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Power Tariffs

Caught between Cost Recovery and Affordability

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Abstract

This is the first paper to build a comprehensive empirical picture of power pricing practices across Sub-Saharan Africa, based on a new database of tariff structures in 27 countries for the years 2004–2008.

Using a variety of quantitative indicators, the paper evaluates the performance of electricity tariffs against four key policy objectives: recovery of historic power production costs, efficient signaling of future power production costs, affordability to low income households, and distributional equity.

As regards cost recovery, 80 percent of the countries in the sample fully recover operating costs, while only around 30 percent of the countries are practicing full recovery of capital costs. However, due to the fact that future power development may be based on a shift toward more economic technologies than those available in the past, existing tariffs look as though they would be consistent with Long Run Marginal Costs in nearly 40 percent of countries and hence provide efficient pricing signals.

As regards affordability, today's average effective tariffs are affordable for 90 percent of today's customers. However, they would only be affordable for 25 percent of households that remain unconnected to the grid. Tariffs consistent with full recovery of economic costs would be affordable for 70 percent of the population. As regards equity, the highly regressive patterns of access to power services, ensure that subsidies delivered through electricity tariffs are without exception also highly regressive in distributional incidence.

The conclusion is that achieving all four of these policy objectives simultaneously is almost impossible in the context of the high-cost low-income environment that characterizes much of SSA today. Hence most countries find themselves caught between cost recovery and affordability.

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POWER TARIFFS: CAUGHT BETWEEN COST RECOVERY AND AFFORDABILITY

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Power tariffs: Caught between cost recovery and affordability[1]

The efficient pricing of electricity is central to a well-functioning power sector. Power pricing guides investment decisions and is critical for cost recovery. It also signals to users the cost of marginal consumption and should ideally encourage the optimal utilization of installed capacity. But achieving efficient power pricing is easier said than done. The power sector is characterized by substantive up-front fixed costs, and it takes many years for capacity to be fully utilized. Beyond that, costs vary across times of the day (peak/off-peak), seasons (dry/rainy), users (residential/commercial), and geographic areas (urban/rural), which should be taken into consideration when setting prices that promote efficient use.

As if the technical issues behind setting efficient tariffs were not complex enough, power providers and regulators also face a conflict between promoting economic efficiency and societal well-being. For example, if income-challenged groups are to enjoy the benefits of power provision, policy makers must set affordable tariffs below production costs or introduce an explicit subsidy regime (Borenstein 2008).

In defining tariff structures, policy makers must balance the financial sustainability of the sector on the one hand and the well-being of various segments of society on the other. Given the importance of power, the ramifications of pricing and bill-collection policies are enormous. For example, as imposed transfers from the producer to the consumer, below-cost tariffs can seriously hamper the financial health of the provider.

Another common way of lowering electricity prices is cross-subsidization, which can only be implemented if monopoly rights are granted to the power utility. Cross-subsidization has several undesirable consequences: it discourages use by the overcharged and promotes overconsumption by the subsidized. In some cases, it also opens the door for particular interest groups and communities to influence policy makers, for example, by asking them to reduce tariffs for select customers such as large industrial users. While this may be used as a mechanism to spur the development of select economic sectors, the reduced tariffs, ironically, might not even be made available to the general public with its more limited purchasing power. How to get tariffs right is a critical question for every policy maker, and there is no one answer.

In this paper we aim to better understand how African countries are dealing with these pricing issues in practice. Most African countries have made efforts to organize their tariff structures and levels so as to recover utility costs while also providing affordable electricity to poorer consumers. But this goal is challenging and has not been reached in most of the countries examined. Obstacles include costly operational inefficiencies, lack of economies of scale due to geopolitical fragmentation, large populations too poor to afford tariffs set at cost-recovery levels, and the dauntingly limited coverage of distribution networks.

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The analysis presented here is based on a database put together as part of the Africa Infrastructure Country Diagnostic (AICD).[2] The database includes the basic institutional characteristics of African power systems as well as standard power sector indicators (performance, capacity, and so on). In addition the database documents the power-tariff regimes of 27 Sub-Saharan African countries in detail.[3] Together, these nations account for over 85 percent of the population and gross domestic product (GDP) of the region. They were carefully selected to represent the economic, geographic, cultural, and political diversity that characterizes Sub-Saharan Africa. They also represent the four Sub-Saharan power pools; include countries with small, medium, and large-scale generation; and constitute a representative mix of predominantly thermal and/or hydro power systems. As such, the sample can be considered a statistically representative basis for inferring tariff-setting trends in Sub-Saharan Africa.

The tariff data set includes one published tariff regime for each country in the sample. Results presented here are based on the latest published tariff regime available for each country during the AICD data collection period (2003–08). For most countries that year was 2006 (see annex 1).

Using the AICD database, we seek to characterize African power tariffs by (i) describing prevalent tariff structures, both residential and nonresidential; (ii) analyzing their ability to recover costs; (iii) assessing their economic efficiency against long-run marginal costs; and (iv) exploring their equitability and affordability vis-à-vis country-specific purchasing power.

What power tariff structures are prevalent in Sub-Saharan Africa?

Most electricity tariffs—and Africa is no exception—are based on block tariff-pricing schemes; that is, the price of power is linked to the level of consumption.

Power tariffs are commonly structured around blocks. A block is a pre-determined range of power consumption; with the unit price of each kWh being fixed within the block. The relation between blocks and prices defines three types of tariff structures:

- Increasing block tariffs (IBTs) is a regime in which the unit price per kWh follows an increasing step-function linked to sequentially defined blocks
- Decreasing block tariffs (DBTs) is a regime in which the unit price per kWh follows a decreasing step-function linked to sequentially defined blocks
- Linear tariffs (LTs) are a regime in which all units of power consumed are charged at exactly the same rate.

[2] http://www.infrastructureafrica.org.

[3] Benin, Botswana, Burkina Faso, Cameroon, Cape Verde, Chad, Congo, the Democratic Republic of Congo, Côte d'Ivoire, Ethiopia, Ghana, Kenya, Lesotho, Madagascar, Malawi, Mali, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, South Africa, Tanzania, Uganda, Zambia, and Zimbabwe.

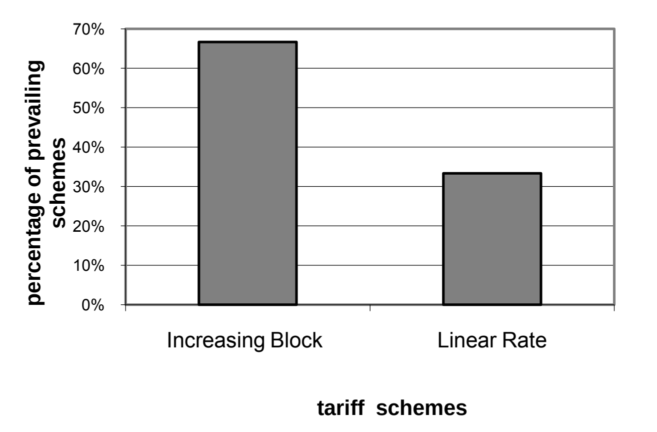
Any of the above tariff structures may be complemented by a fixed monthly charge, and are then described as two-part electricity tariffs. The fixed charge can be used to cover the fixed administrative costs associated with serving a customer, and is sometimes also used to discriminate between customers based on other cost-related characteristics such as load served and network location.

a. Residential tariffs

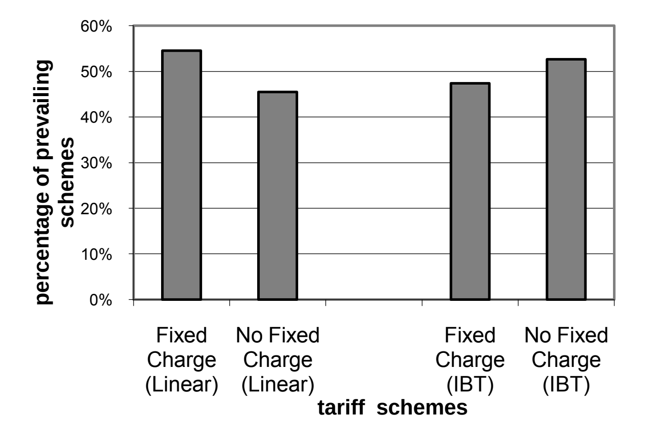
Two-thirds of the prevailing pricing schemes in Africa are IBTs, and the remaining third are linear (figure 1a). The use of linear rates is more common in countries with prepayment systems (Malawi, Mozambique, and South Africa) (table 1). The prevalence of IBTs is consistent with recent trends in power regulation. IBTs have often been put forward as a good tool for reconciling cost-recovery targets with distributional aims, although their success in doing so is critically dependent of the details of tariff design (Filipović and Tanić 2009; Borenstein 2008). A more detailed description on residential tariff structures practiced in Africa can be found in Annex 2.

Figure 1. Prevalence of specific tariff schemes

a. Block tariff pricing



b. Fixed charges



Source: Africa Infrastructure Country Diagnostic Power Tariff Database.

About half of the sample countries have adopted two-part tariffs (figure 1b), combining fixed charges with block tariff pricing. Among countries practicing linear tariffs, the use of two-part tariffs is more common than where IBTs are applied. For African countries the fixed charge tends to be relatively high: between $1.00 and $3.00 per month (table 1). As a reference, the average fixed charge in Latin American countries is $0.70 (Foster and Yepes 2006).

Table 1. Residential tariff schedules								
	Tariff type	Fixed charge per month? Yes/No	Fixed charge ($/month)	Number of blocks	Size of the first block, kWh	Price, first block	Price, highest block	% increase from first block to highest block
Benin	IBT	No	—	3	20	9.6	16.3	70
Botswana	Linear	Yes	1.63	1	—	5.9	5.9	—
Burkina Faso	IBT	Yes	1.1	3	50	18.4	20.8	13
Cameroon	IBT	No	—	3	50	8.6	12	40
Cape Verde	IBT	No	—	2	40	22.5	28	24
Chad	IBT	No	—	3	30	15.7	38.1	143
Congo, Dem. Rep. of	IBT	No		11	100	3.98	8.52	114
Congo, Rep. of	Linear	Yes	5.06	1	—	11	11	—
Côte d'Ivoire	IBT	Yes	0.64	2	40	6.9	14.2	106
Ethiopia	IBT	Yes	0.16–1.58	7	50	3.2	8	150
Ghana	IBT	Yes	0.54	3	300	7.6	15.3	101
Kenya	IBT	Yes	1.74	4	50	4.9	44	798
Lesotho	Linear	No	—	1	—	7.2	7.2	—
Madagascar	Linear	Yes	2.98	1	—	7.6	7.6	—
Malawi	IBT	Yes	0.92	3	30	2	4.1	105
MWI–prepaid	Linear	No	—	1	—	3.1	3.1	—
Mali	IBT	No	—	4	200	26.6	31	17
Mozambique	IBT	Yes	2.79	4	100	4	12.1	203
MOZ–prepaid	Linear	No	—	1	—	11	11	—
Namibia	Linear	No	—	1	—	11.7	11.7	—
Niger	Linear	Yes	0.43	1	—	13.6	13.6	—
Nigeria	IBT	Yes	0.15–2,38	5	20	0.9	6.5	622
Rwanda	Linear	No	—	1	—	14.6	14.6	
Senegal	IBT	No	—	3	—	23.8	26.2	10
South Africa	IBT	No	—	2	50	0	7.2	—
Tanzania	Linear	Yes	1.93	1	—	10.8	10.8	—
TZN–low use	IBT	No	—	2	50	4.1	13	217
Uganda	IBT	Yes	1.1	2	15	3.4	23.3	585
Zambia	IBT	Yes	1.3	3	300	1.6	3.7	131
Zimbabwe	IBT	No	—	3	50	0.60	13.5	2,159

Source: Africa Infrastructure Country Diagnostic Power Tariff Database
Note: For details see annex 2. MWI = Malawi; MOZ = Mozambique; TZN = Tanzania.
— Not available.

The structure of blocks—their number, size, and respective price levels—is what ultimately defines how tariffs reflect costs, affect demand, and address equity issues. The sample countries have adopted widely differing approaches to tariff design, with one third of countries practicing linear tariffs (as in Rwanda and Tanzania) and the remaining two thirds practicing IBTs.

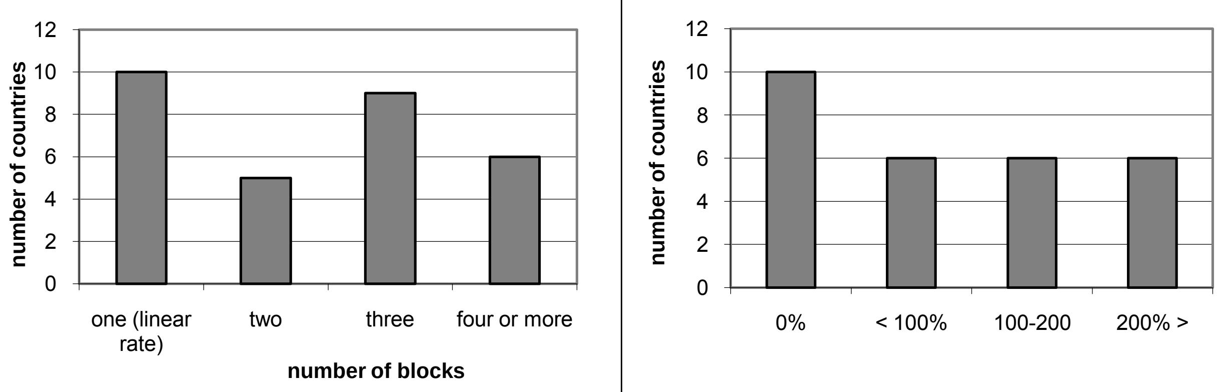
Looking at the two thirds of sample countries that practice IBTs, most have adopted relatively simple structures (figure 2a) with two or three blocks (as in Benin, Burkina Faso, Cameroon, Cape Verde, Côte d'Ivoire, Ghana, Madagascar, Malawi, Senegal, Tanzania, Uganda, Zambia). A minority of countries have opted for more complicated structures that use four and more blocks (the Democratic Republic of

Congo, Ethiopia, Kenya, Mali, Mozambique, and Nigeria). The Democratic Republic of Congo is an extreme case, as it uses an 11-block IBT. Interestingly enough, despite the large number of blocks, the price difference across blocks is very small, suggesting that the regime is complicated without really discriminating very much between large and small consumers.

Figure 2. Characterization of residential block pricing

a. Number of pricing blocks

b. Tariff price differential between first and highest block (%)



Source: Africa Infrastructure Country Diagnostic Power Tariff Database

The conventional wisdom is that IBTs are designed so that the first and smallest "lifeline" block covering subsistence consumption is subsidized to promote equity, while the subsequent blocks are priced at a higher level that will ultimately enable cost recovery. This of course assumes that poorer customers will have lower consumption. This assumption is more reasonable in the case of power – where usage is driven by ownership of appliances more prevalent among wealthier households and businesses – than it is for example in the water sector – where usage is more correlated with the size of the household.

The first question is whether African countries tend to define the consumption level of the first block at a level low enough to be consistent with subsistence consumption and hence with the "lifeline" principle underlying this tariff design (table 2). The response to this question is quite positive. Two-thirds of the sample countries define the first block at 50 kilowatt-hours (kWh)/month or less; a consumption level that is below the average residential power consumption in Africa (75-100 kWh/month) (Foster and Briceño-Garmendia 2009). For example, Uganda sets the first block at 15 kWh/month; Cape Verde and Côte d'Ivoire at 40 kWh/month; and Burkina Faso, Cameroon, Ethiopia, Kenya, Tanzania at 50 kWh/month. But the sizes of the first blocks in Mozambique and the Democratic Republic of Congo (100 kWh), Mali (200 kWh) and in Zambia and Ghana (300 kWh) seem too high to meet the needs of low-consumption, low-income residential customers.

Table 2. Size of the first pricing block, and differential between that and second		
1st block monthly consumption threshold (kWh)	Countries	Price differential between first and second block (%)
300	Ghana, Zambia	Between 30 and 100
200	Mali	Less than 30
100	Mozambique	Over 100
	Congo, Dem. Rep of	Less than 10
50 or less	Uganda, Madagascar, Kenya, Nigeria, Tanzania, Chad, Cote d'Ivoire, South Africa, Zimbabwe	Over 100
	Ethiopia, Benin, Malawi	Between 30 and 100
	Cameroon, Cape Verde, Burkina Faso	Less than 30

Source: Africa Infrastructure Country Diagnostic Power Tariff Database

The second question is whether tariff levels on successive blocks rise steeply enough to ensure that costs can be fully recovered on higher volumes of consumption. This principle holds in many cases. Most countries with a first-block threshold set at subsistence consumption levels (50 kWh or less), have a price jump of over 100 percent to the second block (Uganda, Madagascar, Kenya, Nigeria, Tanzania, Chad, Côte d'Ivoire, South Africa, Zimbabwe), signaling a clear intention to differentiate among customers so that larger consumers contribute to cost recovery. But the tariff structures of a few countries—for example, the Democratic Republic of Congo, Cameroon, Cape Verde, and Burkina Faso—are not highly differentiated by consumption level. This makes the implementation of targeted subsidies difficult (table 2).

Thereafter, prices among higher consumption blocks do not rise as steeply as they do between the first and second block. In Burkina Faso, the second block is priced only 6 percent higher than the first one and the third block only 7 percent above the second one. In Ethiopia the price increase from the first block to the second is 31 percent and from the second to the third, 40 percent. In Malawi, the increase is 47 percent in the first case and 42 percent in the second one.

Despite the fact that IBTs already incorporate a "lifeline" principle, a number of countries have felt the need to introduce parallel "social tariff" that provide an even larger discount to qualifying customers. For example, the Democratic Republic of Congo, Madagascar, Mali, and Benin (whose block pricing structure does not differentiate low-consumption, low-income customers) provide such a parallel "social tariff" (table 3). Most of these social tariffs are linear in nature and include fixed charges; albeit modest ones. The criteria for determining social tariff eligibility are usually based either on total consumption or technical characteristics of service (voltage, load). The very existence of such parallel "social tariffs" – most of which have eligibility criteria based on low consumption – in itself may be a signal that the main IBT is not managing to perform its intended social function.

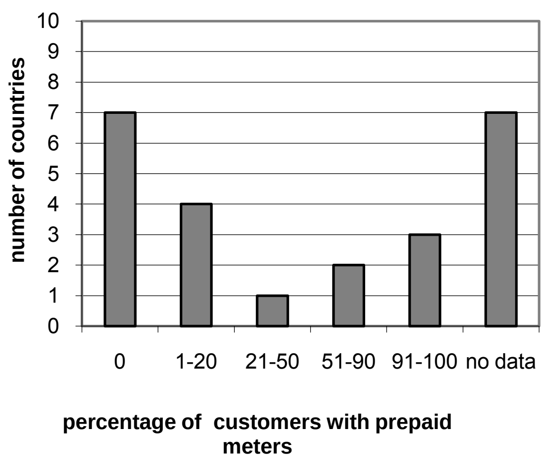
Table 3. Tariff schedules for low-income, low-consumption customers				
	Type of tariff	Fixed charge ($)/month	Block border	Price per block, cents/kWh
Benin	social tranche	n.a.		9.6
Botswana	n.a.	n.a.		n.a.
Burkina Faso	block 1, residential	0.18		14.3
Cameroon*	block 1 residential	12.90		8.6
Cape Verde	block 1, residential	—		22.5
Chad	block 1 residential	n.a.		15.7
Congo, Dem. Rep. of	social tariff	0.01		4.0
Congo, Rep. of	n.a.	n.a.		n.a.
Côte d'Ivoire	block 1 residential	0.64		6.9
Ethiopia	block 1 residential	0.16		3.2
Ghana	block 1 residential	0.54		7.6
Kenya	block 1 residential	1.74		4.9
Lesotho	—	—		—
Madagascar	economic tariff	0.30	25	6.0
			> 25	27.6
Malawi	block 1 residential	0.92		2.0
Mali	social tariff	n.a.	50	13.2
			100	20.3
			200	23.9
			>200	27.7
Mozambique	block 1 residential	n.a.		4.0
Namibia	n.a.	n.a.		n.a.
Niger	—	—		—
Nigeria	pensioners' tariff	0.23		3.0
Rwanda	—	—		—
Senegal	tranche 1 residential	n.a.	150	0.24
South Africa	block 1 residential	n.a.		—
Sudan	—	—		—
Tanzania	n.a.	n.a.		3.0
Uganda	block 1 residential	1.09		3.4
Zambia	block 1 residential	1.31		1.6
Zimbabwe	tranche 1 residential	n.a.		0.6

Source: Africa Infrastructure Country Diagnostic Power Tariff Database
Note: For details see annex 13.
n.a. Not applicable.
— Not available.

