Low prevailing electricity tariffs, meanwhile, often hinder incentives to conserve power (Ye, Koch, and Zhang, 2018). Changes in electricity tariffs can also influence the market for electricity-conserving technologies. In some South African cities, a 10% increase in tariffs resulted in heat pumps becoming a more economically viable investment in large residential units such as hospitals, hotels, and boarding houses, and could expand the market for these technologies among households (Meyer and Greyvenstein, 1991, 1992). Electricity price changes may also discourage the use of energy-intensive appliances such as stoves. Among urban households in Ethiopia, the price of electricity was a determinant of electric stove adoption (Alem *et al.*, 2014; Beyene and Koch, 2013). Further, wealthier households may have higher price elasticities as they are more likely to be able to afford energy-efficient home appliances, as suggested by Iimi *et al.* (2019) in a study of Ethiopian households.

### iii) Effects across households

In line with this finding, households do not experience price impacts equitably. Low-income households are more likely to be located in rural areas and are less likely to have a grid connection. Of those households with grid connections, average consumption is lower than in wealthier households. At the same time, though, low-income households are more likely to use electricity to meet basic needs (for which demand is inelastic), compared to wealthier households, which may have more flexibility in their consumption. Thus, the incidence of changes in electricity tariffs is greater on poor households than on rich households, but applies to a lower level of consumption, such that the cost increase for them may remain lower overall (Andriamihaja and Vecchi, 2007; Boccanfuso, Estache, and Savard, 2009a; Maboshe, Kabechani, and Chelwa, 2019). In Mali, tariff increases were projected to affect the welfare of urban and educated households most negatively (Boccanfuso, Estache, and Savard, 2009b). In Ethiopia, wealthier households were found to have a greater price elasticity than poorer households, attributed to their electricity use patterns (Iimi *et al.*, 2019). Irregular tariff increases were also found to disproportionately affect wealthier households in Ghana, who reacted by changing their energy consumption patterns (Boamah and Rothfuß, 2018).

Despite lower connection rates and lower average consumption, low-income households do experience direct and indirect impacts from tariff price changes. Tariff increases can impact unconnected households through an increase in the prices of goods and services provided by electricity-intensive sectors (such as from commercial and manufacturing firms), thus increasing non-electricity expenditures for connected and unconnected households alike (Landis and Timilsina, 2014). Maboshe *et al.* (2019) found that Zambian households in the lowest-income quintile experienced a three times larger expenditure loss compared to households in the highest quintile, following a 75% tariff increase in 2017, likely due to their high pre-existing electricity expenditure as a share of disposable income. Despite the low rates of grid connection, they likewise found that the poorest households experienced a welfare loss of 9.4%, compared to a loss of 3.9% among the wealthiest

households. This occurred largely through an increase in household electricity expenditure and partially through an increase in expenditure on other goods and services, though the latter effect was more evenly experienced across households.

To mitigate the negative impacts of tariff price increases on the poor, several studies have considered the viability of compensation mechanisms and policies that transfer fiscal savings incurred from tariff increases to low-income households. Such transfer programmes may be relatively inexpensive in countries where grid access or consumption by low-income consumers is low (Boccanfuso, Estache, and Savard, 2009a). In Zambia, an allocation of fiscal savings to the poorest 50% of grid-connected households reduced poverty by 4 percentage points (Maboshe, Kabechani, and Chelwa, 2019). Such transfers were also found to be sufficient to compensate for the negative general equilibrium effects of tariff rate hikes on the poor in Senegal (Boccanfuso, Estache, and Savard, 2009a). However, a study in Tunisia found that various compensation mechanisms to the public (via the universal or targeted transfer of total fiscal savings from the reform) reverse the negative distributional effects of the tariff increase, even as they make a negligible dent in poverty rates and inequality (measured by the Gini index), compared to pre-reform levels (Cuesta, El Lahga, and Lara Ibarra, 2017). These studies highlight the importance of public investment in social programmes to accompany electricity tariff increases.