Another important aspect of social policy in the power sector has been the growing use of prepayment meters. These have dual advantages. On the one hand, they help low income customers to control their expenditures on electricity by spreading them out into small frequent payments that they can more readily afford. On the other hand, they eliminate the commercial risk to the utility of serving low income customers. Although growing in popularity worldwide, providing a prepaid option is a relatively new practice in Africa, and its impact is still not well understood. But for those countries for which data are available, roughly 60 percent have introduced the use of prepayment meters (figure 3). Indeed, Lesotho, Namibia, Mozambique, and South Africa already offer this option to a majority of residential customers.

Figure 3. Prepaid services

a. Frequency distribution of countries adopting prepaid meters



b. Time trend in percentage of customers using prepaid meters

	2000	2001	2002	2003	2004	2005
Tanzania					4	4
Benin	0	0	6	6	6	7
Burkina Faso	10	10	10	10	10	10
Malawi	2	4	6	8	10	14
Ghana		5	4	4	10	28
Rwanda					48	65
Mozambique				80	73	
Namibia				93		98
Lesotho			100	100	100	100
South Africa						100

Source: Africa Infrastructure Country Diagnostic Power Indicators Database

b. Nonresidential tariffs

Nonresidential tariffs can be classified in two groups: commercial and industrial (Table 4). Linear tariffs are the most common regime for nonresidential customers in Africa (figure 4). About 60 percent of commercial customers and over 50 percent of industrial customers are billed based on linear tariffs. A more detailed description on commercial and industrial tariff structures practiced in Africa can be found in Annexes 3 and 4.

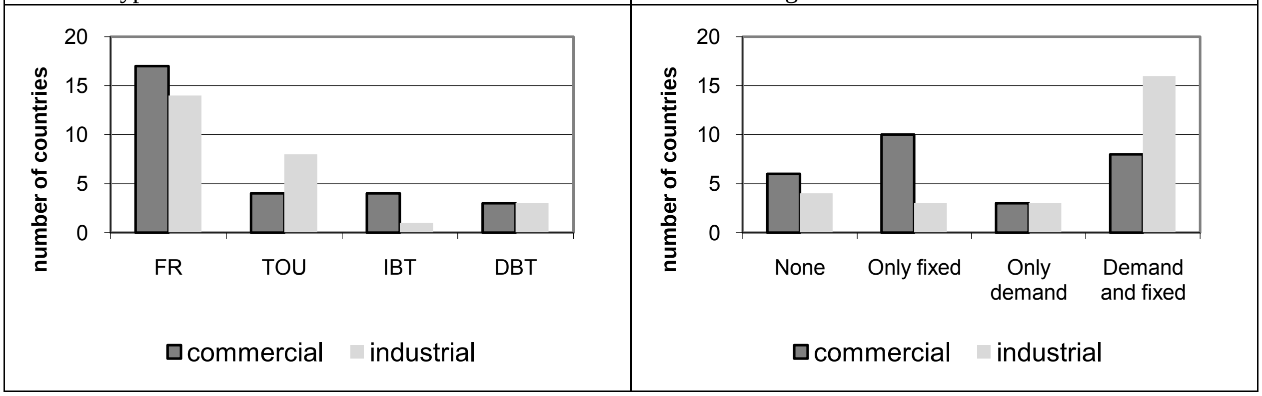
Pricing for nonresidential customers is typically more complex than for residential customers. It is usually structured as a three-part tariff including a monthly fixed charge (defined by characteristics of the network), a demand charge (defined by the level of peak demand served in kilovolts or kilowatts), and a volume charge (defined by the energy served and reflected in the definition of the blocks). In addition, volume charges may be differentiated by time-of-use (TOU). In fact, only a handful of countries (Benin, Cape Verde, Rwanda, and Mali) apply simple linear tariffs to their nonresidential customers without making use of any of these additional features.

Fixed charges are somewhat more prevalent among non-residential customers, than was the case for residential customers. They are practiced by 18-19 countries in the sample.

Demand charges are widespread for non-residential customers, but are almost twice as frequent for industrial customers as for commercial customers (figure 4b). This suggests that most countries find it important to reflect load considerations in designing tariffs for nonresidential customers (table 3). Peak demand is a critical cost driver in the power sector, because it defines the amount of installed capacity needed to provide a given volume of electricity.

Figure 4. Prevalence of specific tariff schemes: Commercial and industrial users

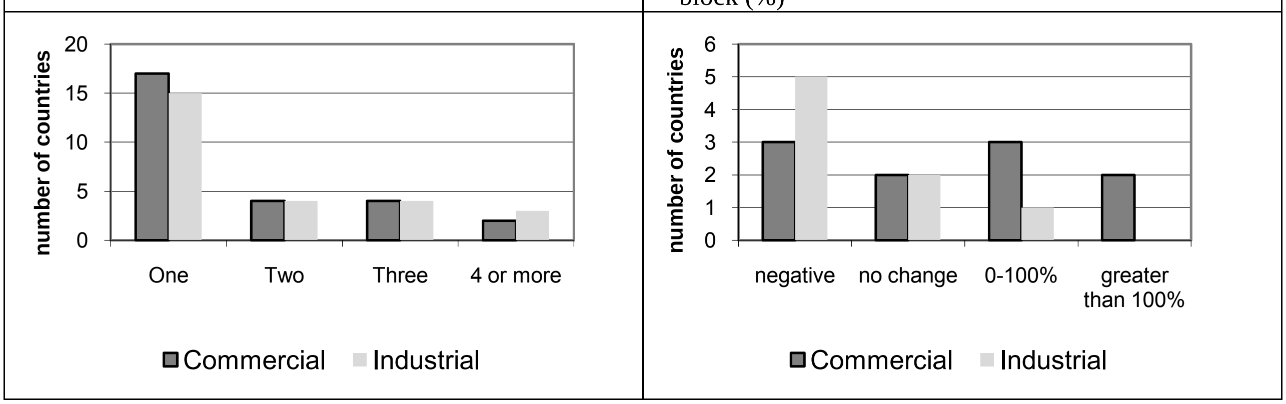
a. Tariff type | b. Fixed charges



Source: Africa Infrastructure Country Diagnostic Power Tariff Database

Figure 5. Characterization of nonresidential block pricing

a. Numbers of pricing blocks | b. Nonlinear tariff price differential between first and last block (%)



Source: Africa Infrastructure Country Diagnostic Power Tariff Database

Volume charges for nonresidential customers are typically linear for at least 15 of the countries in the sample. In the cases where block tariff structures are used, they are more frequently decreasing blocks (DBT) rather than increasing blocks (IBT) and these are relatively simple with not more than three blocks (figure 5b). The reason for preferring decreasing blocks is to capture the strong scale economies associated with power generation and transmission. The volumetric charge tends to be higher for commercial than for industrial customers. Most commercial tariffs start at over 12 cents/kWh, while most industrial tariffs start at around 8–10 cents/kWh. On average, African commercial tariffs are about 40 percent higher than industrial ones. Only the Democratic Republic of Congo, the Republic of Congo, and Chad have commercial tariffs set at a lower level than residential ones (table 5).

Table 4. Nonresidential tariff regimes						
	Commercial			Industrial		
	Tariff type	Fixed charge/month? yes/no	Demand charge? yes/no	Tariff type	Fixed charge/month? yes/no	Demand charge? yes/no
Benin	Linear	No	No	Linear	No	No
Botswana	Linear	No	No	Linear	Yes	Yes
Burkina Faso	TOU	Yes	Yes	TOU	Yes	Yes
Cameroon	DBT	No	Yes	TOU	No	Yes
Cape Verde	Linear	No	No	Linear	No	No
Chad	IBT	No	Yes	TOU	No	Yes
Congo, Dem. Rep. of	DBT	No	No	DBT	No	No
Congo, Rep. of	Linear	Yes	No	Linear	Yes	Yes
Côte d'Ivoire	DBT	Yes	No	TOU	Yes	No
Ethiopia	TOU	Yes	No	TOU	Yes	No
Ghana	IBT	Yes	No	Linear	Yes	Yes
Kenya	Linear	Yes	No	DBT	Yes	Yes
Lesotho	Linear	No	Yes	Linear	No	Yes
Madagascar	Linear	Yes	Yes	Linear	Yes	Yes
Malawi	Linear	Yes	Yes	Linear	Yes	Yes
Mali	Linear	No	No			
Mozambique	Linear	Yes	Yes	Linear	Yes	Yes
Namibia	Linear	Yes	Yes	Linear	Yes	Yes
Niger	Linear	Yes	Yes	Linear	Yes	Yes
Nigeria	IBT	Yes	No	IBT	Yes	Yes
Rwanda	Linear	No	No	Linear	No	No
Senegal	TOU	Yes	No	TOU	Yes	No
South Africa	IBT/Linear	Yes	No	TOU	Yes	Yes
Tanzania	Linear	Yes	Yes	Linear	Yes	Yes
Uganda	TOU	Yes	No	TOU	Yes	Yes
Zambia	Linear	Yes	No	DBT	Yes	Yes
Zimbabwe	Linear	Yes	Yes	Linear	Yes	Yes

Source: Africa Infrastructure Country Diagnostic Power Tariff Database

Note: IBT – increasing block tariff; DBT – decreasing block tariffs; TOU – time of use tariff. *Source:* Africa Infrastructure Country Diagnostic Power Tariff Database

Time-of-use tariffs (TOUs) are only practiced in a minority of cases, and are twice as prevalent among industrial tariff structures as among commercial tariff structures. TOUs allow power consumption to be associated with hours (peak/off-peak/night) and/or seasons (summer/winter, dry/regular), creating incentives for more efficient use of the power network. One-third of industrial and one-fifth of commercial tariff regimes in Africa incorporate TOUs.

Table 5. Nonresidential blocks: Number, size, and price level

	Commercial				Industrial			
	Number of blocks	First block Size	First block Price (cents)	Price differential between first and last block (%)	Number of blocks	First block Size	First block Price (cents)	Price differential between first and last block (%)
Benin	1	n.a.	15.1	—	1	n.a.	10.7	—
Botswana	1	n.a.	6.7	—	1	n.a.	3.1	—
Burkina Faso	2	TOU	31.6	–47	2	TOU	22.6	–54
Cameroon	2	180kWh/kVA	11.3	–12	2	TOU	8.7	–2
Cape Verde	1	n.a.	21.8	—	1	n.a.	17.7	—
Chad	3	30 kWh	15.9	152	3	TOU	20.5	85
Congo, Dem. Rep. of	5	200 kWh	11.1	–4	5	200	15.2	-4
Congo, Rep.	1	n.a.	9.7	—	1	n.a.	11.2	—
Côte d'Ivoire	2	18/kVA bimonthly	18.6	–15	3	TOU	10.7	–18
Ethiopia	3	TOU	6.7	–6	3	TOU	4.7	26
Ghana	3	300	11.1	44	1	n.a.	5.4	—
Kenya	1	n.a.	21.4	—	3	20 kWA	16.4	–15
Lesotho	1	n.a.	1.2	—	1	n.a.	1.1	—
Madagascar	1	n.a.	16.9	—	1	n.a.	9.9	—
Malawi	1	n.a.	3	—	1	n.a.	2.4	—
Mali	1	n.a.	23.2	—	0	n.a.		—
Mozambique	1	n.a.	5.4	—	1	n.a.	4.5	—
Namibia	1	n.a.	8.4	—	1	n.a.	7.7	—
Niger	1	n.a.	12.2	—	1	n.a.	8.8	—
Nigeria	4	15 kVA	5	30	5	15 kVA	5	30
Rwanda	1	n.a.	17.2	—	1	n.a.	17.2	—
Senegal	2	TOU	14.4	44	2	TOU	11.8	45
South Africa	3/1	25 kVA	4	138	2	TOU	2.6	–31
Tanzania	1	n.a.	5.3	—	1	n.a.	4.9	—
Uganda	1	n.a.	21.8	—	1	n.a.	16.7	—
Zambia	1	n.a.	3.7	—	4	1200	2.2	–45
Zimbabwe	1	n.a.		—	1	n.a.		—

Source: Africa Infrastructure Country Diagnostic Power Tariff Database

Notes: For details see Annexes 3 and 4. n.a. Not applicable; — Not available; kVa = kilovolt-ampere.

Do power tariffs recover costs?

a. What is the level of average effective residential tariffs?

The effective tariff is the price per kilowatt-hour of electricity consumed at a specific consumption level when all charges—variable and fixed—are taken into account. In a multipart tariff system with a block pricing scheme, the difference between the effective tariff for a kilowatt-hour at a low level of consumption and a kilowatt-hour at a high level of consumption can be significant.

The effective tariff is calculated by dividing the total bill based on the current tariff schedule (in currency) by consumption (in kilowatt-hours). It can also be referred to as the unit price at a particular consumption level. Based on the two-part tariffs described in the preceding section, effective residential electricity tariffs can be estimated following the formula: $T = (\sum a_{i=1}^{n} * x_{i=1}^{n} + b) / x$, where *a* is the metered consumption unit price (per kilowatt-hour), *x* is the volume consumed (metered), *i* is the block number (in the case of block tariffs), and *b* is the fixed charge.[4] Effective tariffs allow for analyzing pricing patterns at different consumption levels as well as comparing price levels with cost recovery and affordability benchmarks.

For the purpose of this analysis, one residential schedule per country was selected. The selection of a specific tariff schedule for the calculation of the effective tariff was done to capture the largest share of residential consumers based on the most commonly used tariff schedule, or the one that most closely corresponds to the monthly average consumption for that country. For example, in South Africa, the residential schedule selected was the “Home Light 1” prepayment option because this is the one that would be most attractive to a South African household with the average residential power consumption level. While South Africa has an admittedly complicated tariff system, other African countries also offer two or three residential schedules. For effective residential tariff calculations, the lower-usage residential tariff was used and the “social tariff” (where relevant) was analyzed separately. Annex 5 lists the representative tariff schedule used for each country.

Table 6 showcases the calculation of effective residential tariffs for select African countries. The variation in effective tariffs for the first consumption tranche (up to 50 kWh/month) is enormous, going from zero in South Africa to about 24 cents/kWh in Cape Verde (table 6). But over 60 percent of African countries establish prices below 10 cents/kWh for their smallest consumers. For average consumption levels of 100 kWh/month, Africa has effective tariffs ranging from 3 cents to 30 cents, which is undoubtedly a wide range.

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[4] Generally there is a third component in the formula that captures maximum demand level and its price. But the demand part of the formula is not applicable to residential customers

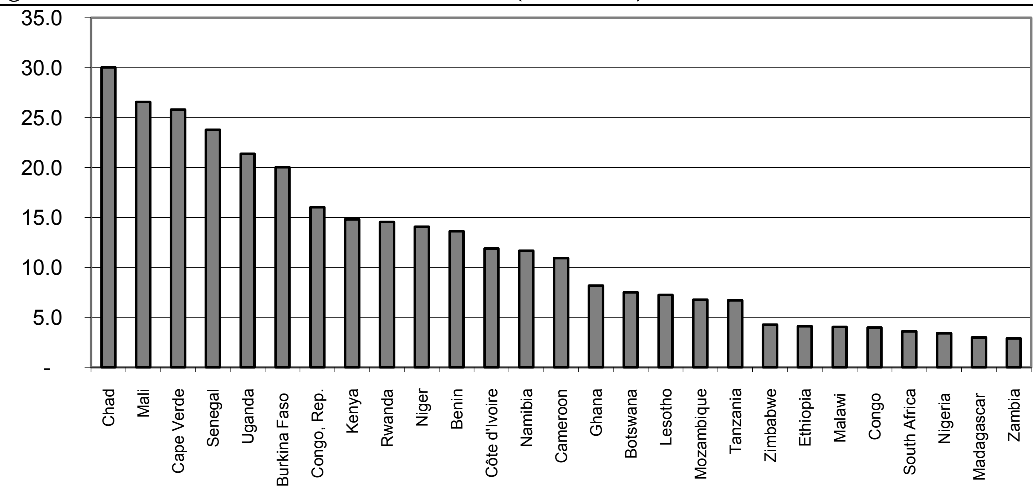
Table 6. Effective residential tariffs by level of consumption (cents)

	Level of consumption (kWh/month)									
	50	**75**	**100**	**150**	**200**	**300**	**400**	**450**	**500**	**900**
Benin	12.6	13.3	13.6	14.0	14.1	19.7	22.5	23.5	24.2	27.2
Botswana	9.1	8.0	7.5	6.9	6.7	6.4	6.3	6.2	6.2	6.0
Burkina Faso	20.6	20.2	20.0	19.9	19.8	20.1	20.3	20.4	20.4	20.6
Cameroon	8.6	10.9	10.9	10.9	10.9	12.0	12.0	12.0	12.0	12.0
Cape Verde	23.6	25.1	25.8	26.5	26.9	27.3	27.4	27.5	27.5	27.7
Chad	22.9	27.3	30.0	32.7	34.1	35.4	36.1	36.3	36.5	37.2
Congo, Dem.	4.0	4.0	4.0	4.0	4.0	3.9	3.9	3.9	3.9	5.5
Congo, Rep. of	21.1	17.7	16.0	14.3	13.5	12.6	12.2	12.1	12.0	11.5
Côte d'Ivoire	9.6	11.1	11.9	12.6	13.0	13.4	13.6	13.6	13.7	13.9
Ethiopia	3.9	4.1	4.1	5.3	5.6	6.1	6.2	6.4	6.6	7.2
Ghana	8.7	8.4	8.2	8.0	7.9	7.8	9.1	9.6	9.9	11.8
Kenya	8.4	12.7	14.8	16.9	18.0	19.1	19.9	20.1	20.4	21.2
Lesotho	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
Madagascar	6.0	4.0	3.0	2.0	1.5	1.0	0.7	0.7	0.6	0.3
Malawi	4.8	4.3	4.0	3.8	3.7	3.6	3.5	3.5	3.5	3.4
Mali	26.6	26.6	26.6	26.6	26.6	28.1	28.8	29.1	29.3	30.0
Mozambique	9.6	7.7	6.8	7.4	7.7	9.0	9.6	9.8	10.0	10.9
Namibia	11.7	11.7	11.7	11.7	11.7	11.7	11.7	11.7	11.7	11.7
Niger	14.5	14.2	14.1	13.9	13.9	13.8	13.7	13.7	13.7	13.7
Nigeria	2.5	3.8	3.4	3.8	4.2	4.9	5.3	5.4	5.6	6.0
Rwanda	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6
Senegal	23.8	23.8	23.8	23.8	24.2	24.8	25.1	25.2	25.3	25.7
South Africa	—	2.4	3.6	4.8	5.4	6.0	6.3	6.4	6.5	6.8
Sudan	—	—	—	—	—	—	—	—	—	—
Tanzania	3.2	5.5	6.7	7.9	8.5	9.0	8.8	8.8	8.8	8.6
Uganda	19.5	20.7	21.4	22.0	22.3	22.6	22.8	22.8	22.9	23.1
Zambia	4.2	3.3	2.9	2.4	2.2	2.0	2.1	2.1	2.1	2.5

Source: Africa Infrastructure Country Diagnostic Power Tariff Database

Notes: Average residential consumption level is highlighted in bold — Not available.

Figure 6. Effective residential tariff for 100 kWh (cents/kWh)

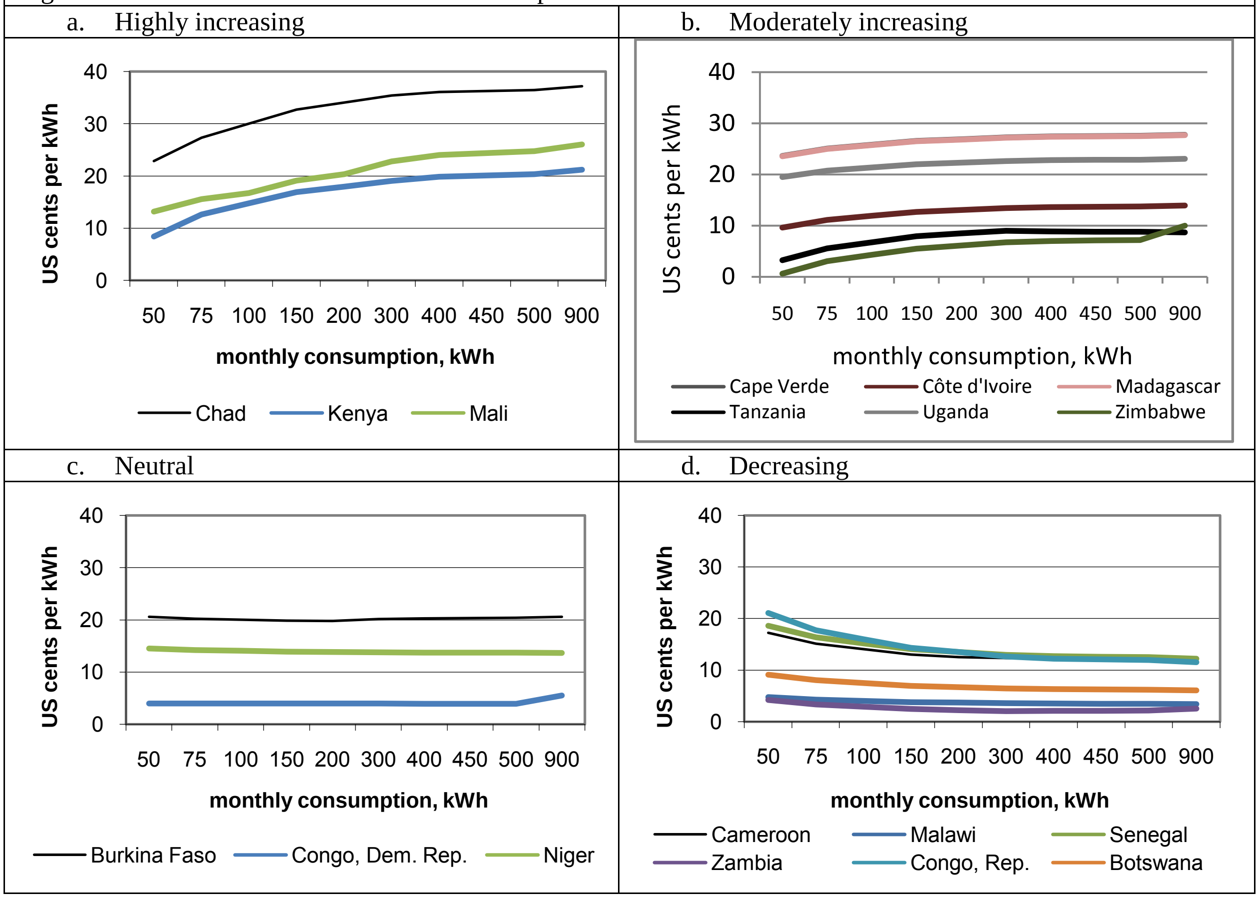


Source: Africa Infrastructure Country Diagnostic Power Tariff Database

On average, residential electricity in Africa is among the most expensive in the world. For the average consumer, residential tariffs are over 12 cents/kWh in about 60 percent of the sample countries and over 20 cents/kWh in close to 25 percent of the sample (Burkina Faso, Cape Verde, Uganda, Madagascar, Mali, and Chad) (figure 6). To compare it against other world regions, Africa's residential electricity price averages between 50 and 150 percent higher than the 8 cents/kWh in Latin-America, Eastern Europe, and East Asia, and up to 400 percent higher than average residential tariffs in South Asia.

What is the pattern of average effective residential tariffs across levels of consumption? Tariffs that increase with consumption effectively impose a penalty on higher consumption and vice versa. About half of the sample countries have increasing average effective residential tariffs (for example, Cape Verde, Chad, Côte d'Ivoire, Ethiopia, Ghana, Kenya, Madagascar, Mozambique, Nigeria, Tanzania, and Uganda [figure 7a and b]). One-third of countries have decreasing average effective residential tariffs, not only because they have explicitly adopted DBT (for example, Senegal) but also because the size of their first blocks is large meaning that the weight of the fixed charge is spread across a larger tranche of consumption. Countries with decreasing residential tariffs include Cameroon, Malawi, Zambia, Senegal, Burkina Faso, Cameroon, the Democratic Republic of Congo, Ghana, and Niger (figure 7c and d).

Figure 7. Effective tariffs across various consumption levels



Source: Africa Infrastructure Country Diagnostic Power Tariff Database

b. What is the level of average effective nonresidential tariffs?

As for residential tariffs, one commercial and one industrial schedule per country were selected for our analysis of nonresidential tariffs. Representative or typical *commercial* customers are defined as small to medium business users with an average consumption level of 900 kWh/month. Representative or typical *industrial* customers are medium to large business users usually associated with high-voltage, high-usage tariffs. But in order to exclude very large industries with preferential tariffs from our analysis, we did not use the highest voltage bracket included in tariff schedules (box 1). In cases where tariff schedules for commercial and industrial users are not differentiated or where several tariffs apply to commercial users, tariff schedules were selected based on both voltage level and load. For example, commercial customers were associated with a tariff for medium-voltage and medium-consumption users, and industrial customers were associated with a tariff for medium- to high-end users.

Box 1. Special tariffs for large electricity users: The case of Zambia

The average effective power tariff in Zambia, at 3 cents/kWh, is one of the lowest in Africa. This current level does not even allow for the recovery of operating costs, yet alone total costs—even though Zambia has one of the lowest average costs in the region (due to a combination of hydropower technologies and excess generation capacity).

Such inefficient pricing policies are compounded by the exceptionally favorable prices that the power utility ZESCO gives to mining companies, in particular the Copperbelt Energy Corporation (CEC). A long-term agreement set mining tariffs at 2 cents/kWh, not only below cost recovery but also one-third lower than the effective tariff for an average residential customer (100 kWh/month).

As the mining sector is the recipient of 50 percent of total ZESCO sales, this translates into a conservative estimate of $30 million in annual subsidies with a projected cumulative deficit of $926 million over the next 10 years.

Zambia's case is not unique in the region. Until 2003 Ghana's power distribution company, VRA, was engaged in a long-term agreement with Volta Aluminum Company, which was VRA's most important customer, consuming one-third of its power generation and benefiting from a preferential electricity price estimated to be half of the cost-recovery level.

Source: Zambia Electricity Regulator Board 2008; World Bank 2008; Chivakul and York 2006

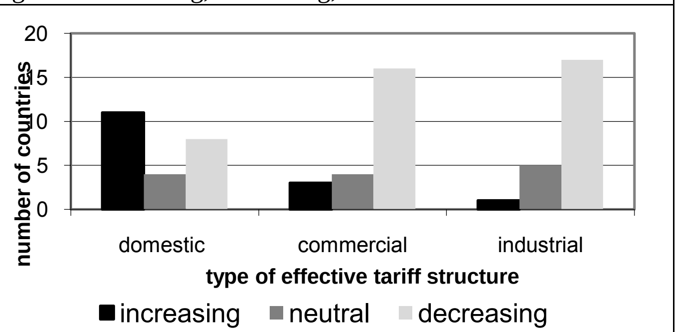
Table 7 lists the effective nonresidential tariffs for select African countries. Commercial effective tariffs are higher overall than industrial ones at similar levels of consumption. Two-thirds of the sample countries have commercial tariffs that are, on average, 20–30 percent higher than the industrial ones (table 7). These countries include Burkina Faso, Cape Verde, Chad, Madagascar, and Ethiopia. Another handful of countries have even higher price differentials—Benin, Côte d'Ivoire, and South Africa have commercial effective tariffs between 40 and 77 percent higher than industrial tariffs. This pattern is not unusual, as the genuine production costs of the high-voltage power consumed by industrial users are lower and exposed to fewer transmission and distribution losses (figure 8). The Democratic Republic of Congo and Mozambique are notable exceptions to this pattern: commercial customers pay on average 30–40 percent more than industrial customers.

Table 7. Effective nonresidential tariffs by level of consumption (cents)						
	Commercial				Industrial	
	Level of consumption (kWh)/month				Level of demand	
	450	**900**	**2,500**	**5,000**	**10 kVA**	**100 kVA**
Benin	15.1	15.1	15.1	15.1	10.7	10.7
Burkina Faso	27.0	26.7	26.5	26.5	14.1	15.0
Cameroon	11.7	11.4	11.3	11.2	8.8	9.2
Cape Verde	21.8	21.8	21.8	21.8	17.7	17.7
Chad	43.7	44.7	45.3	45.5	45.6	38.8
Congo, Dem. Rep. of	11.0	11.0	10.8	10.8	14.6	14.6
Côte d'Ivoire	17.8	16.9	16.3	16.1	10.7	10.7
Ethiopia	9.8	8.3	7.3	7.0	4.8	4.7
Ghana	12.6	13.9	15.2	15.6	5.7	6.4
Kenya	22.1	21.7	21.5	21.4	16.6	15.1
Lesotho	9.3	9.3	9.3	9.3	1.5	3.3
Madagascar	30.9	25.3	21.7	20.7	11.1	10.5
Malawi	8.1	6.9	6.1	5.8	2.6	3.1
Mozambique	9.0	8.0	7.5	7.3	4.7	5.1
Namibia	15.2	14.0	13.2	13.0	12.7	13.6
Niger	13.4	13.2	13.0	12.9	9.0	9.3
Nigeria	5.1	5.0	5.0	5.5	5.0	5.1
Rwanda	17.2	17.2	17.2	17.2	17.2	17.2
Senegal	23.8	22.8	26.2	26.0	15.8	15.8
South Africa	11.4	7.7	5.3	4.7	2.7	2.7
Tanzania	8.6	8.0	7.6	7.5	5.0	5.4
Uganda	22.0	21.9	21.8	21.8	16.8	17.0
Zambia	5.1	4.4	3.9	3.8	2.3	2.5
Congo, Rep.	11.7	10.7	10.1	9.9	11.2	11.2
Mali	23.2	23.2	23.2	23.2		
Botswana	7.7	7.2	6.9	6.8	3.3	4.0

Source: Africa Infrastructure Country Diagnostic Power Tariff Database

Notes: Average commercial consumption level is highlighted in bold — Not available.

Figure 8. Increasing, decreasing, and neutral tariff structures



Source: Africa Infrastructure Country Diagnostic Power Tariff Database

c. What have been historic costs of power production?

As we have discussed, Africa faces effective tariffs that are up to twice as high as in other developing regions. This reflects the use of costly technologies as well as the small scale of most African power generation systems.

But what have been the historic costs across the various power systems? The first step toward answering this question is to attribute to each kilowatt-hour produced both the capital and operating (O&M) costs of the three power production segments: generation, transmission, and distribution.

O&M unit costs are calculated by prorating total operational costs (as reported in utilities' income statements) by the total generated electricity over a given year. Data are derived from the AICD's fiscal spending database,[5] and individual results have been verified by country power experts. Operational costs include salaries associated with system operations, fuel charges, the cost of parts needed for daily operations, and so on.

Unit capital costs are calculated using the levelized power methodology (commonly used by the International Energy Agency). This requires allocating the value of an asset over its lifetime capacity. In essence the unit capital cost is a ratio of the net present value of total lifetime investment to the total electricity produced.[6] For this purpose an annualization factor is applied to the value of generation, transmission, and distribution assets. The overnight investment or capital needed to replace existing assets is the proxy for asset value, to allow for cross-country comparison.

The annualization factor is a reversed version of a standard formula for the net present value of a periodic investment of equal amount. It takes into account both depreciation and interest rates:

$$ACC = OI * \frac{r}{1-(1+r)^{-T}}$$

; where *ACC* is annualized capital cost, *OI* is overnight investment, *r* is annual discount rate, and *T* is plant life (in years).

In most African countries, the cost of each kilowatt-hour is 10–20 cents (figure 9). In a handful of countries—such as South Africa, Zambia, the Democratic Republic of Congo, Ethiopia, Mozambique, and Malawi (all of them significant hydro-power producers, with the exception of South Africa)—the power cost is below 10 cents/kWh. Niger and Mali, at the upper extreme, have unit costs over 30 cents/kWh. The balance between capital and operating costs also varies from country to country, largely determined by generation technology. By way of example, capital costs as a percentage of total costs range from 14 percent in Botswana to 77 percent in Nigeria. Full details of these calculations are provided in Annexes 6-8.

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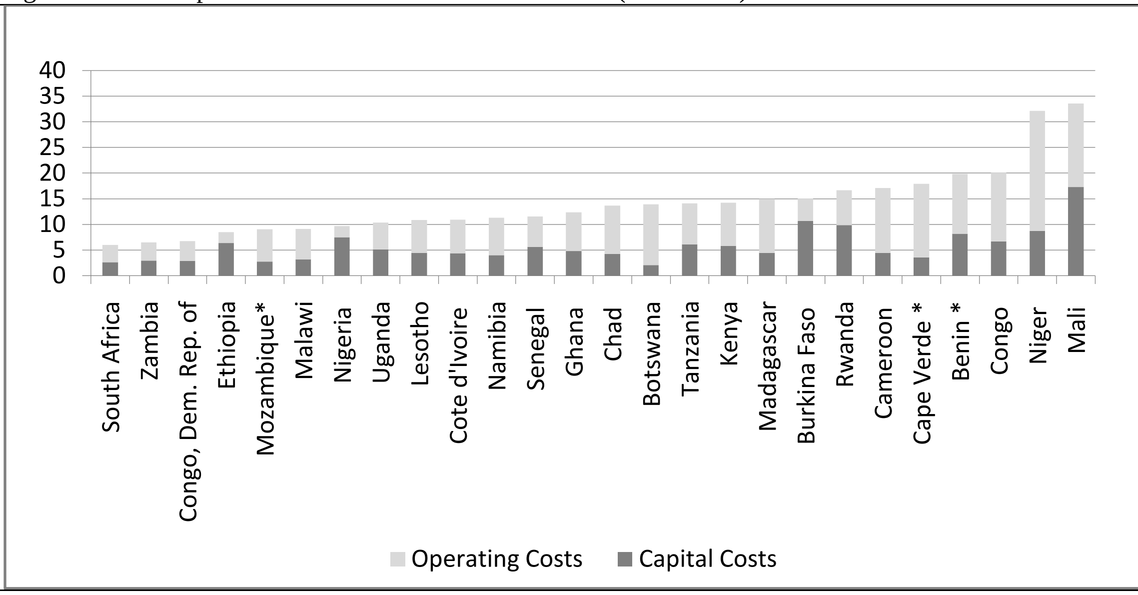
[5] http://www.infrastructureafrica.org.

[6] Lifetime capital costs are estimated using: (i) the discounted net present value of lifelong capital costs (for example, the sum of the annual investment expenditure throughout the life of a plant), (ii) the discounted historical cost of existing assets, and (iii) the relative value of a similar asset (replacement cost). We are using method (i), with the overnight construction costs as a proxy for the net present value of the lifelong investment expenses.

Figure 9. Historic power costs in select African countries (cents/kWh)

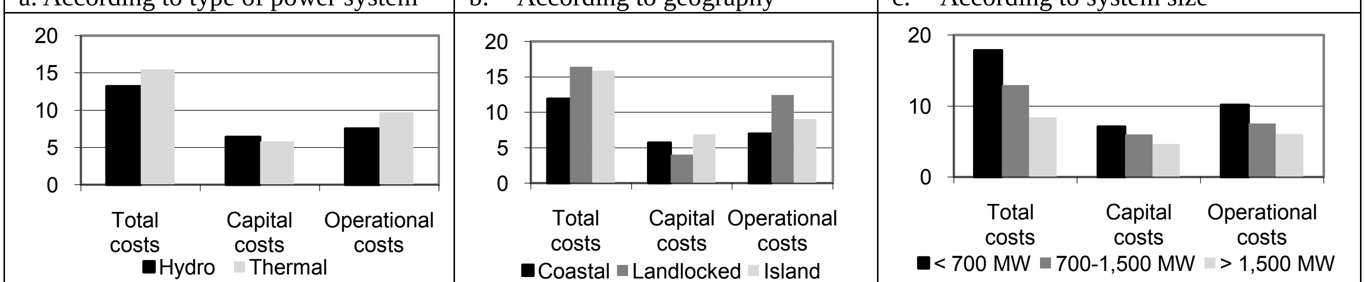


Source: Africa Infrastructure Country Diagnostic Power Tariff Database
Note: For details see annex 8.

But what drives costs? In general, hydro-based systems tend to be more skewed towards capital cost and thermal-based systems more skewed toward operating cost In terms of geography. Africa's landlocked and island nations seem to bear a significant power cost disadvantage vis-à-vis the coastal countries. High power costs are also driven by the size of markets and their associated scales of production (figure 10).

Figure 10. Differences in average costs (US cents per kWh)

a. According to type of power system | b. According to geography | c. According to system size



Source: Africa Infrastructure Country Diagnostic Power Tariff Database
Note: For details see annex 7.

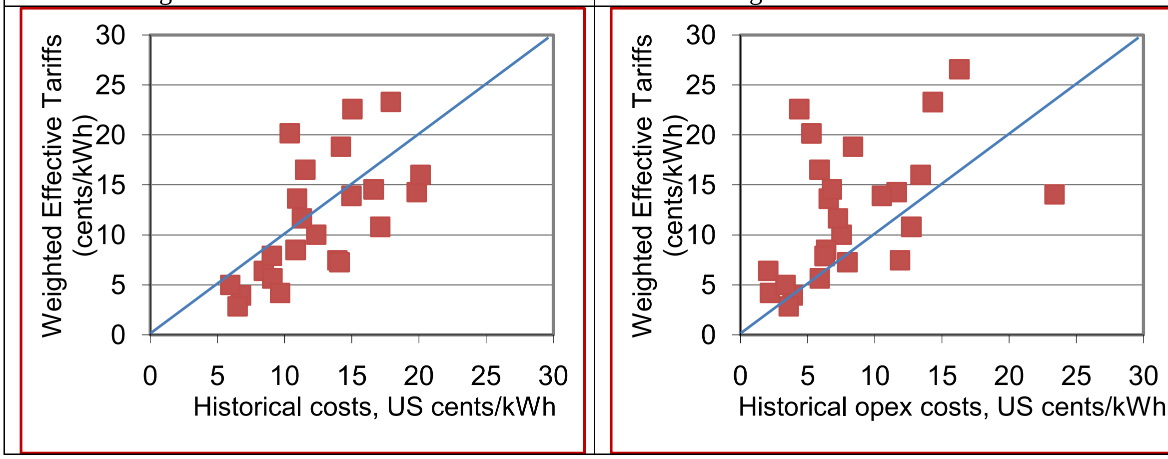
d. Do average effective tariffs cover historic costs?

Existing effective tariffs allow for the recovery of operational costs for close to 80 percent of African countries (figure 11b). But when capital investments are considered, the picture looks less rosy. On average, sample countries recover only two-thirds of their capital costs. Indeed, barely one-third of the sample countries are practicing full capital cost recovery (figure 11a); Among the countries that should be able to cover total costs under existing tariff regimes (contingent on their ability to collect bills) are Burkina Faso, Côte d'Ivoire, Kenya, Namibia, and Senegal.