### 4.3.3 Impacts of tariff rate reform on commercial and industrial sectors

#### i) Effects on electricity demand

Among commercial and industrial firms, price elasticities of demand for electricity consumption are generally negative and relatively inelastic. Much of the existing literature focuses on South Africa, which has a more industrialised economy than other African countries. Another reason South Africa is a common subject of study is due to the nationwide electricity supply crisis that occurred in 2007–2008, which led to insecurity in electricity supply and extensive blackouts. Multiple studies (Blignaut, Inglesi-Lotz, and Weideman, 2015; Gonese, Hompashe, and Sibanda, 2019; Inglesi-Lotz, 2014) have linked this crisis to low prices, and the resulting inability of the national electricity producer Eskom to expand generation capacity to match growing demand in the country. We further explore this issue in our discussion of impacts of tariff rate reform on the production sector.

Prior to South Africa's energy crisis, researchers attempting to identify the price elasticity of electricity in different economic sectors often found results to be statistically insignificant (Blignaut, Inglesi-Lotz, and Weideman, 2015). Statistically significant elasticities usually did not cover the same time periods (see Table 3). As discussed above, one early study (Pouris, 1987) estimated the long-run price elasticity from 1950 to 1983, reaching a figure of -0.90. Kohler (2014) finds a long-run price elasticity in the industrial sector of -0.939 from 1989 to 2009. Price increases since 2008 have led to a better understanding of the determinants of firms' electricity demand.

Blignaut *et al.* (2015) found that the commercial sector had a small and statistically insignificant price elasticity in the pre-crisis period from 2002 to 2007, then determined the elasticity to be -0.19 after 2008. However, findings among industrial subsectors have varied somewhat. For example, Gonese *et al.* (2019) observed that price increases have a negative effect on output in the transport, communication, and construction sectors, while the mining sector actually raises output following price increases. In contrast, Blignaut *et al.* (2015) found the mining sector to be the most reactive to price increases, with a price elasticity for electricity of -0.465 from 2008 to 2012, a finding supported by Boonzaaier *et al.* (2012). Last, Mahony and Baartman (2018) noted that a drop in industrial consumption of electricity has coincided with price increases since 2011.

Studies of price reactivity in the industrial and commercial sectors of other African countries are sparse. Talbi and Nguyen (2014) found the price elasticity for electricity in Tunisian industry to be relatively inelastic (-0.59), due to the long lifetime of equipment used in the industrial sector and associated limitations in potential responses to higher prices (Talbi and Nguyen, 2014). Haji and Haji (1994) found that rising electricity tariffs led to similarly modest reductions in industrial electricity use in Kenya. A study of 21 large firms in South Africa found demand to be relatively inelastic as infrastructure investments inhibited substitution of electricity (Boonzaaier *et al.*, 2012).

**Table 3: Studies of commercial or industrial electricity demand**

Authors	Period	Country	Sector	Price elasticity
Blignaut <i>et al.</i> (2015)	1976–1996	South Africa	26 economic sectors	Average varies from -0.306 to 0.760
Inglesi-Lotz (2014)	1970–2007	South Africa	Industrial	-0.95
Inglesi-Lotz and Blignaut (2011)	1993–2006	South Africa	5 economic sectors	Industrial: -0.869; Transport, Commercial, Mining, Agriculture: statistically insignificant
Talbi and Nguyen (2014)	1980–2004	Tunisia	Industrial	-0.59
Haji and Haji (1994)	1961–1988	Kenya	5 industrial sectors	Varying from -0.093 in Total Industry to -0.778 in Total Manufacturing
Kohler (2014)	1989–2009	South Africa	Industrial	Total: -0.939; Industrial: varying from negative to statistically insignificant

### ii) Effects on conservation behaviour and technologies

Energy-efficient technologies appear as a focus in two recent studies from Ghana. Apeaning and Thollander (2013) noted that the government implemented heavy subsidies on energy prices, such that the resulting low prices served as a weak incentive for firms to adopt energy-efficient equipment. On the other hand, the threats of rising energy prices were strong drivers for the implementation of energy-efficient technologies in Ghanaian industry. Adom (2017) suggested that due to the low-price elasticity of electricity, industrial firms require more than just price increases to reduce electricity consumption. Energy conservation is an important topic in Ghana, where rapid economic growth is causing demand to outpace supply. The country's power sector is simultaneously saddled with supply-side challenges (including fuel supply constraints), a financially inviable state-owned utility, and prolonged power outages (Gyamfi *et al.*, 2015). If Ghanaian electricity producers are not able to expand capacity or otherwise match demand for electricity, there is a risk of chronic, widespread load-shedding similar to that which occurs in South Africa.

### iii) Disparate effects in the industrial sector

We next investigate the effects of tariff increases across industrial sectors. Our findings are restricted in scope to papers focused on South Africa, and results vary considerably. Gonese *et al.* (2019) identified that the transport, communications, and finance sectors suffered most from electricity price increases in terms of sectoral output from 1994 to 2015, while agriculture and trade saw the least change in their output as a result of price increases. Inglesi-Lotz and Blignaut (2011) also found a weak impact of electricity prices on output from the agriculture and trade sectors (consistent with Boonzaier *et al.*, 2012) as these sectors are less reliant on electrical energy and may engage in co-generation of power. Inglesi-Lotz and Blignaut (2011) found that electricity price elasticity was significant only for the industrial sector from 1993 to 2006 (at -0.869), and was insignificant for the transport, commercial, mining, and agricultural sectors. Blignaut *et al.* (2015) reveal that there was an important shift in responsiveness to electricity prices following the 2008 price increases in South Africa among nine of 11 industrial sectors studied (including agriculture, transport, manufacturing, and mining). Many of these sectors, which exhibited insignificant electricity price elasticities from 2002 to 2007, now showed negative and significant elasticities. Only the commercial and the gold and platinum mining sectors represent anomalies in this trend (the latter likely due to output increases resulting from global market price fluctuations).

#### 4.3.4 Impacts of tariff rate reform on producers and regulators

### i) Effects of sector privatisation

A 2016 World Bank study of electricity utilities in Sub-Saharan African found that only two of 39 utilities were recovering their full costs (Kojima and Trimble, 2016). Growing fiscal deficits incurred by utilities and governments may incentivise the privatisation of electricity sectors to improve service delivery and shed fiscal burdens. Several studies demonstrate that privatisation is tied to increased tariffs (at least in the short term), which may play a role in the unpopular nature of this reform, and have regressive effects (Boccanfuso, Estache, and Savard, 2009a; Nagayama, 2009). However, privatisation resulted in the expansion of grid connections in Cameroon, which mirrors trends in other parts of the Global South (Boccanfuso, Estache, and Savard 2009b; Marwah, 2017). Conversely, a study of Zimbabwe's electricity sector discusses how low tariffs impeded private sector investment in new generation projects (Mangwengwende, 2002). In Uganda, privatisation helped reduce distribution losses and increase private investment in the electricity sector, though lack of large-scale private investment and reluctance to expand connections in rural areas remain persistent challenges (Mawejje *et al.*, 2013).