Figure 11. Cost-recovery capabilities of effective tariff regimes

a. Weighted effective tariffs and total costs

b. Weighted effective tariffs and OPEX



Source: Africa Infrastructure Country Diagnostic Power Tariff Database

Note: OPEX = operational expenditure.

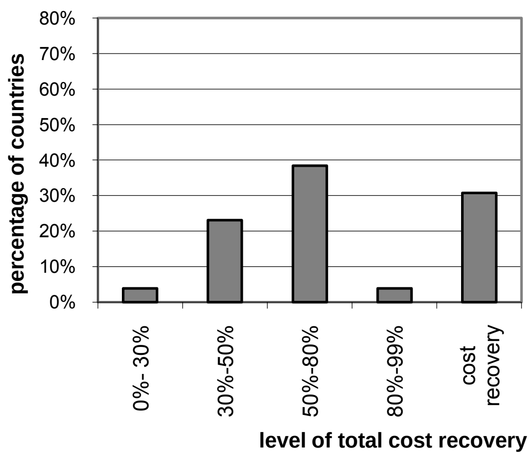
Lack of full cost recovery can be partly explained by the large weight of residential customers in utilities' revenue structure, whose charges – for political and social reasons – often fail to reflect costs. Excluding South Africa, roughly 50 percent of the total power billing in Africa is associated with households, for just over 40 percent of the total power supplied (figure 13). This is a very high share by global standards. In South Africa, by contrast, the total share of residential billing stands much lower at 17 percent versus only 8 percent of total power supplied. Only in 30 percent of the sample countries do residential tariffs allow for 100 percent cost recovery (figure 12a). While residential tariffs do better at covering operating costs (figure 12b), this is not enough to guarantee financial sustainability in the medium to long term.

It is important to underscore that setting tariffs at cost-recovery levels is one thing and actually recovering costs is another. African utilities are characterized by bill-collection rates of well below 100 percent. This translates to financial losses that can amount to more than the entire turnover of a utility (see annex 14 for details).

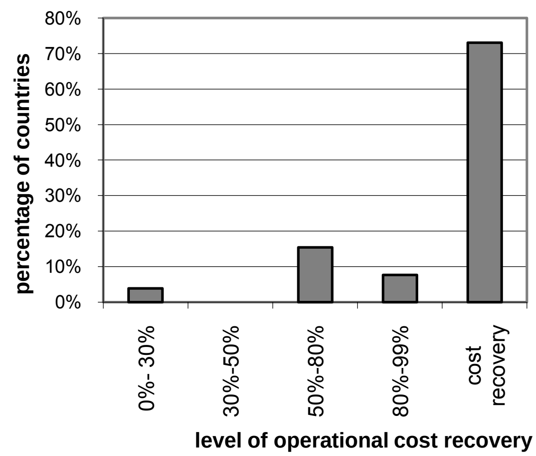
Have African utilities been improving their cost-recovery rates over time? Power tariffs increased substantially over the period 2001 to 2005, but not fast enough to keep pace with rising costs (figure 14). Indeed, by 2005, average revenues had only just caught-up with the average costs in 2001.

Figure 12. Cost-recovery capabilities of residential effective tariffs at 100 kWh/month consumption

a. Total cost recovery



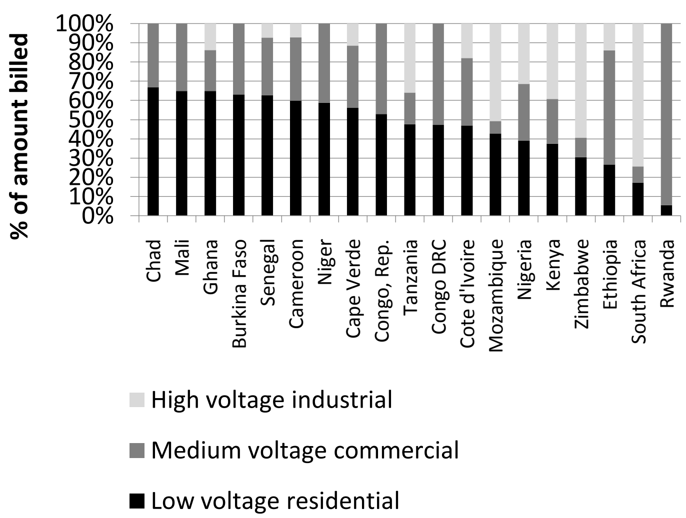
b. Operational cost recovery



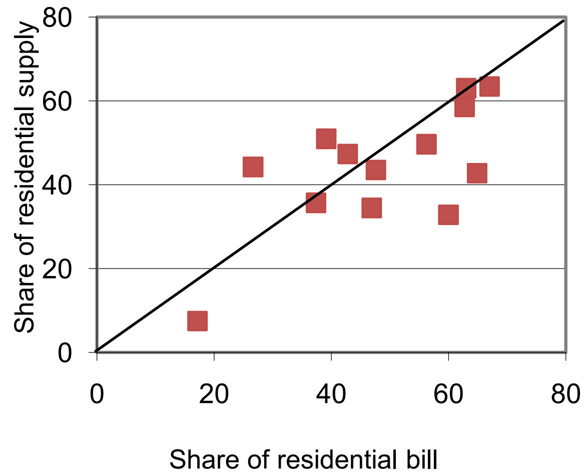
Source: Africa Infrastructure Country Diagnostic Power Tariff Database

Figure 13. Household billing as a share of total power billing

a. Composition of annual billing per type of customer



b. Residential share of billing and consumption

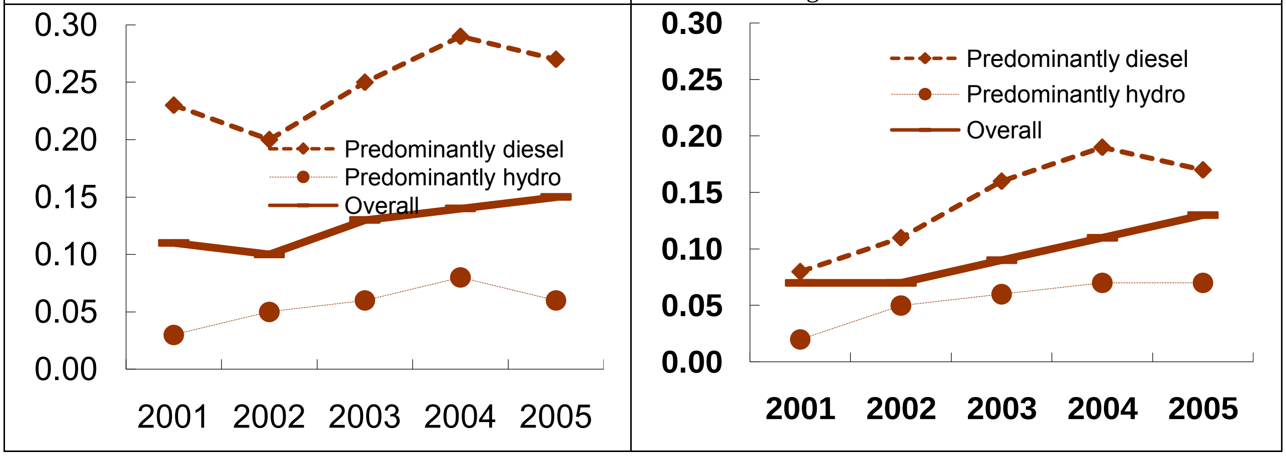


Source: Africa Infrastructure Country Diagnostic Power Tariff Database

Note: See annex 9 for details.

Figure 14. Costs and revenues over time ($/kWh)

a. Unit costs | b. Average revenues



Source: Africa Infrastructure Country Diagnostic Power Tariff Database

e. Do IBT structures allow for costs to be recovered?

As noted above, IBTs are premised on the notion that surcharges on higher volumes of consumption will compensate for discounts on lower volumes of consumption, so that the utility breaks even overall. However, this outcome is contingent on the block sizes and associated price levels being correctly calibrated. It is often the case that the surcharges apply (if at all) to very high levels of consumption that are rarely reached in practice. In the case of Africa, the answer is more promising than might be anticipated.

A minority of countries have residential tariffs that recover costs independent of consumption levels, meaning that even the lowest priced block is priced high enough to recover costs (category I in table 8). (This is ideal from a cost recovery perspective, but raises questions as to whether these IBTs are also performing the intended social function of providing subsidized power to small consumers.) A second batch of countries has IBTs that succeed in recovering operational costs (category II), but will not—or are not likely to—attain total cost recovery based on their historical average household consumption. The third group of countries (category III in table 8) is recovering costs within a consumption range that is close to the historic average. Finally, a fourth group of countries (category IV)—given current tariffs and the historical consumption patterns—will never attain operational (let alone total) cost recovery.

Table 8. Break-even consumption levels			
ID	Countries	Operational cost	Total cost
I	Burkina Faso Cape Verde Chad Namibia Senegal Uganda	At any level	At any level
II	Côte d'Ivoire	At any level	90
	Mozambique		300
	Ghana		1,070
	Ethiopia Lesotho Rwanda Mali	At any level	Never
	Nigeria	24	Never
	Tanzania	155	
III	Botswana	27	20
	Zambia	65	27
	Congo, Rep. of	20	29
	Kenya	50	91
	Benin	12	110
	South Africa	94	290
IV	Congo, Dem. Rep. of	600	600
	Cameroon Madagascar Malawi Niger	Never	Never
Source: Africa Infrastructure Country Diagnostic Power Tariff Database			

Are power tariffs efficient from an economic standpoint?

We have shown that average effective tariffs are not all that successful at recovering historic costs, and this is important from a *financial* perspective. However, historic costs are not necessarily a good guide to future power development costs. What is important from an economic perspective is whether average effective tariffs cover long-run marginal costs (LRMC) of system development. In this section we assess whether power tariffs provide this correct economic signal, and thus do not lead to the over- or under-consumption of power from an economic standpoint.

a. What do LRMCs look like in Africa?

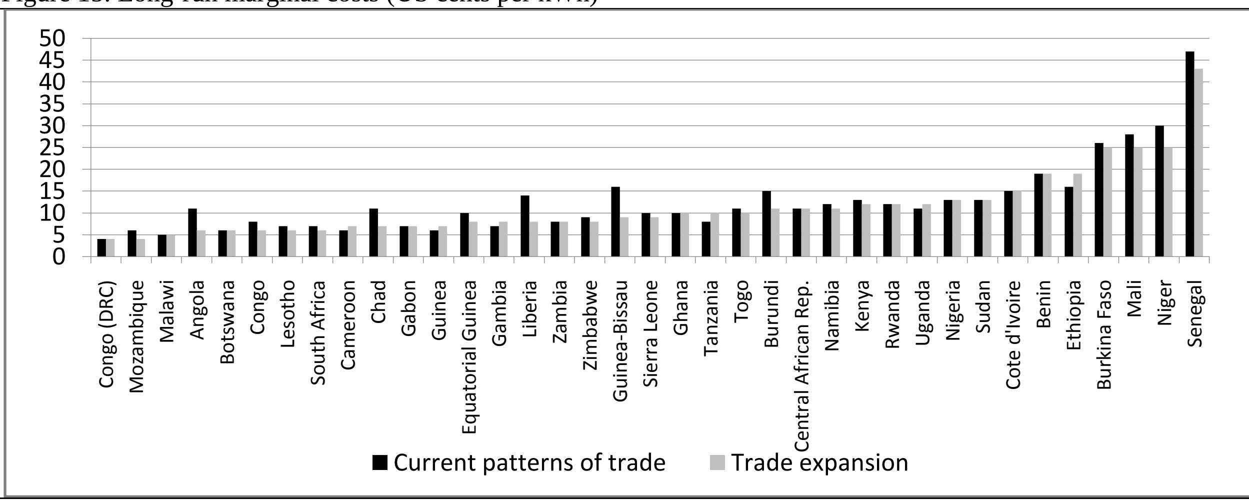
So far, we have seen that tariffs in Africa are high compared with those in other developing regions, but not high enough to allow for historic cost recovery. We have also seen that high tariff levels are a direct consequence of high costs, which are driven by the use of sub-optimal primary energy sources (small scale diesel versus large hydro), difficult geography (with higher costs faced by landlocked countries and islands), and diseconomies of scale (due to the prevalence of small national systems). However, in principle, these costs could come down in the future as countries harness more cost-effective sources of energy and exploit regional power trade to expand the scale of production.

LRMCs are calculated using a dynamic model that estimates the needs of African power systems based on economic growth projections and electrification targets. The model simulates optimal (least-cost) strategies for generating, transmitting, and distributing electricity in response to demand increases. It also estimates the cost of meeting power demand under a range of alternative scenarios, including cross-border trade (Vennemo and Rosnes 2008).[7]

With few exceptions, a more efficient selection of technologies (with and without greater regional trade) would render LRMCs below 10 cents/kWh (figure 15). Only four countries—Burkina Faso, Mali, Niger, and Senegal—would face LRMCs over 20 cents/kWh.

Developing African power systems with a view toward expanding regional trade clearly reduces LRMCs across most countries. In fact, if regional trade were fully pursued countries would see their LRMCs reduced by about 10 percent on average, and as high as 40 percent in some cases (figure 16a). These would translate into LRMC reductions of as high as 7 cents/kWh, but more typically in the 1–5 cents range (figure 16b).

Figure 15. Long-run marginal costs (US cents per kWh)



Source: Adapted from Vennemo and Rosnes 2008

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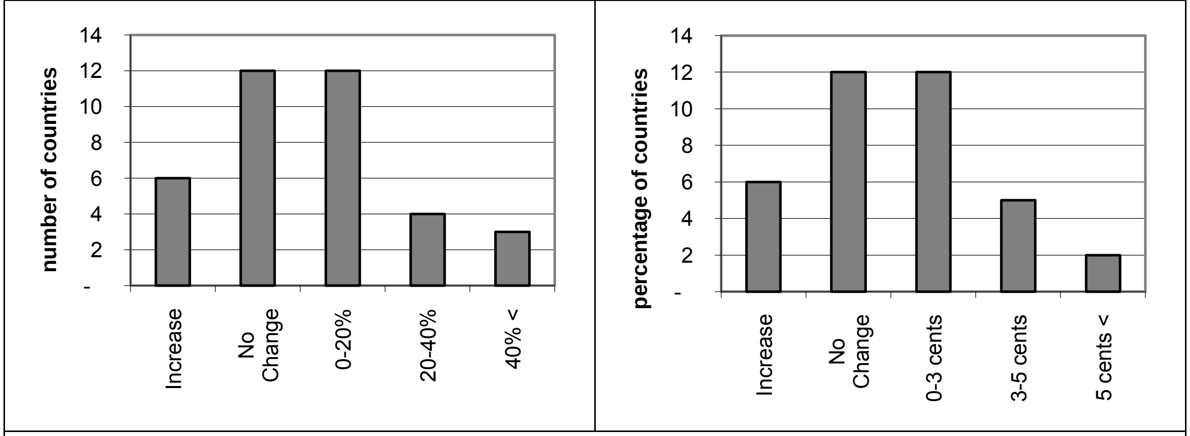
[7] For a brief description of the model, see annex 10.

Figure 16. How trade expansion would effect long-run marginal costs

a. Percent reduction on LRMC | b. Monetary reduction on LRMC



Source: Adapted from Vennemo and Rosnes 2008

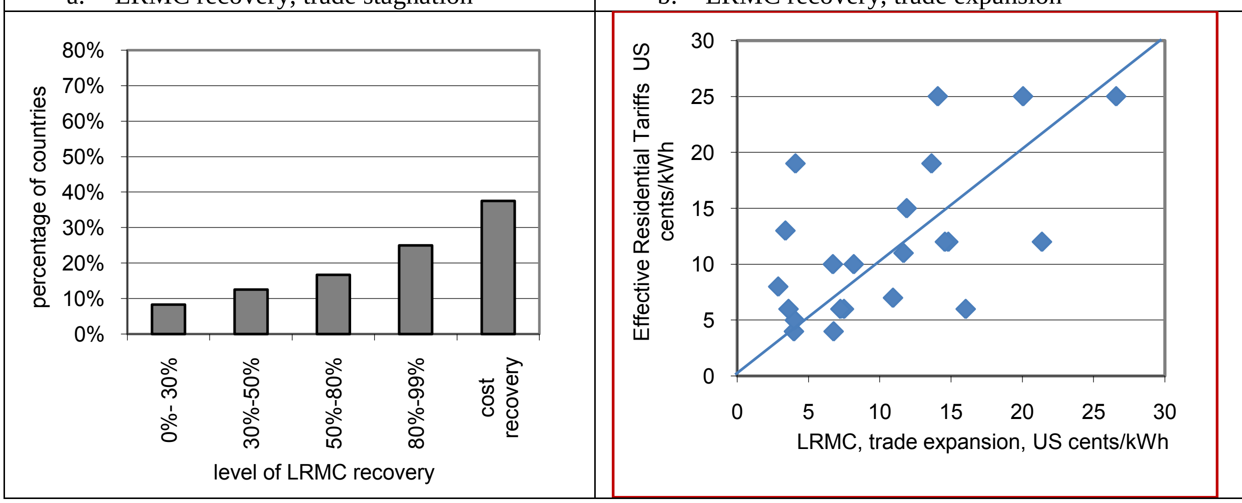
Note: See details in annex 11.

b. Do existing average effective tariffs cover LRMC?

It is relevant to ask whether existing average effective tariffs are high enough to cover LRMC even if they may not be high enough to cover average historic costs as was demonstrated above. The analysis shows that 38 percent of the sample countries have already achieved average effective tariffs that are high enough for full capital cost recovery (figure 17a). Compare this with only 30 percent of countries that can fully recover historic costs.

Figure 17. Cost-recovery capabilities of residential effective tariffs vis-à-vis LRMCs

a. LRMC recovery, trade stagnation | b. LRMC recovery, trade expansion



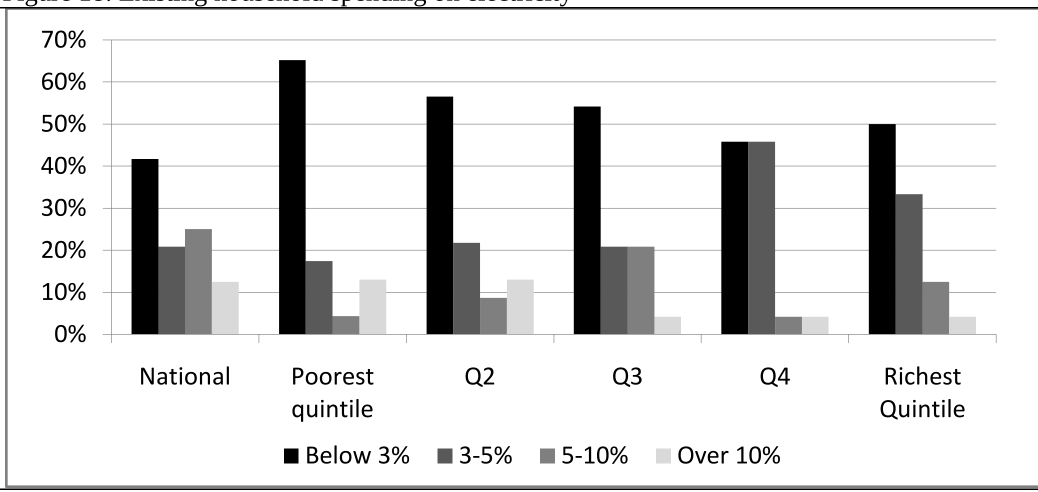
Source: Adapted from Vennemo and Rosnes 2008 and Africa Infrastructure Country Diagnostic Power Tariff Database.

Are power tariffs equitable and affordable?

c. Can African households afford power services?

Based on information reported in household surveys, on average power bills absorb almost 6 percent of total household budgets. For most countries the share falls below 3 percent; however in a few cases (such as Malawi and Mozambique) it can be as high as 10 or even 20 percent (figure 18). This share is relatively stable across quintiles.

Figure 18. Existing household spending on electricity

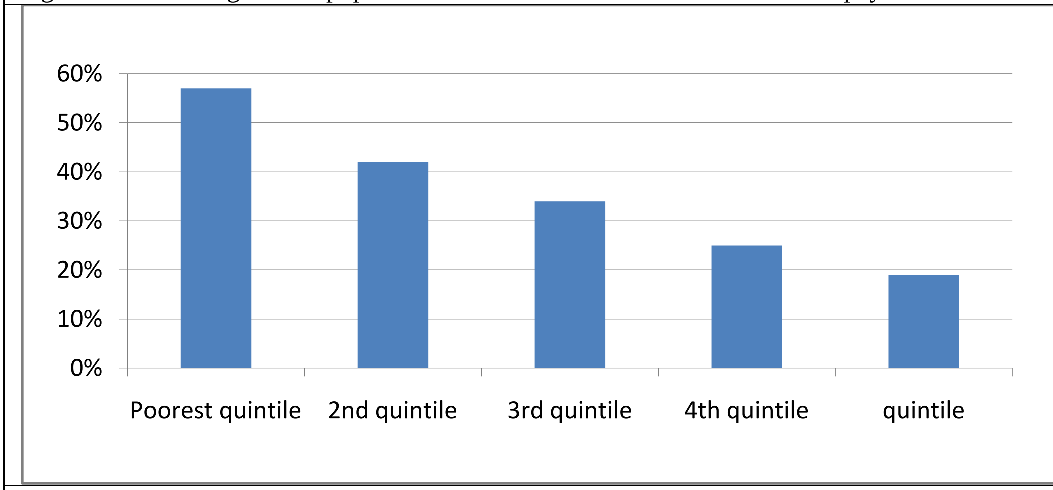


Source: Adapted from Banerjee and others (2008).

In order to gauge whether power is affordable, two types of evidence can be considered.

One possible measure of affordability is non-payment of services. Based on household surveys, we can compare across quintiles the percentage of households that report *paying* for power against the percentage of households that report *using* service. Those using without paying include both clandestine users who steal power from the network and formal customers who fail to pay their bills. Overall, about 40 percent of people connected to electricity do not pay for it (figure 19). Nonpayment rates range from about 20 percent in the richest quintile to about 60 percent in the poorest quintile. A significant nonpayment rate, even among the richest quintiles, suggests that a culture of nonpayment exists in addition to affordability issues.

Figure 19. Percentage of the population with service connections who do not pay for service



Source: Banerjee and others 2008.

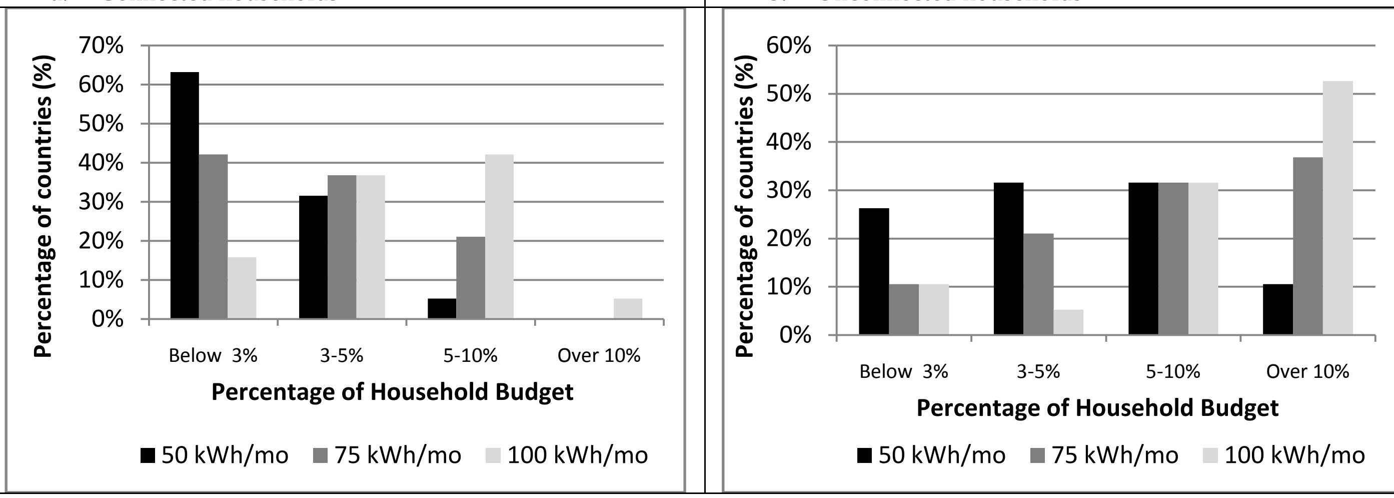
Another possible measure of affordability is whether the *full economic cost* of a *subsistence level* of consumption falls above a *normative affordability threshold*. Economic cost is defined as the tariff that would fully cover both operating and capital costs and is country specific; reaching an average level of US$0.18/kW for SSA as a whole. Subsistence consumption is defined as 50 kWh per month, which is enough to cover very minimal usage for lighting (roughly one light bulb for two hours per day). The affordability threshold is typically defined as spending on subsistence power needs of between 3 and 5 percent of the total household budget. These values are normative, and are informed by power spending patterns by low income households that have been observed across a wide range of household surveys (recall figure 18 above).

By looking at the distribution of household budgets, one can calculate the percentage of households for which subsistence consumption priced at full economic cost would absorb more than 5 percent of their budgets and thus prove unaffordable. For example, looking across the distribution of household budgets for all of SSA, monthly bills of $2 would be affordable for almost the entire population, whereas monthly bills of $10 would only remain affordable for the entire population of *middle-income* African countries.

Based on existing average effective tariffs, the bill for subsistence consumption levels looks very affordable *for those that are already connected to the grid* (Figure 20a). With a 3 percent affordability threshold, the subsistence consumption of 50kWh/month priced at the current average effective tariff is affordable in 60 percent of the sample countries. If the affordability threshold is further raised to 5 percent, the subsistence consumption is affordable in over 90 percent of the sample countries. However, the picture looks very different for those that are *not currently connected to the grid*. In these cases, the subsistence consumption level priced at the current average effective tariff would only be affordable in about 25 percent of the countries in the sample (Figure 20b). In conclusion, a significant majority of those connected can afford power at existing prices, while a significant majority of those unconnected cannot do so. This raises questions of circularity: either existing tariffs determine who is connected or tariffs are designed to be affordable to those who are connected.

Figure 20. Monthly electricity expenditure as a percentage of total household budget

a. Connected households | b. Unconnected households



Source: Adapted from Banerjee and others, 2008

An equally important question is whether tariffs would remain affordable if today's tariffs were adjusted to allow for the recovery of full economic costs. For this purpose, we use two cost recovery benchmarks: the average historic cost and the Long Run Marginal Cost (table 9).

Under historic cost recovery, a subsistence level of consumption of 50 kWh per month would range in cost from $3 to $16 a month. These monthly bills would on average be affordable for 72 percent of households across the sample. There are only a handful of countries where less than half of the population could afford these bills, notably: Niger (7 percent), Ethiopia (12 percent), Malawi (43 percent).

If instead, a forward-looking Long Run Marginal Cost is used for cost recovery purposes, the results are very similar on average. Monthly bills would on average be affordable for 73 percent of households across the sample. However, the position of individual countries looks quite different. For one group of countries (DRC, Malawi, Tanzania and to a lesser extent Benin and Kenya), LRMC based tariffs are significantly more affordable than historic cost recovery tariffs. For a second group of countries (Ethiopia, Uganda), LRMC based tariffs are significantly less affordable than historic cost recovery tariffs.

Table 9. Monthly power bill for subsistence consumption (50 kWh)						
	Monthly bill ($)			**Share of households that can afford the monthly bill (%) (*)**		
	Effective tariff	Historic cost	LRMC	Effective tariff	Historic cost	LRMC
Benin	6.31	9.92	9.50	95	68	72
Burkina Faso	10.29	7.53	12.50	51	69	36
Cameroon	4.30	8.56	3.50	100	100	100
Cape Verde	11.81	8.95		100	100	—
Congo, Dem. Rep. of	1.99	3.38	2.00	100	63	91
Côte d'Ivoire	4.81	5.47	7.50	100	99	98
Ethiopia	1.97	4.23	9.50	60	12	1
Ghana	4.36	6.18	5.00	97	93	96
Kenya	4.21	7.10	6.00	99	87	95
Madagascar	2.98	7.49		92	55	—
Malawi	2.39	4.54	2.50	92	43	91
Niger	7.25	16.07	12.50	55	7	19
Nigeria	1.25	4.84	6.50	97	84	74
Senegal	9.31	5.77	21.50	100	100	—
South Africa	—	2.98	3.00	100	100	100
Tanzania	1.60	7.04	5.00	99	59	84
Uganda	9.74	5.19	6.00	20	66	55
Zambia	2.09	3.26	4.00	100	97	96
Sub-Saharan African average	4.81	6.58	7.28	86.51	72.39	73.73

Source: Adapted from Vennemo and Rosnes 2008 and Africa Infrastructure Country Diagnostic Power Tariff Database.

Notes: See Annex 12 for further details

(*) it is assumed that a bill is affordable if it is below 5 percent of the household budget.

— Not available.

A frequent argument used for not raising tariffs to full cost recovery levels is the potential impact on poverty. However, empirical evidence suggests that the immediate poverty-related effect of raising tariffs to cost-recovery levels is generally quite small, although it may have second-order effects. Detailed analysis of the effect of significant tariff increases of the order of 40 percent for power and water services in Senegal and power services in Mali confirms that the immediate poverty-related effect on consumers is small, essentially because very few poor consumers are connected to the service (Boccanfuso, Estache, and Savard 2008a; 2008b; 2008c). As the consequences of higher power or water prices work their way through the economy, however, broader second-order effects on wages and prices of goods in the economy as a whole can have a more substantial impact on poverty (Boccanfuso, Estache, and Savard 2008a; 2008b; 2008c).

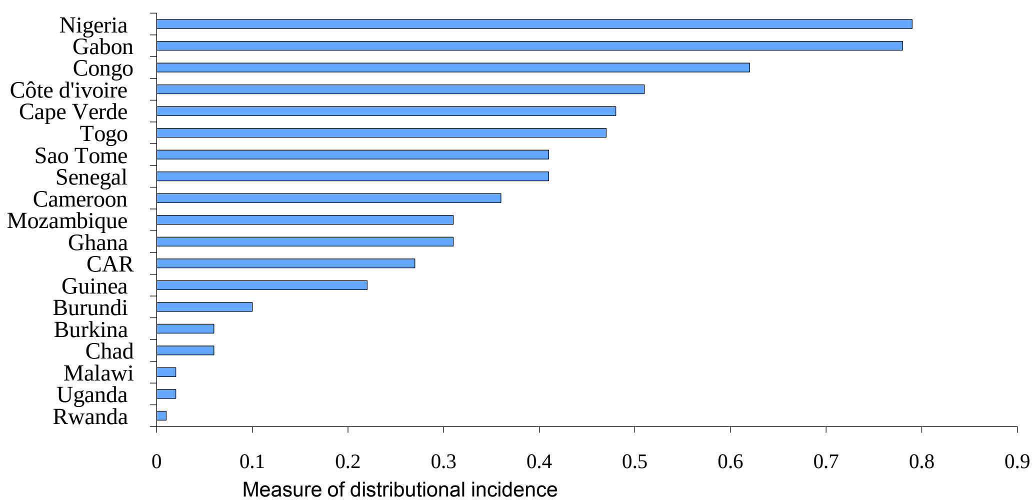
d. Are power tariffs equitable?

Notwithstanding these findings, most African countries subsidize tariffs for power. On average, power tariffs recover only 80 percent of costs. The resulting implicit subsidies amount to as much as $2.3 billion a year on aggregate (or 0.4 percent of Africa's GDP) (Foster and Briceño-Garmendia 2009). The aggregate burden of underpricing can be as much as 1–1.5 percent of a country's GDP (as in Cameroon, the Democratic Republic of Congo, Ghana, Mali, Malawi, Nigeria, South Africa, Tanzania, Zambia, Uganda) and even higher (Botswana and Niger). From the utility's perspective, underpricing can amount to losses valued as much (and even more than) 100 percent of the utility's turnover (see annex 14 for details).

Because electricity subsidies are typically justified by the need to make services affordable to low-income households, a key question is whether subsidies reach such households. Results across a wide range of African countries show that the share of subsidies going to the poor is less than half their share of the population, indicating a very pro-rich distribution (figure 21). This result simply reflects the fact that connections to power are already highly skewed toward more affluent households. In SSA as a whole, access to power among the bottom three quintiles of the budget distribution is no more than 12 percent on average compared to 72 percent in the top budget quintile.

To put these results in perspective, one must compare them with the aims achieved by other forms of social policy. Estimates for Cameroon, Gabon, and Guinea indicate that expenditures on primary education and basic health care reach the poor better than do power and water subsidies (Wodon 2007)

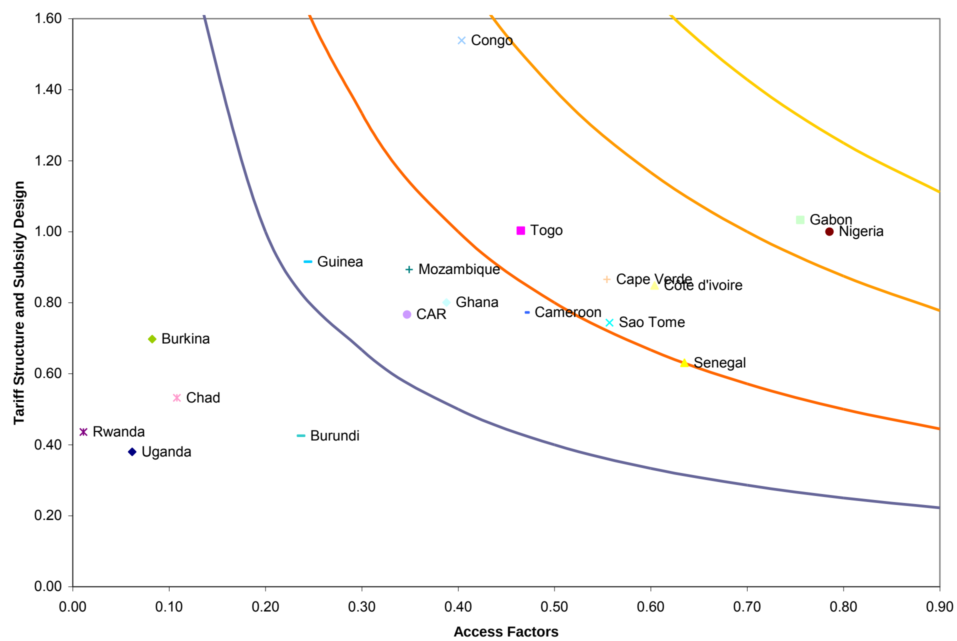
Figure 21. Extent to which electricity reaches the poor



Sources: Banerjee and others 2008; Wodon 2007.
Note: A measure of distributional incidence captures the share of subsidies received by the poor, divided by the proportion of the population in poverty. A value greater than 1 implies that the subsidy distribution is progressive (pro-poor), because the share of benefits allocated to the poor is larger than their share of the total population. A value less than 1 implies that the distribution is regressive (pro-rich).

A key message is that power subsidies will always be highly regressive as long as access is highly regressive. The distributional score presented above (figure 21) can be decomposed into access and subsidy design factors (figure 22). The access factor is related to the availability of electricity in the area where the household lives and to the household's choice to connect to the network if service is available. The subsidy design factor relates to who is targeted to receive the subsidies, rates of subsidization, and consumption levels. As for the overall distributional score, values higher (lower) than one for access and subsidy design factors are indications that those factors are progressive (regressive).

Figure 22. Access factors and subsidy design factors affecting targeting performance



Source: Banerjee and others 2008.
Note: Access factors capture the rates of connection among the poor to the network divided by the rates of connection to the population as a whole. Subsidy design factors are the ratio of the average benefit from the subsidy among all poor households connected to the network divided by the average benefit among all households connected to the network. A value greater than 1 implies that the factor distribution is progressive (pro-poor), because the share of benefits allocated to the poor is larger than their share in the total population. A value less than 1 implies that the distribution is regressive (pro-rich).

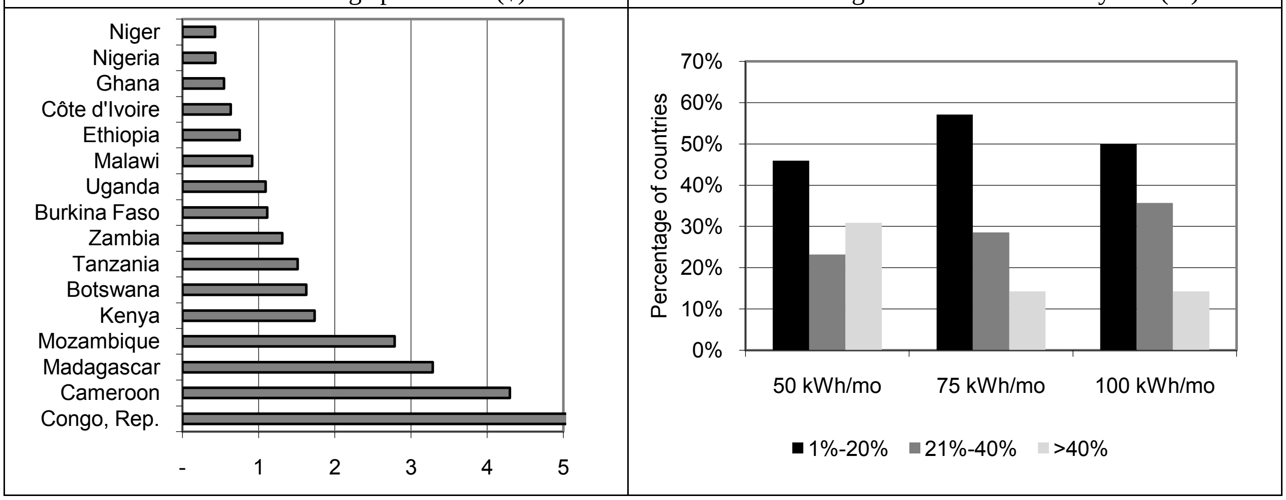
In general the findings are that the subsidy design factor exceeds the access factor. As was to be expected, given the pattern of connections to power, the access factor is always less than one meaning highly regressive. The tariff factor, on the other hand, ranges from 0.4 (indicating a highly regressive tariff structure) and 1.6 (indicating a moderately progressive tariff structure). The most progressive tariff structures are found in DRC, Gabon and Togo. However, for the bulk of countries analyzed are marginally below unity, suggesting that the tariff structures are at best distributionally neutral. However, this is not much of an achievement given that the intention behind the predominantly IBT tariff structures is to favor the poor. This finding is explained by the fact that the traditional IBTs that prevail in Africa tend to be poorly targeted because tariff structures subsidize consumption in the first blocks even for customers whose aggregate consumption is high. On top of that, the consumption threshold for the lower blocks tends to be too high to single out the poor, the price difference between blocks is not very large, and fixed charges are too high.[8]

[8] Also discussed in Wodon (2007) and Banerjee and others (2008).

How much are poor customers penalized by fixed charges and block structures? As noted above, over 50 percent of the sample countries have incorporated fixed charges in their tariff schemes. Fixed charges in African countries range from US$0.43 cents to US$5.00 per month (figure 23a). Furthermore, these charges constitute a large portion of the aggregate monthly bill particularly at subsistence levels of consumption (figure 23b). At 50 kWh/month—subsistence consumption—the fixed charge represents more than 40 percent of the monthly bill in over 30 percent of the countries. At higher levels of consumption—75kWh/month and 100 kWh/month—the weight of the fixed charge is less prominent. This indicates the disproportionate weight of the fixed charge in the bills of households consuming at the subsistence level.