### ii) Effects on financial performance and cost recovery

Improving the financial solvency of electric utilities often represents a major objective of tariff reform, yet rigorous quantitative evaluations of tariff reform impacts on cost recovery remain a significant gap in the literature (Rodriguez Pardina and Schiro, 2018). In *ex ante* studies in Senegal and Mali, increased tariffs were found to contribute to greater cost recovery for utilities (Boccanfuso, Estache, and Savard 2009a, 2009b). In Ghana, a study showed that a 10% increase in tariff boosts electricity supply in the short and long run by 1–2% (Adom, 2016). A modelling study in Tunisia showed that even a partial reduction of the state's electricity subsidy (corresponding to a 10% tariff increase) would contribute to a fiscal savings of 13% (Cuesta, El Lahga, and Lara Ibarra, 2017). Observational studies in Zimbabwe and Uganda found a relationship between higher tariffs and utility profitability (Alleynes, 2013; Mangwengwende, 2002). Kenya introduced cost-reflective tariffs as early as 1996, which, along with sector reforms, have contributed to an influx of private energy investment (Clements *et al.*, 2013; Godinho and Eberhard, 2019a).

Where tariff increases are politically fraught (as in Ghana), utilities can also improve cost recovery by reducing technical losses and improving collection rates, as demonstrated in Kenya and Uganda (Alleynes, 2013). Despite price improvements, cost recovery may still decline if prices do not adjust for changes in input costs and inflation (Huenteler *et al.*, 2017). In Nigeria, privatisation and tariff increases led to greater losses for the utility due to poor management, low collection rates, and consumer unwillingness to pay. These findings emphasise the need for organisational reform to accompany tariff reform (Peng and Poudineh, 2019). Tesfamichael *et al.* (2021) also argue that the impact of electricity tariff change may depend on the way the institutions respond to energy governance and service delivery challenges.

### iii) Effects on non-technical losses

As mentioned earlier, non-technical losses from electricity theft are a common problem for many African utilities. In Ghana, interview respondents largely attributed electricity theft to dissatisfaction with high electricity tariffs and not solely to the inability to pay (Boamah and Rothfuß, 2018; Yakubu, Babu, and Adjei, 2018). There is also evidence from Uganda that shows a similar increase in electricity theft following tariff increases, though Uganda is one of the few countries that has succeeded in achieving near-full cost recovery for their utility through a series of tariff increases over the last two decades (Godinho and Eberhard, 2019b).

Heavy emphasis on consumer group consultation and public communication also contributed to the relative success of implementing cost-reflective tariffs and led the Ugandan government to introduce an Automatic Tariff Adjustment Mechanism in 2014 to modify prices according to changing input costs (Clements *et al.*, 2013; Godinho and Eberhard, 2019b). Similarly, Zimbabwe was able to improve cost recovery for their utility, the Zimbabwe Electricity Supply Authority, with broad customer support for the raising of tariffs (Mangwengwende, 2002).

## 5. Discussion and needs for further research

Our review of electricity tariff impacts in Africa spanned several different reform modalities, including bill payment, tariff structure, and tariff rate reform. We also examined how the impacts of changes in tariff rate vary across end-users and economic sectors. The following discussion is similarly broken down by modality.

Studies on electricity payment reform represent a significant gap in the literature, particularly in Africa. Given that utilities are increasingly experimenting with new payment modalities, additional research is needed on the impacts of the prepayment of electricity bills on households. Preliminary evidence suggests that prepaid meters may facilitate a greater awareness of electricity use, encourage conservation, and reduce overall consumption. While reduced demand may be beneficial for utilities, the effects on household welfare are not well understood. Further, some evidence suggests that prepayment mechanisms may increase intra-household bargaining power for women and provide new ways for accessing electricity services. Prepaid metering may face political opposition where public opinion of the electricity service is especially unfavourable, as seen in Ghana. Utilities and governments should accompany such reforms with public messaging and consumer consultation.

Studies on tariff structure reform focus largely on the inefficient targeting of increasing block and lifeline tariffs. IBTs and lifeline tariffs create allocative inefficiencies of electricity subsidies by subsidising consumption from high-tier consumers, who are often wealthier and more urban households. VDTs may reduce distributional inequities among connected households, though they largely fail to solve the issue of poorly targeted subsidies if low-income consumers remain unconnected. Further, VDTs do not address the issue of shared connections (which low-income households may utilise legally or illegally) and create challenges for prepaid metering. Thresholds for lifeline tariffs should also be set appropriately and in alignment with the energy services that governments wish to subsidise, and need to be effectively marketed towards eligible customers.