Figure 23. Fixed portion of residential tariffs

a. Residential fixed charge per month ($) | b. Fixed charge as a share of monthly bill (%)



Source: Africa Infrastructure Country Diagnostic Power Tariff Database.

e. Are there any other kinds of hidden subsidies?

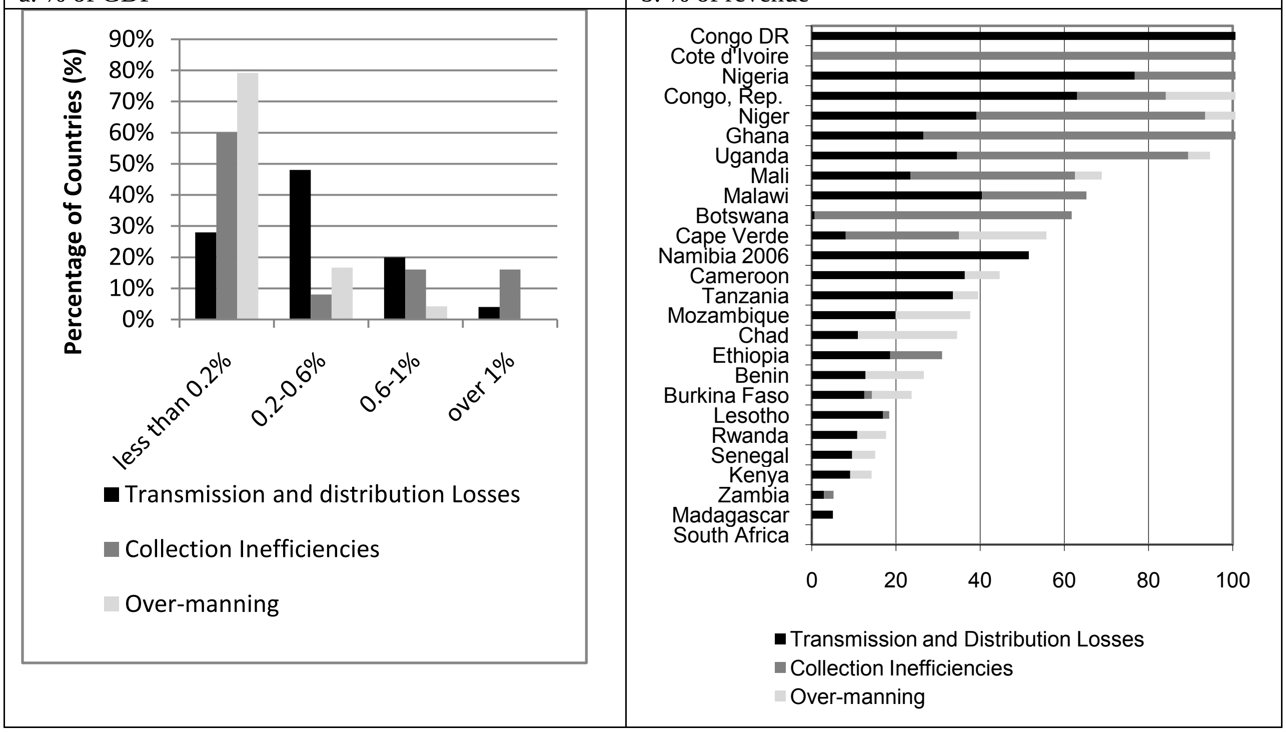
Besides tariffs, there are also other less explicit mechanisms by which policy makers subsidize consumption. For instance, when policy makers overlook, tolerate, or even promote certain operational inefficiencies, they are in practice transferring resources from one sector of the economy to another, from the producer to the consumer, from future taxpayers to current customers, and so on.

Tolerance of nonpayment is an implicit tax on utilities (and/or a transfer to consumer). Tolerance of pilferage—one of the main causes of transmission and distribution losses—is an implicit subsidy to customers and an implicit burden on future taxpayers. Acceptance and promotion of over-employment represents an untargeted transfer of resources from the utility to the society. These inefficiencies can be empirically quantified and prove to be substantial relative to GDP (Briceño-Garmendia, Foster, and Smits 2008). For most countries, over-manning as well as collection inefficiencies amount to less than 0.2 percent of GDP, whereas transmission and distribution losses tend to be much larger in value amounting to around 0.2-0.6 percent of GDP (figure 24a). These operational inefficiencies also look very large in comparison with utility revenues; amounting to between 20 and 60 percent of utility revenues in most cases, and exceeding 100 percent of utility revenues in a few cases (figure 24b).

In countries such as the Democratic Republic of Congo, the Republic of Congo, Nigeria, Namibia, and Cameroon—to name only a few—transmission and distribution losses (technical and nontechnical) are the lead cause of hidden losses (figure 24b). In Côte d'Ivoire, Niger, Ghana, Uganda, and Botswana—to cite some examples—under-collection of bills is the main offender, though it is observed that unpaid bills are from the government or other public enterprises. Finally, over-manning seems to be an issue for countries such as Cape Verde and Chad.

Figure 24. Monetary costs of overlooked inefficiencies

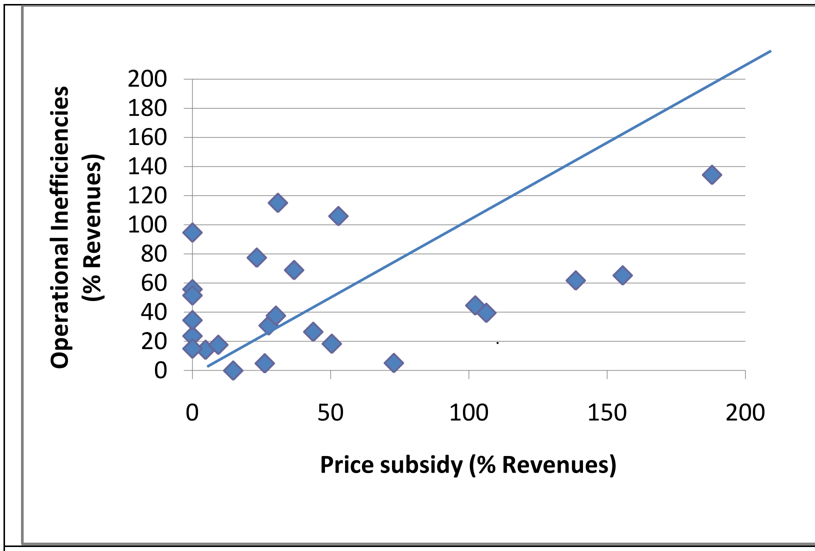
a. % of GDP | b. % of revenue



Source: Briceño-Garmendia, Foster, and Smits 2008

In fact it is not infrequent that the financial burden of the myriad operational inefficiencies is higher than the cost of subsidizing via under-pricing. In about half of the countries in our sample, the magnitude of these operational inefficiencies is higher than the magnitude of price subsidies (figure 25).

Figure 25. Weight of underpricing vis-à-vis operational inefficiencies



Source: Africa Infrastructure Country Diagnostic Power Tariff Database.

Overall, how would we rate Sub-Saharan African power tariffs?

A scorecard combining four of the key goals in the design of power tariffs—cost recovery, efficiency, equity and affordability—illustrates the challenges of simultaneously achieving these sometimes conflicting objectives. For each of these objectives a quantitative indicator is used based on the foregoing analysis. Cost recovery is measured as the ratio of the current average effective tariff to the average historic cost of power production. Efficiency is measured as the ratio of the current average effective tariff to the Long Run Marginal Cost of power production. Affordability is measured as the percentage of households that are able to purchase a subsistence level of consumption of 50 kWh/month at the prevailing average effective tariff without spending more than 5 percent of their household budgets. Equity is measured as the share of the subsidy captured by households living under the poverty line divided by the percentage of households in the population that live under the poverty line.

The analysis shows that the average scores for the sample are 78 percent for cost recovery, 82 percent for efficiency, and 87 percent for affordability. And for equity the average score is 0.29 indicating a highly regressive distributional incidence, relative to a score of 1.00 for a tariff that is neutral in distributional terms (table 10).

Table 10: Scorecard for performance of country's power tariffs against four key policy objectives				
Objective	Cost Recovery	Efficiency	Affordability	Equity
Indicator	Ratio of average effective tariff to average historic cost	Ratio of average effective tariff to LRMC	Share of population that can afford subsistence consumption priced at average effective tariff	Percentage of subsidy captured by poor as a ration of percentage of poor in the population
Benin	0.72	0.75	0.95	
Botswana	0.54	1.00		0.06
Burkina Faso	1.00	0.87	0.51	
Cameroon	0.63	1.00	1.00	0.36
Cape Verde	1.00		1.00	0.48
Chad	1.00	1.00		0.06
Congo, Dem. Rep. of	0.59	1.00	1.00	0.62
Congo	0.80	1.00		
Cote d'Ivoire	1.00	0.91	1.00	0.51
Ethiopia	0.76	0.40	0.60	
Ghana	0.81	1.00	0.97	0.31
Kenya	1.00	1.00	0.99	
Lesotho	0.79	1.00		
Madagascar	0.93		0.92	
Malawi	0.62	1.00	0.92	
Mali	0.79	0.95		
Mozambique	0.87	1.00		0.31
Namibia	1.00	0.97		
Niger	0.44	0.47	0.55	
Nigeria	0.44	0.32	0.97	
Rwanda	0.88	1.00		0.01
Senegal	1.00	0.35	1.00	
South Africa	0.84	0.72	1.00	0.41
Sudan				
Tanzania	0.52	0.91	0.99	
Uganda	1.00	1.00	0.20	0.02
Zambia	0.44	0.36	1.00	
Zimbabwe		0.47		
Average	**0.78**	**0.82**	**0.87**	**0.29**

Source: Derived from Africa Infrastructure Country Diagnostic Power Tariff Database.

What becomes immediately clear is that some countries rank very high for cost recovery but do very poorly for equity and affordability and vice versa (table 11). Countries such as Chad, Mozambique, Rwanda, and Uganda tend to rank well for cost recovery but poorly for affordability and equity. On the other end, countries such as South Africa, the Democratic Republic of Congo, Tanzania, and Zambia fare relatively well in terms of equity and affordability but have not been able to achieve cost recovery. What is striking is that achieving all four objective simultaneously is almost impossible in the context of the high-cost low-income environment that characterizes much of SSA today. Hence most countries are caught between cost recovery and affordability.

Table 11. Overview of scorecard results		
	Target fully achieved	Performs above the median
Cost recovery	Burkina Faso, Cape Verde, Chad, Côte d'Ivoire, Kenya, Namibia, Senegal, Uganda	Ghana, Madagascar, Mozambique, Rwanda, South Africa,
Efficiency	Chad, Kenya, Uganda, Ghana, Mozambique, Rwanda, Botswana, Cameroon, Lesotho, Malawi, Congo, Rep. of	Namibia, Congo, Dem. Rep. of
Affordability	Senegal, Cameroon, Cape Verde, South Africa, Congo, Dem. Rep. of	Kenya, Tanzania, Zambia, Côte d'Ivoire
Equity	None	Cameroon, Cape Verde, South Africa, Côte d'Ivoire, Congo, Dem. Rep. of

Source: Derived from Africa Infrastructure Country Diagnostic Power Tariff Database.

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Annexes

Annex 1. Country coverage, country classification, and year of tariff schedule data set

	Economic/CPIA classification				Power pools				Capacity level			Generation type		Reference
	Resource rich	MIC	LIC fragile	LIC nonfragile	CAPP	EAPP	SAPP	WAPP	Low	Medium	High	Hydro	Thermal	Year of the tariff
Benin				1				1	1				1	2003
Botswana		1					1		1				1	2008
Burkina Faso				1				1	1				1	2006
Cameroon	1				1					1		1		2003
Cape Verde		1						1	1				1	2006
Chad	1				1				1				1	2005
Congo, Rep. of	1				1				1			1		2007
Congo, Dem. Rep. of			1				1				1	1		2005
Côte d'Ivoire			1					1			1	1		2006
Ethiopia				1		1				1		1		2004
Ghana				1				1			1	1		2006
Kenya				1		1					1	1		2006
Lesotho		1					1		1			1		2006
Madagascar				1						1			1	2005
Malawi				1			1			1		1		2006
Mali				1				1		1		1		2008
Mozambique				1			1				1	1		2006
Namibia		1					1			1		1		2006
Niger				1					1				1	2003
Nigeria	1							1			1		1	2005
Rwanda				1		1			1			1		2005
Senegal				1				1		1			1	2006
Seychelles		1							1				1	2006
Sudan	1					1				1			1	2003
Tanzania				1		1				1		1		2006
Uganda				1		1				1		1		2006
Zambia	1						1				1	1		2005
Zimbabwe			1				1				1		1	2008Dec

Source: Africa Infrastructure Country Diagnostic Power Tariff Database.

Note: LIC = low-income country; MIC = middle-income country; CAPP = Central Africa Power Pool; EAPP = East African Power Pool; SAPP = Southern African Power Pool; WAPP = West African Power Pool.

Annex 2. Residential tariff schedules

Country	Tariff type	Fixed charge/month, LCU	Fixed charge/month, $	Demand level, kVa	Demand level, kWh	Demand charge, kWh/kVa/month	Demand charge, monthly, $	Number of blocks	Block range, kWh	Block border, kWh	Price per block, LCU/kWh	Price per block, $/kWh
Benin	IBT	no	no					3	<20	20	56	0.096
									20–200	200	85	0.146
									>200		95	0.163
Botswana	FR	11.11	1.63			no		1			0.4	0.06
Burkina Faso	IBT	582	1.11					3	<=50	50	96	0.184
									>50–200	200	102	0.195
									>200		109	0.208
Cameroon*	IBT*		no					3	<=50	50	50	0.086
									50–200	200	60/67	0.109
									>200		65/75	0.120
Cape Verde	IBT	no	no					2	<=40	40	20	0.225
									>40		25	0.280
Chad	IBT	no	no					3	<=30	30	83	0.157
									?? 30–60	60	177	0.336
									?? >60		201	0.381
Congo, Dem. Rep. of**	IBT	no	no					11	<=100	100	—	0.040
									>100–200	200	—	0.039
									>200–300	300	—	0.039
									>300–400	400	—	0.039
									>400–500	500	—	0.038
									>500–600	600	—	0.038
									<=600	600	—	0.089
									>600–800	800	—	0.088
									>800–1,000	1,000	—	0.087
									>1,000–1,200	1,200	—	0.086
									>1,200		—	0.085
Congo, Rep. of	FR	2,268	5.06			no		1			49.08	0.11
Côte d'Ivoire	IBT	333	0.64					2	<=40	40	36	0.069
									>40		74	0.142
Ethiopia***	IBT				**cons levels for fixed charge**			7	<=50	50	0.27	0.032
		1.40	0.16		0–25				>50–100	100	0.36	0.041
		3.40	0.39		26–50				>50–100	100	0.50	0.058
		3.82	0.44		51–105				>100–200	200	0.55	0.064
		10.24	1.19		105–300				>200–300	300	0.57	0.066
		13.65	1.58		301+				>300–400	400	0.59	0.068
									>400		0.69	0.080
Ghana	IBT	5,000	0.54					3	<=300	300	700	0.076
									>300–700	700	1,200	0.131
									>700		1,400	0.153
Kenya 2000	IBT	75	1.04					4	<=50	50	1.6	0.021
									>50=300	300	6.7	0.092
									>300–3,000	3,000	7.0	0.097
									>3,000–7,000	7,000	13.8	0.191
Kenya adjusted	IBT	n.a.	1.74					4	<=50	50	n.a.	0.049
									>50=300	300	n.a.	0.212
									>300–3,000	3,000	n.a.	0.223
									>3,000–7,000	7,000	n.a.	0.440
Kenya 2008		120.00	1.74						<=50	50	2	0.029
									>50=1,500	1500	8.1	0.117
									>1,500		18.57	0.269
Lesotho	FR	no	no					1			0.49	0.072
Madagascar	FR	5,962	2.98					1			152	0.076
Malawi billing	IBT	124.71	0.92					3	<=30	30	2.7	0.020
									>30–750	750	3.9	0.029
									>750		5.6	0.041
prepayment	FR	no	no					1			4.2	0.031
Malawi 2009 billing	IBT	124.71	1.05						<=30	30	2.7	0.023
									>30–750	750	3.9	0.033

Country	Tariff type	Fixed charge/month, LCU	Fixed charge/month, $	Demand level, kVa	Demand level, kWh	Demand charge, kWh/kVa/month	Demand charge, monthly, $	Number of blocks	Block range, kWh	Block border, kWh	Price per block, LCU/kWh	Price per block, $/kWh
									>750		5.6	0.047
prepayment	FR	no	no								4.2481	0.04
Mali	IBT	no	no					4	<=200	200	119	0.27
									>200		139	0.31
Mozambique												
billling	IBT	70,799	2.79					4	>=100	100	1,010	0.040
									100–200	200	2,198	0.087
									>200–500	500	2,929	0.115
									>500		3,077	0.121
prepayment	FR	no	no					1			2,802.0	0.110
Namibia	FR	no	no					1			0.79	0.117
Niger	FR	250	0.43					1			79.25	0.136
Nigeria* **	IBT	20	0.15	<5	1,084.1			5	<20	20	1.2	0.009
		30	0.23	>5–15	3,252.2				>20–60	60	4	0.030
		120	0.91	>15–45	9,756.5				>60–180	180	6	0.046
		5,000	38.09	>45–500	108,405				>180–2,000	2,000	8.5	0.065
		31,250	238.06	>500–20,000					>2,000–80,000	80,000	8.5	0.065
Rwanda	FR	no	no					1			81.25	0.146
Senegal												
UDS, special domestic customers (poor)		no	no					3	>20		95.48	0.183
									20–44		106.55	0.204
									>44		62	0.119
UDG, general domestic customers	VDT	no	no					3	>20	20	120	0.230
									20–44	44	87	0.17
									>44		62	0.119
Senegal 2008	IBT	no	no						<150	150	106	0.238
									151–250	250	114	0.255
									>250		117	0.262
South Africa	IBT	no	no					2	<=50	50	—	—
									>50		0.49	0.072
Tanzania******	IBT											
low usage								2		50	40	0.032
											128	0.102
general usage	FR	1,892.00	1.51		>=275					>=275	106	0.085
Tanzania 2008	IBT											
low usage								2		50	49	0.041
											156	0.130
general usage	FR	2,303.00	1.93		>=275					>=275	129	0.108
Uganda	IBT	2,000	1.09					2	<=15	15	62	0.034
									>15		426	0.233
Zambia	IBT	5,845	1.31					3	>=300	300	70	0.016
									<300–700	700	100	0.022
									>700		163	0.037
Zimbabwe	IBT							3	<50	50	29,289.15	0.01
									51–500	500	389,020.02	0.08
									>500		661,469.58	0.13

Source: Africa Infrastructure Country Diagnostic Power Tariff Database.

Note: kVa = kilowatt-ampere, LCU = **[[?]]**, kWh = kilowatt-hour, IBT = increasing block tariff, FR = **[[?]]**, UDG= **[[?]]**, UDS= **[[?]]**, VDT= **[[?]]**.

* Cameroon: Each price applies to all consumed within the corresponding consumption range, as in tariff 1 = unit price if cons<50; tariff 2 = unit price if 50<cons<200; tariff 3 = unit price if cons>200; second tariff is dry-season tariff, dry season is from January to June.

*** Ethiopia: Consumption levels for fixed charge: 0–25, 26–50, 51–105, 105–300, 301+ kWh.

**** Nigeria: Consumption levels for fixed charge: <5, >5–15, >15–45, >45–500, >500–20,000 kVa.

***** Tanzania: General usage fixed charge is applicable if consumption reaches or exceeds 275 kWh/month and is not charged below it.

** Congo, Dem. Rep. of: According to a Project Appraisal Document of 2007, average residential tariff in 2005 was 1.2 cents/kWh; collected revenue was 0.4 cents. Tariff was increased early 2007 by 50 percent to 1.7 cents/kWh.

n.a. Not applicable.

— Not available.

Annex 3. Commercial tariff schedules

Country	Type of tariff	Threshold of power for demand charge (kVa)	Threshold of power that can be received (kWh)	Fixed charge/ month, LCU	Fixed charge/ month, $	Demand charge per KVa/month, LCU	Demand charge per KVa/month, $	Demand charge per kWh, $	Number of blocks	Block range	Price per block, LCU/kWh	Price per block, $/kWh
Benin	FR								1		88.00	0.15
Botswana	FR			30	4.36				1		0.46	0.07
Burkina Faso	TOU			1,169	2.24	2,882	5.51	0.023	2	(10 am–2 pm and 4 pm–7 pm)	165.00	0.32
										(12 am–10 am/2 pm–4 pm/7 pm–12 am)	88.00	0.17
Cameroon*	DBT					2,000	3.44	0.013	2	180 kWh/kVa of subscribed load	63/68	0.11
										>1,801 kWh/kVa of subscribed load	55/60	0.10
Cape Verde	FR								1		19.20	0.22
Chad	IBT					8,055	15.27	0.056	3	<=30	84.00	0.16
										???30–60	186.00	0.35
										???>60	211.00	0.40
Congo, Dem. Rep. of	DBT								5	200		0.111
										500		0.11
										1,000		0.109
										1,500		0.108
										>1,500		0.107
Congo, Rep. of	FR			3,972	8.87				1		43.56	0.10
Côte d'Ivoire	DBT			1,882	3.60				2	<=180 * kVa bimonthly	97.09	0.19
										>180 * kVa bimonthly	83.25	0.16
Ethiopia	TOU			122	14.12				3	equivalent flat rate	0.58	0.067
										peak hour	0.74	0.086
										off-peak hour	0.54	0.063
Ghana	IBT			25,000	2.72				3	300	1,020.00	0.11
										600	1,250.00	0.14
										>600	1,450.00	0.16
Kenya	FR			150	2.08				1	>7,000	6.70	0.09
Kenya adjusted				n.a.	3.47				1		n.a.	0.21
Lesotho	FR					133	19.64	0.081	1		0.08	0.012
Madagascar	FR			101,271	50.56	13,370	6.67	0.027	1		338.44	0.169
Malawi	FR			1,509	11.10	961	7.07	0.026	1		4.09	0.03
Malawi 2009				1,509								
Mali											104.00	0.23
Mozambique	FR			207,308	8.16	105,973	4.17	0.017	1		1,378.00	0.05
Namibia	FR			75	11.08	80	11.81	0.044	1		0.57	0.08
Niger	FR			1,500	2.58	1,000	1.72	0.007	1		70.71	0.12

Country	Type of tariff	Threshold of power for demand charge (kVa)	Threshold of power that can be received (kWh)	Fixed charge/ month, LCU	Fixed charge/ month, $	Demand charge per KVa/month, LCU	Demand charge per KVa/month, $	Demand charge per kWh, $	Number of blocks	Block range	Price per block, LCU/kWh	Price per block, $/kWh
Nigeria	IBT	5–15	3,252	90	0.69				4		6.50	0.05
		15–45	9,756	120	0.91						8.50	0.06
		55–500	108,405	240	1.83						8.50	0.06
		500–2,000	80,000			250	1.90	0.007			8.50	0.06
Rwanda	FR								1		95.88	0.17
Senegal	TOU			4,023	8.98				2	regular hours	88.84	0.20
										peak hour	142.15	0.32
South Africa	IBT	<=25	5,420	227	33.58				3		0.27	0.04
		25–50	10,841	276	40.80						0.27	0.04
		50–100	21,681	430	63.53						0.27	0.04
	FR	<=25	5,420	no					1		0.64	0.09
Tanzania	FR			6,615	5.28	7,245	5.79	0.021	1		66.00	0.05
Uganda	TOU			2,000	1.09				1		398.80	0.22
Zambia	FR	15		29,227	6.55				1		163.00	0.04

Source: Africa Infrastructure Country Diagnostic Power Tariff Database.

Note: TOU = time-of-use tariff; DBT = decreasing block tariff.
*Cameroon: fixed charge is 2,500 per kilowatt if subscribed load is up to 200 hours and 4,200 per kilowatt if it is above 200 hours; second tariff is dry-season tariff, dry season is from January to June.
n.a. Not applicable

Annex 4. Industrial tariff schedules

Country	Type of tariff	Threshold of power demanded (kVA)	Threshold of power demanded (V)	Fixed charge/ month, LCU	Fixed charge/ month, $	Demand charge per KVA/month, LCU	Demand charge per KVA/month, USD	Demand charge for 10 kVA/mo, $/mo	Demand charge for 100 kVA/mo, $/mo	Number of Blocks	Block range	Price per block, LCU/kWh	Price per block, $/kWh
Benin	FR									1		62.00	0.107
Botswana				30	4.36	59	8.61	86.11	861	1		0.21	0.03
Burkina Faso	TOU			1,050	2.01	5,962	11.40	114.02	1,140	2	(10am–2pm & 4pm–7pm)	118.00	0.226
											(12am–10am/2pm–4pm/7pm–12am)	54.00	0.103
Cameroon	TOU	>200 hours		108	0.19	2,778	4.78	47.79	478	2	(11pm-6pm)	40/61.25	0.087
											(6pm-11pm)	40/50	0.085
Cape Verde	FR									1		15.60	0.177
Chad	TOU					8,055	15	152.71	1,527	3	regular hours	108.00	0.205
											night hours		
											peak hours	200.00	0.379
Congo (DRC)	DBT									5	200		0.152
											500		0.150
											1,000		0.149
											1,500		0.148
											>1500		0.146
Congo, Rep.	FR			1,260	2.81	15	0.03	0.35	3	1		50.16	0.11
Côte d'Ivoire	TOU			3,303	6.32					3	(7:30am–7:30pm, 11pm–12am)	55.71	0.107
											(7:30pm–11pm)	75.95	0.144
											(11pm–7:30am)	46.09	0.088
Ethiopia	TOU			116	13.39					3	equiv. flat rate	0.41	0.047
											peak hour	0.51	0.059
											off-peak hour	0.39	0.046
Ghana	FR			125,000	13.62	90,000	9.81	98.10	981	1		500.00	0.054
Kenya	DBT		240-415	600	8.32	300	4.16	41.61	416	3		5.16	0.072
			11,000-33,000	2,000	27.74	200	2.77					4.60	0.064
			66,000-132,000	7,500	104.02	100	1.39					4.40	0.061
Kenya adjusted				nap	13.90	nap	6.95	69.49	463	3		nap	0.164
				nap	46.32	nap	4.63					nap	0.147
				nap	173.72	nap	2.32					nap	0.140
Lesotho	FR					147	21.76	217.58	2,176	1		0.07	0.011
Madagascar	FR			1,137,264	567.77		—	—	—	1		199.00	0.099
Malawi	FR			1,455	10.70	899	6.61	66.06	661	1		3.28	0.024
Mali	TOU			1,471	3.28					1		75.75	0.169
Mozambique	FR			973,079	38.31	131,794	5.19	51.89	519	1		1,144.00	0.045
Namibia (Nampower)	FR			324	47.85	75	11.04	110.36	1,104	1		0.84	0.124

Country	Type of tariff	Threshold of power demanded (kVA)	Threshold of power demanded (V)	Fixed charge/ month, LCU	Fixed charge/ month, $	Demand charge per KVA/month, LCU	Demand charge per KVA/month, USD	Demand charge for 10 kVA/mo, $/mo	Demand charge for 100 kVA/mo, $/mo	Number of Blocks	Block range	Price per block, LCU/kWh	Price per block, $/kWh
Niger	FR			15,000	25.81	2,778	4.78	47.79	478	1		51.22	0.088
Nigeria	IBT	5-15		90	0.69				175	5		6.50	0.050
		15-45		120	0.91							8.50	0.065
		55-500		240	1.83	230	1.75					8.50	0.065
		500-2000				250	1.90					8.50	0.065
		>2000				270	2.06					8.50	0.065
Rwanda	FR									1		95.88	0.172
Senegal	TOU			9,855	22.01					2		58.01	0.130
												83.54	0.187
South Africa	TOU	<=100		159	23.48	6.74	1.00	9.95	100	2	June-August	0.18	0.026
		100-500		547	80.72	6.74	1.00				Sept-May	0.12	0.018
		500-1000		3,131	462.30	6.74	1.00						
		>1000		3,131	462.30	6.74	1.00						
Tanzania	FR			7,012	5.60	7,123	5.69	56.90	569	1		61.00	0.049
Uganda	TOU			20,000	10.92	5000	2.73	27.30	273	1		369.70	0.167
Zambia	DBT	16-300		78,002	17.48	6,943	1.56	15.56	291	4	1,200	100.00	0.022
		300-2000		136,003	30.47	12,990	2.91				8,000	85.00	0.019
		2000-7500		272,006	60.94	19,587	4.39				30,000	63.00	0.014
		>7500		544,012	121.88	19,696	4.41					52.00	0.012

Source: Africa Infrastructure Country Diagnostic Power Tariff Database.
n.a. Not applicable.
— Not available.

Annex 5. Representative schedule used in calculations

	Residential	Commercial	Industrial	Social	Public lighting
Benin	Electricite basse tension, Domestique (BT1) (client categorie: menages lumieres et climatisation)	Professionnel (BT2) (client categorie: commercial)	Electricite moyenne tension, Tarif 2 (client categorie: moyenne industries, force motrice brasseries)	The first 20 kWh within tarif domestique are called "tranche sociale")	Electricite basse tension, Eclaraige publique (BT3) (client categorie: municipalites)
Botswana	TOU 4 domestic	TOU 6 small business	TOU 8 large business	n.a.	—
Burkina Faso	Basse tension, monophase 2 fils, categorie: Usage domestique particuliers et administration, tarif type B (monophase)	Basse tension, double tarif, categorie: Tarifs horaires particuliers et administration, tarif type D1 (nonindustrial)	Moyenne tension, categorie: Tarifs horaires particuliers et administration, tarif type E2 (industrial)	No tariff named “social.” Used the following tariff as social: Basse tension, monophase 2 fils, categorie: Usage domestique particuliers et administration, tarif type A (monophase)	Tariff type F: Eclairage public
Cameroon	LV Domestic subscribers	LV Business subscribers	MV tariffs	No tariff titled "social." Used first tranche residential as social.	No such tariff in the schedule
Cape Verde	BT: low voltage	BT Especial: low voltage special	MT: medium voltage	No tariff titled "social." Used first tranche residential as social.	Iluminaçao Publica: public lighting
Chad	Basse tension, Usage domestique (I.1.a).	Basse tension, Gros clients (I.1.b).	Moyenne tension, Tarif preferentiel (I.2.b).	No tariff titled "social." Used first tranche residential as social.	Basse tension, Eclairage public.
Congo, Dem. Rep. of	Clients avec compteur, clients basse tension, residentialle 1 and residentielle 2	Clients avec compteur, clients basse tension, commerciale	Clients avec compteur, clients basse tension, force motrice	Tariff titled "social": Clients avec compteur, clients basse tension, sociale.	—
Congo, Rep. of	Tarifs en basse tension, T1, Mono, puisance souscrite (kW): 1,2.	Tarifs en basse tension, T7-1, Tri-phase, puisance souscrite (kW): 12.	Tarifs en moyenne tension et haute tension, T13, 32.9<puisance souscrite (kW)<150.	n.a.	—
Côte d'Ivoire	Basse tension, tarif modere domestique	Basse tension, tarif general professionnel	Moyenne et haute tensions, tarif general	No tariff titled "social." Used first tranche residential as social.	Tarif eclairage public
Ethiopia	Residential category, single phase	Nonresidential category: LV industry three-phase	Nonresidential category: HV industry @ 15 KV three-phase	No tariff titled "social." Used first tranche residential as social.	Nonresidential category: three phase street lighting
Ghana	Third schedule, tariff category: residential	Third schedule, tariff category: nonresidential	Third schedule, tariff category: SLT-MV (special load tariff - medium voltage)	No tariff titled "social." Used first tranche residential as social.	—
Kenya 2000	Tariff A0 Domestic	Tariff A1 Small commercial and industrial	Tariff B1, B2, or B3 (same schedule) Medium commercial and industrial.	No tariff titled "social." Used first tranche residential as social.	Tariff E Street lighting
Lesotho	Prepayment customers, domestic tariff	Maximum demand customers, commercial LV tariff	Maximum demand customers, industrial MV tariff	—	—

	Residential	Commercial	Industrial	Social	Public lighting
Madagascar	Basse tension, BT generale (average of zones 1 to 3)	Moyenne tension, MT horaire (average of zones 1 to 3)	HAute tension, HT horaire (average of zones 1 to 3)	Basse tension, BT economique (average of zones 1 to 3)	—
Malawi	Scale 1, Metering type: billing, domestic tariff	Scale 3, Metering type: Standard (billing), standard maximum demand tariff—low voltage customers	Scale 4, Metering type: Standard (billing), standard maximum demand tariff—medium voltage customers		
Mali	Tarification nationale basse tension, Tarif normal (compteurs 2 fils> 5 amperes et compteurs 4 fils)	Tarification nationale moyenne tension, Tarif monome (puissance souscrite<25 kW)	Tarification nationale moyenne tension, Tarif binome horaire	Tarification nationale basse tension, Tarif social (compteurs 2 fils 5 amperes)	Tarification nationale basse tension, Tarif eclairage public
Mozambique	Domestic, customers with conventional meters	LV large customers	MV customers	Used "tarifa sociale," which coincides with the first tranche of the domestic tariff.	—
Namibia	Nored, prepaid	Nored, business single phase	Nored, business three phase	n.a.	Nored, streetlights
Niger	Basse tension, Unique: Electricite usage domestique, K33.1 to K33.5	Basse tension, Unique: K32	Moyenne tension, Longue utilisation: average of K22 and K23	—	Basse tension, Unique: K34
Nigeria	Residential category, single phase	Commercial	Industrial	No tariff titled "social." Used tariff titled "pensioners" instead.	Street lighting
South Africa	Homelight (for low-usage residential customers in urban areas), Homelight 1, prepaid (first 50 kWh free)	Business rate (for small businesses in urban areas, up to 100 kVa), Business rate 1	Miniflex (TOU for urban customers from 25 kVa to 5 MVa	No tariff titled "social." Used first tranche residential (free of charge) as social.	Public lighting
Senegal	Tarif UP2	Tarif moyenne tension, Tarif General (TG)	Tarif moyenne tension, Tarif Longue Utilization (TLU)	n.a.	Eclairage Public BT
Tanzania	Domestic low-usage tariff (D1) (for up to 50 kWh) and general-usage tariff (T1) (for above 50 kWh)	Low-voltage maximum-demand tariff (T2)	High-voltage maximum-demand tariff (T3)	Domestic low-usage tariff	—
Uganda	Code 10.2/10.3: Low voltage supply for small general services (domestic)	Code 10.2/10.3: Low voltage supply for small general services (commercial)	Code 20: Low voltage supply for medium scale industries	No tariff titled "social." Used first tranche residential as social.	Code 50: Street lighting
Zambia	Metered residential tariffs (capacity 15 kVa)	Commercial tariffs (capacity 15 kVa)	Maximum demand tariffs, MD2—capacity 301 to 2000 kVa	No tariff titled "social." Used first tranche residential as social.	Street lighting

Source: Africa Infrastructure Country Diagnostic Power Tariff Database.

Note: LV = low voltage, MV = medium voltage, BT = basse tension o baixa tensao, MT = moyen tension, KVa= kilovolt, HV = high voltage, MVa = megavolt**.**
n.a. Not applicable.
— Not available.

Annex 6. Methodological notes and inputs for historic cost calculation

Calculating the historical capital costs of generation

Step 1. Calculations are based on *generation unit overnight investment costs per kilowatt*. For oil-, coal-, and gas-based production, internationally accepted unit overnight investment costs ($/kW)[9] are assumed. For hydroproduction, country-specific unit costs calculated as weighted averages[10] of unit costs for hydropower projects in each country are applied.[11]

Step 2. *Unit costs are discounted* using the annualization factor assuming a 10 percent discount rate and a standard expected lifetime of the power plant, which differs depending on the type of generation.[12]

Step 3. *Unit generation investment cost per kilowatt for each country* is calculated considering the country-specific generation mix (percentage of each type of generation in total) and discounted unit costs produced at step 2.

Step 4. Capital costs of generation per kilowatt-hour are calculated by multiplying country-specific discounted unit costs (step 3) by the country's generation capacity and dividing by the country's power generation.

Calculation of historical capital costs of transmission and distribution

Step 1. A proxy used for total lifetime investment is the *overnight transmission and distribution (T&D) investment calculated under the assumption of constant 2005 access to power.*[13,14]

Step 2. Since the scenario of constant 2005 access was run for the "trade expansion" option only, an *adjustment is made to exclude the cost of the new cross-border transmission lines*. This was done using the annualized cross-border investment as a share of the total.

Step 3. Since constant 2005 access rates in the investment needs model is applied to the population in 2015, we adjusted the denominator (generation 2005) using—as a proxy for the generation increase—growth in the number of households between 2005 and 2015. Then we applied the annualization factor to come out with the present value of required annual future T&D investment per kilowatt-hour.

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[9] Source of the unit costs: AICD, BP5 (Investment Needs Paper); original sources: International Energy Agency, Energy Information Administration (United States), Royal Academy of Engineering (United Kingdom).
[10] Weighted by plant capacity.
[11] Source of unit costs for hydropower projects: AICD, BP5 (Investment Needs Paper).
[12] For hydroplants, the assumed lifetime is 50 years; for coal plants, 25 years; and for oil and gas plants, 30 years.
[13] With population growth, the number of people with access to power is increasing under this scenario, although the percentage of population with access is constant.
[14] Source: AICD, BP5 (Investment Needs Paper).

Annex 7. Inputs for calculating historical costs

	Unit costs ($/MW)		Economic lifetime (years)
	Discount rate	10%	
Generation			
Hydro	Country specific		50
Coal	1,100		25
Gas	670		30
Oil	810		30
Transmission	Country specific		40
Distribution			40

Sources: Rosnes and Vennemo, 2008

Note: MW = megawatt.