Several studies highlight the importance of redirecting subsidies towards lowering connection costs and fixed costs, which create access barriers for low-income consumers (Clements *et al.*, 2013). Low tariffs and the inability to recover costs incentivise utilities to charge high fees for connection, limiting access (Golumbeanu and Barnes, 2013). Even for partially privatised and financially viable electricity sectors, high connection costs persist and present an obstacle to grid expansion (Blimpo, McRae, and Steinbuks, 2018). In Tanzania, connection charges can be three times the monthly minimum wage, and households may have limited savings mechanisms to offset this (Van Den Broek and Lemmens, 1997). Connection subsidies in the form of loans or deferred payments may encourage grid connection and better target low-income consumers. Connection subsidies should follow reforms to improve the profitability of utilities, as utilities may use non-price barriers to delay the connection of unprofitable customers (Blimpo, McRae, and Steinbuks, 2018).

In addition to underpricing higher-income households, poorly targeted subsidies also result from the underpricing of commercial and industrial consumers. Special prices for the industrial and commercial sectors impose significant fiscal costs on governments. The practice of preferential pricing for these consumers has historical roots, as these consumers first existed to guarantee minimum demand for utilities (Alleyne, 2013). However, persistent underpricing of these consumers has curtailed revenues and even contributed to households cross-subsidising electricity costs for industry. South Africa, which arguably has one of the longest experiences with electricity reforms on the continent, still receives scrutiny for underpricing industry (Thopil and Pouris, 2013). Price adjustments for commercial and industrial consumers may also prove politically challenging as these consumers represent a large share of demand and can more easily lobby for prices in their favour, compared to residential consumers (Mangwengwende, 2002; Peng and Poudineh, 2019). There is a need for more research to understand the disparate impacts of tariff reform on various industrial and commercial sectors; this may also elucidate potential indirect effects on the public if certain industries are more responsive to electricity price changes. The public may be indirectly impacted by higher industrial electricity prices via higher costs for goods or services and/or job or wage losses, effects that are largely unexplored in the literature and carry important equity implications.

Our review finds that price elasticities of electricity demand are low on aggregate, and similarly shows that sectoral elasticities are low for residents, businesses, and industries. The largely inelastic nature of electricity demand suggests that pricing policies can only partially solve problems in the electricity sector (Adom, 2016). This also suggests that aggregate willingness to pay for electricity is high, providing further evidence for the large allocative inefficiencies of electricity subsidies. Low elasticities are commonly attributed to low prevailing prices and low connection rates among low-income customers. Few studies have calculated price elasticities across households, which could elucidate inter-household variation in demand responses to price changes. However, evidence from Ethiopia suggests that higher-income households actually have higher price elasticities than low-income households, which rely more on electricity for basic needs alone (Iimi *et al.*, 2019). Low price elasticities may also be attributed to the low substitutability of electricity for other fuels. Lastly, it is important to highlight that electricity consumption decisions are not solely price-dependent, and service-related inadequacies (e.g. unreliable supply, frequent outages) and information asymmetries remain important challenges for consumers (Tesfamichael *et al.*, 2021)

Despite low rates of connection, low-income households appear to suffer disproportionately from tariff increases as a result of welfare losses associated with price changes for goods and services. While energy subsidy removal remains an important facet of sector reform, governments must consider the direct and indirect impacts of tariff reform on the poor and implement



appropriate policies to compensate for these effects and protect vulnerable members of society. This will be especially crucial as climate mitigation policies will likely increase electricity prices, especially for countries that are more reliant on thermal power generation (Dagnachew *et al.*, 2018). Climate change can also create energy supply challenges and contribute to uncertainties in generation projections, especially for hydropower (Adom, 2016). Pricing reform and private investment may allow for greater renewable energy generation and addressing inefficiencies in energy supply may also improve environmental outcomes. Policymakers can also learn from the efforts of intermediaries such as Africa GreenCo., which aims to de-risk the sale of renewable electricity from private companies to public utilities or large-scale customers (Africa GreenCo., 2022). Thus, long-term equity and environmental considerations of tariff reform deserve greater attention in the literature.

In countries where electricity demand outpaces capacity of supply, conservation is a key objective for sector reform. Evidence from the residential, commercial, and industrial sectors suggests that increased tariffs may help induce energy conservation behaviour. Low prevailing tariffs may diminish this effect and encourage overconsumption and inefficient use (Ye, Koch, and Zhang, 2018). Further, governments and regulators should anticipate rebound effects from policies that expand energy conservation technologies or practices – such effects are again more likely when tariffs remain too low (Labidi and Abdesslem 2018). The discouragement of electricity-intensive appliances (such as electric stoves) represents a key trade-off of higher tariffs, which may be associated with other positive social benefits (such as improved health and time savings) (Jeuland *et al.*, 2018). Non-price instruments (such as policies to promote the use of energy-efficient technologies or practices) may also serve an important role in promoting conservation where demand exceeds supply (Gam and Rejeb, 2012).

Increasing electricity tariffs can improve cost recovery for utilities, increase supply, attract private sector investment, and shrink fiscal deficits. Improving collection rates and reducing aggregate losses are simultaneously important for improving revenues. The political unpopularity of such reforms may contribute to increased electricity theft, further emphasising the need for public communication and stakeholder consultation in the reform process. As mentioned above, greater sectoral and intra-sectoral disaggregation of analysis is important if governments and utilities are to understand how tariff reform affects various end-users.

## 6. Conclusion

Our review presents a comprehensive assessment of the literature on tariff reform impacts in Africa since 1987. We structured our review according to three modalities that governments and regulators use to implement reforms: tariff payment, tariff structure, and tariff rates. Where relevant, we disaggregated the discussion of impacts by sector, including residential, commercial and industrial, and providers. Our review also featured discussion of areas where the literature on tariff reform in Africa is well-studied, and where there are opportunities for future research. First, we found that prepaid meters have the potential to facilitate energy literacy, promote energy conservation, and reduce overall demand. However, there is a need for future studies to better describe the impacts of these technologies within and across households. Second, IBTs, lifeline tariffs, and differential pricing poorly target consumers, resulting in the underpricing of higher consumers and the overpricing of lower consumers. These allocative inefficiencies create regressive electricity subsidies, exacerbated by low connection rates among low-income consumers. More research is necessary to explore how VDTs and connection cost subsidies may improve the targeting of government spending and cost recovery. Third, price elasticity of electricity demand is unquestionably inelastic across all sectors. While increased tariffs may not often affect low-income groups directly, distributional effects from higher tariffs (including higher expenditures on other goods or services) may disproportionately affect these end-users. More studies are necessary to understand the macroeconomic and distributional impacts of tariff reform, and potential compensatory mechanisms to mitigate regressive impacts. Fourth, raising tariffs improves cost recovery for utilities when accompanied by improvements to collection rates and organisational reforms. Governments can mitigate negative impacts from tariff increases (such as public unrest and greater incidences of electricity theft) by communicating with the public and engaging consumer groups in the reform process. In the spirit of this exercise in cross-country comparison, policymakers and regulators should learn from the experiences of other countries on the continent and elsewhere to determine a set of tariff reform options that best serve their context and objectives. While tariff reform carries significant political and economic risk, intermittent supply and low connection rates will continue to impede economic growth and leave millions of Africans without power. Careful and creative tariff reform is necessary to balance these trade-offs and transition African energy sectors towards financial viability and equity in access.

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*The views expressed in this Working Paper do not necessarily reflect the UK government's official policies.*