Country	Installed capacity, MW	Generation, GWh/year	T&D overnight excluding cross-border, discounted, $ million	T&D investment unit cost, cents/kWh	Generation investment unit Cost, $/kW				Generation investment unit cost, cents/kWh	Capex, cents/kWh	Opex, cents/kWh	Total cost per unit, cents/KWh
					Oil	Gas	Coal	Hydro				
Angola	830	3,722	126	4	810	670	1,100	1,966	5	9		
Benin *	60	124	23	3	810	670	1,100	4,671	5	8	12	**20**
Botswana	132	631	15	1	810	670	1,100	1,496	1	2	12	**14**
Burkina Faso	236	516	15	2	810	670	1,100	4,767	8	11	4	**15**
Burundi	37	92	6	3	810	670	1,100	3,476	11	14		
Cameroon	875	4,004	53	1	810	670	1,100	1,428	3	4	13	**17**
Cape Verde *	80	250	1	1	810	670	1,100	3,356	3	4	14	**18**
Central African Republic	40	115	1	1	810	670	1,100	1,500	4	5		
Chad	29	117	2	2	810	670	1,100	1,568	3	4	9	**14**
Congo, Dem. Rep. of	2,443	7,193	46	1	810	670	1,100	644	2	3	4	**7**
Congo, Rep. of	121	400	10	2	810	670	1,100	1,775	5	7	13	**20**
Côte d'Ivoire	1,084	5,524	61	2	810	670	1,100	2,283	3	4	7	**11**
Equatorial Guinea	13	28	1	2	810	670	1,100	2,292	6	7		
Ethiopia	814	2,589	111	4	810	670	1,100	1,016	3	6	2	**8**
Gabon	415	1,774	6	0	810	670	1,100	3,356	5	6		
Gambia	30	160	5	3	810	670	1,100	3,356	2	4		
Ghana	1,490	6,750	103	2	810	670	1,100	2,098	3	5	8	**12**
Guinea	274	850	14	1	810	670	1,100	1,547	4	6		
Guinea-Bissau	21	65	1	1	810	670	1,100	4,100	3	4		
Kenya	1,312	5,347	96	2	810	670	1,100	2,889	4	6	8	**14**
Lesotho	76	410	5	1	810	670	1,100	1,938	3	4	6	**11**
Liberia	188	350	4	1	810	670	1,100	4,158	5	6		
Madagascar	227	973	20	2	810	670	1,100	1,496	3	4	11	**15**
Malawi	285	1,368	10	1	810	670	1,100	1,488	3	3	6	**9**
Mali	280	515	29	5	810	670	1,100	3,225	12	17	16	**34**
Mauritius	688	2,321	13	1	810	670	1,100	1,496	2	3		
Mozambique*	2,383	15,914	25	0	810	670	1,100	1,432	3	3	6	**9**
Namibia	264	1,580	57	2	810	670	1,100	1,778	2	4	7	**11**
Niger	145	202	7	1	810	670	1,100	3,356	8	9	23	**32**
Nigeria	5,898	24,079	1,132	5	810	670	1,100	1,222	2	7	2	**10**
Rwanda	39	116	13	4	810	670	1,100	1,930	5	10	7	**17**
Senegal	509	2,105	231	2	810	670	1,100	3,356	3	6	19	**25**
Sierra Leone	50	80	15	2	810	670	1,100	3,089	8	11		
South Africa	41,904	228,071	981	0	810	670	1,100	1,496	2	3	3	**6**
Sudan	961	4,341	92	3	810	670	1,100	2,509	3	6		
Tanzania	919	1,880	44	2	810	670	1,100	1,957	4	6	8	**14**
Togo	85	230	8	1	810	670	1,100	2,387	10	11		
Uganda	303	1,893	35	2	810	670	1,100	2,377	4	5	5	**10**
Zambia	1,700	8,850	43	0	810	670	1,100	1,336	2	3	4	**7**
Zimbabwe	2,099	8,890	61	0	810	670	1,100	1,386	3	3		

Sources: Rosnes and Vennemo, 2008 *Note*: GWh = gigawatt-hour

Annex 8. Historic unit cost of power

cents/kWh

Country	T&D capital cost	Generation capital cost	Total capital cost	Operating cost	Total cost
Angola	4.4	4.8	9.2		
Benin*	3.1	5.1	8.2	11.6	19.8
Botswana	0.6	1.4	2.0	11.9	13.9
Burkina Faso	2.3	8.4	10.7	4.4	15.1
Burundi	3.2	11.1	14.3		
Cameroon	1.3	3.1	4.4	12.7	17.1
Cape Verde*	0.5	3.1	3.6	14.3	17.9
Central African Republic	1.0	4.3	5.3		
Chad	1.6	2.7	4.2	9.4	13.7
Congo, Dem. Rep. of	0.7	2.2	2.9	3.9	6.8
Congo, Rep. of	1.8	4.9	6.7	13.4	20.1
Côte d'Ivoire	1.6	2.8	4.4	6.6	10.9
Equatorial Guinea	1.7	5.7	7.4		
Ethiopia	3.5	2.9	6.4	2.1	8.5
Gabon	0.4	5.4	5.7		
Gambia	2.5	1.7	4.2		
Ghana	1.5	3.3	4.8	7.5	12.4
Guinea	1.5	4.3	5.8		
Guinea-Bissau	1.0	3.0	4.0		
Kenya	1.5	4.3	5.8	8.4	14.2
Lesotho	1.2	3.2	4.5	6.4	10.8
Liberia	0.9	5.1	6.0		
Madagascar	1.7	2.8	4.5	10.5	15.0
Malawi	0.6	2.6	3.2	5.9	9.1
Mali	5.1	12.2	17.3	16.3	33.6
Mauritius	0.6	2.0	2.6		
Mozambique*	0.2	2.5	2.8	6.3	9.0
Namibia	1.7	2.4	4.0	7.3	11.3
Niger	1.1	7.7	8.8	23.4	32.1
Nigeria	5.3	2.2	7.5	2.2	9.7
Rwanda	4.4	5.5	9.8	6.8	16.6
Senegal	2.2	3.4	5.6	19.4	25.0
Sierra Leone	2.2	8.5	10.7		
South Africa	0.5	2.1	2.6	3.4	6.0
Sudan	2.6	2.9	5.5		
Tanzania	1.8	4.3	6.1	8.0	14.1
Togo	1.0	9.7	10.7		
Uganda	1.6	3.5	5.1	5.3	10.4
Zambia	0.4	2.5	2.9	3.6	6.5
Zimbabwe	0.5	2.9	3.4		

Sources: Rosnes and Vennemo, 2008

Annex 9. Value and volume of sales to residential customers as percentage of total

	Share of residential sales (LCU) in total	Share of residential supply (GWh) in total
Benin		48.7
Burkina Faso	63	63.1
Cameroon	60	32.8
Cape Verde	56.2	49.7
Chad	67	63.5
Congo, Dem. Rep. of	47.3	
Congo, Rep. of	52.9	
Côte d'Ivoire	46.9	34.5
Ethiopia	26.6	44.3
Ghana	64.8	42.8
Kenya	37.4	35.7
Lesotho	100	35.2
Madagascar		60
Malawi		36
Mali	64.9	
Mozambique	42.8	47.4
Niger	58.7	99.9
Nigeria	39.1	51
Rwanda	5.5	
Senegal	62.7	58.6
South Africa	17.2	7.5
Tanzania	47.6	43.6
Uganda		33.2
Zimbabwe	30.5	

Source: Africa Infrastructure Country Diagnostic Power Tariff Database.

Annex 10. A calculation of long-run marginal costs

The long-run marginal cost (LRMC) of power was calculated using the investment needs model developed under the umbrella of the Africa Infrastructure Country Diagnostic (Rossines and Vennemo 2008). The model is based on estimates of future increase in demand and cost of corresponding supply. It minimizes the total annualized cost of system expansion and operation. This includes the operation and maintenance (O&M) cost of producing and distributing electricity according to expanded demand, as well as the capital cost of refurbishing old capacity and constructing new capacity, including generation plants, cross-border transmission, and distribution and connection.

The model is run under two trade scenarios (trade expansion, under which all economically viable cross-border transmission capacity is developed, and trade stagnation, under which no further cross-border transmission capacity is built) and three future access-rate assumptions (current access level, 35 percent access, and national access targets).

As model outcomes, two sets of country-level LRMCs are produced: (i) LRMC under trade expansion, national access targets and (ii) LRMC under trade stagnation, national access targets.

Some details of demand and cost of meeting demand estimations:

Projecting power demand over 2005–15. Demand consists of (i) market demand associated with different levels of economic growth, structural change, and population growth; (ii) suppressed demand created by blackouts and practice of power rationing; and (iii) social demand, as expressed in political targets for increasing popular access to electricity. Based on historic trends, demand is projected to grow at 5 percent per year in Sub-Saharan Africa to reach levels of 680 terawatt-hours (TWh), including: at 4–5 percent per year in SAPP and EAPP, at 7 percent per year in CAPP, 9 percent per year in the island states, and 12 percent per year in WAPP.

Cost of supply needed to meet the projected demand comprises cost of refurbishment, new construction, and O&M. The analysis covers thermal generation—natural gas, coal, heavy fuel oil, and diesel—and renewable generation technologies—large hydropower, mini-hydro, solar photovoltaic, and geothermal. Operation of current nuclear power is considered, but not as new investment.

- *Cost of refurbishment* of existing capacity is estimated based on refurbishment needs of each country in megawatts (plant-specific data) and unit cost of refurbishment for thermo and hydro generation. For hydro generation, unit costs are based on estimated costs of actual planned hydropower projects in each region. Thermal power plant technology is generic and the unit costs are therefore the same across countries. The refurbishment requirements for T&D are based on asset age.

- *Cost of construction* of new capacity for cross-border electricity transmission is estimated. As in case of refurbishment, unit cost of construction is standard for thermal plants and country specific for hydro plants. Cost of T&D construction equals line length times unit cost. Unit costs of lines to be built—per km and per megawatt—are country specific. For lines between countries, average unit costs of two countries are used.

- *O&M* includes fuel costs and variable costs of operation and maintenance of the system. The system includes both existing capacity as of 2005 that is still operating in 2015 and new capacity added over the 10-year period. Since the marginal costs of social demand (new connections) are driven by nonmarket considerations, they tend not to equalize with trade. Therefore, they are not considered in the LRMC calculation.

Annex 11. Effects on long-run marginal costs of trade expansion

		LRMC decrease (%)	Reduction in LRMC (cents)	Net exports, trade expansion, TWh	Thermal capacity as % of total	Installed capacity, MW
Countries with LRMC reductions	Angola	45	5	(6.0)	41	843
	Guinea-Bissau	44	7	(0.2)	100	65
	Liberia	43	6	(1.7)	100	350
	Chad	36	4	(1.3)	100	29
	Mozambique	33	2	5.9	9	2,383
	Burundi	27	4	(0.7)	3	92
	Congo	25	2	(4.4)	24	400
	Equatorial Guinea	20	2	(0.1)	77	28
	Niger	17	5	(1.5)	100	105
	Lesotho	14	1	(0.7)	0	76
	South Africa	14	1	(36.4)	91	40,481
	Zimbabwe	11	1	(3.5)	64	8,890
	Mali	11	3	(1.9)	45	515
	Sierra Leone	10	1	(0.9)	92	80
	Togo	9	1	(0.9)	21	230
	Senegal	9	4	(1.4)	100	300
	Namibia	8	1	(3.8)	6	393
	Kenya	8	1	(2.8)	39	1,211
	Burkina Faso	4	1	(1.0)	87	180
Countries with no change on LRMC	Benin	0	0	(0.9)	98	60
	Botswana	0	0	(4.3)	100	132
	Central African Republic	0	0	—	53	115
	Congo, Dem. Rep. of	0	0	51.9	1	2,443
	Côte d'Ivoire	0	0	0.9	44	1,084
	Gabon	0	0	(1.0)	59	1,774
	Ghana	0	0	(9.6)	26	1,622
	Malawi	0	0	(1.5)	8	285
	Nigeria	0	0	2.1	67	5,898
	Rwanda	0	0		10	31
	Sudan	0	0	13.1	68	4,341
	Zambia	0	0	(1.8)	0	1,778
Countries with LRMC increases	Uganda	–9	–1	2.8	26	321
	Gambia	–14	–1	0.1	100	160
	Cameroon	–17	–1	6.7	8	902
	Guinea	–17	–1	17.4	54	850
	Ethiopia	–19	–3	26.2	17	755
	Tanzania	–25	–2	2.4	39	881

Sources: Adapted from Rosnes and Vennemo, 2008 and AICD Power Tariffs Database

Annex 12. Average monthly electricity tab based on subsistence consumption

	Monthly electricity tab ($)			Monthly electricity tab as a percentage of household budget (%): connected households			Monthly electricity tab as a percentage of household budget (%): unconnected households		
	Consumption 50 kWh/month	Consumption 75 kWh/month	Consumption 100 kWh/month	Consumption 50 kWh/month	Consumption 75 kWh/month	Consumption 100 kWh/month	Consumption 50 kWh/month	Consumption 75 kWh/month	Consumption 100 kWh/month
Benin	12.6	13.3	13.6	5.0	8.0	10.9	9.4	14.9	20.3
Burkina Faso	20.6	20.2	20.0	4.4	6.5	8.5	13.4	19.8	26.2
Cameroon	8.6	10.9	10.9	3.1	5.8	7.8	6.0	11.4	15.2
Cape Verde	23.6	25.1	25.8						
Chad	22.9	27.3	30.0	1.6	2.9	4.3	4.0	7.2	10.6
Congo, Dem. Rep. of	4.0	4.0	4.0						
Côte d'Ivoire	9.6	11.1	11.9	1.5	2.7	3.8	3.3	5.7	8.1
Ethiopia	3.9	4.1	4.1	2.2	3.5	4.6	3.8	5.9	7.9
Ghana	8.7	8.4	8.2	2.1	3.0	3.9	3.3	4.8	6.2
Kenya	8.4	12.7	14.8	1.7	3.9	6.1	3.6	8.1	12.6
Lesotho	7.2	7.2	7.2						
Madagascar	6.0	4.0	3.0	0.5	0.5	0.5	1.5	1.5	1.5
Malawi	4.8	4.3	4.0	1.9	2.6	3.2	3.7	4.9	6.2
Mozambique	9.6	7.7	6.8	3.2	3.9	4.5	8.7	10.5	12.3
Namibia	11.7	11.7	11.7						
Niger	14.5	14.2	14.1	3.3	4.8	6.4	7.1	10.4	13.7
Nigeria	2.5	3.8	3.4	1.2	2.7	3.3	2.1	4.9	5.8
Rwanda	14.6	14.6	14.6	3.0	4.5	6.0	7.7	11.6	15.5
Senegal	18.6	16.4	15.2	3.1	4.0	5.0	5.9	7.8	9.7
South Africa	—	2.4	3.6	—	0.3	0.6	—	1.4	2.7
Sudan									
Tanzania	3.2	5.5	6.7	1.6	4.2	6.7	2.9	7.5	12.1
Uganda	19.5	20.7	21.4	4.1	6.5	8.9	10.7	17.0	23.4
Zambia	4.2	3.3	2.9	1.2	1.4	1.6	2.8	3.4	3.9

Source: AICD Power Tariffs Database

— Not available.

Annex 13. Social tariff schedules

	Type of tariff	Fixed charge (LCU)/month	Fixed charge ($)/month	Block border	Price per block, LCU/kWh	Price per block, $/kWh
Benin	social tranche	n.a.	n.a.		56	0.10
Burkina Faso	1 to 3 A, tranche 1	94	0.18		75	0.14
Cameroon*	tranche 1 residential	7,500	12.90		50	0.09
Cape Verde	tranche 1 residential	—	—		20	0.23
Chad	tranche 1 residential	n.a.	n.a.		83	0.16
Congo, Dem. Rep. of	social tariff	2.65	0.01		n.a.	0.04
Côte d'Ivoire	tranche 1 residential	333	0.64		36	0.07
Ethiopia	tranche 1 residential	1.4	0.16		0.27	0.03
Ghana	tranche 1 residential	5,000	0.54		700	0.08
Kenya	tranche 1 residential	—	1.74		n.a.	0.05
Lesotho	—	—	—		—	—
Madagascar	economic tariff	600	0.30	25	120	0.06
					553	0.28
Malawi	tranche 1 residential	125	0.92		2.67	0.02
Mozambique	tranche 1 residential	n.a.	n.a.		1,010	0.04
Namibia	n.a.	n.a.	n.a.		n.a.	n.a.
Niger	—	—	—		—	—
Nigeria	"pensioners"	30	0.23		4	0.03
Rwanda	—	—	—		—	—
Senegal	tranche 1 residential	n.a.	n.a.	150	106	0.24
South Africa	tranche 1 residential	n.a.	n.a.		0	0
Sudan	—	—	—		—	—
Tanzania	n.a.	n.a.	n.a.		38	0.03
Uganda	tranche 1 residential	2000	1.09		62	0.03
Zambia	tranche 1 residential	5,845	1.31		70	0.02
Congo, Rep. of	n.a.	n.a.	n.a.		n.a.	n.a.
Mali	social tariff	n.a.	n.a.	50	59	0.13
				100	91	0.20
				200	107	0.24
				>200	124	0.28
Botswana	n.a.	n.a.	n.a.		n.a.	n.a.
Zimbabwe	tranche 1 residential	n.a.	n.a.		29,289	0.01

Source: AICD Power Tariffs Database

n.a. Not applicable.

— Not available.
* Cameroon: fixed residential charge is 2,500 per kW if subscribed load is up to 200 hours and 4,200 per kW if it is above 200 hours.

Annex 14. Operational inefficiencies

	% of revenues				% of GDP			
	Transmission and distribution losses	Underpricing	Undercollection of bills	Overmanning	Transmission and distribution losses	Underpricing	Undercollection of bills	Overmanning
Benin	12.8	39.1	0.5	13.8	0.2	0.7	0.0	0.2
Botswana	0.7	138.7	61.1		0.0	1.8	0.8	—
Burkina Faso	12.5	0.0	14.7	9.5	0.2	0.0	0.3	0.2
Cameroon	36.3	57.9	0.0	8.3	0.8	1.2	0.0	0.2
Cape Verde	8.1	0.0	29.6	20.8	0.2	0.0	0.9	0.6
Chad	11.0	0.0	9.1	23.6	0.0	0.0	0.0	0.1
Congo, Rep. of	63.1	30.9	21.0	30.9	0.6	0.3	0.2	0.3
Côte d'Ivoire	—	0.0	417.1	24.2	—	0.0	4.4	0.3
Congo, Dem. Rep. of	163.6	201.6	0.0	—	1.3	1.6	0.0	—
Ethiopia	18.6	33.5	6.3	—	0.2	0.3	0.1	—
Ghana	26.5	52.4	2.1	—	0.7	1.5	0.1	—
Kenya	9.1	0.0	34.6	5.1	0.3	0.0	1.1	0.2
Lesotho	16.9	32.5	19.5	—	0.3	0.6	0.3	—
Madagascar	5.0	2.3	0.0	—	0.3	0.2	0.0	—
Malawi	40.5	105.3	75.1	—	0.5	1.3	0.9	—
Mali	23.4	36.8	39.1	6.4	0.6	1.0	1.0	0.2
Mozambique	19.9	15.0	4.6	17.7	0.3	0.2	0.1	0.3
Namibia	51.6	0.0	—	—	0.1	0.0	—	—
Niger	39.1	116.5	0.0	12.5	0.6	1.8	0.0	0.2
Nigeria	76.8	195.1	50.3	—	0.4	1.0	0.3	—
Rwanda	10.8	9.3	0.0	6.8	0.2	0.1	0.0	0.1
Senegal	9.6	0.0	10.8	5.4	0.3	0.0	0.3	0.2
South Africa	0.0	5.9	0.0	—	0.0	1.0	0.0	—
Tanzania	33.5	90.9	0.0	6.1	0.5	1.3	0.0	0.1
Uganda	34.6	0.0	39.4	5.2	0.6	0.0	0.7	0.1
Zambia	2.9	72.9	2.3	—	0.0	1.2	0.0	—

Source: Briceño-Garmendia, Smits, and Foster, 2008
— Not available.

About AICD and its country reports

This study is a product of the Africa Infrastructure Country Diagnostic (AICD), a project designed to expand the world's knowledge of physical infrastructure in Africa. AICD provides a baseline against which future improvements in infrastructure services can be measured, making it possible to monitor the results achieved from donor support. It also offers a solid empirical foundation for prioritizing investments and designing policy reforms in Africa's infrastructure sectors.

the AICD is based on an unprecedented effort to collect detailed economic and technical data on African infrastructure. The project has produced a series of original reports on public expenditure, spending needs, and sector performance in each of the main infrastructure sectors, including energy, information and communication technologies, irrigation, transport, and water and sanitation. *Africa's Infrastructure—A Time for Transformation*, published by the World Bank and the Agence Française de Développement in November 2009, synthesized the most significant findings of those reports.

The focus of the AICD country reports is on benchmarking sector performance and quantifying the main financing and efficiency gaps at the country level. These reports are particularly relevant to national policy makers and development partners working on specific countries.

The AICD was commissioned by the Infrastructure Consortium for Africa following the 2005 G8 (Group of Eight) summit at Gleneagles, Scotland, which flagged the importance of scaling up donor finance for infrastructure in support of Africa's development.

The AICD's first phase focused on 24 countries that together account for 85 percent of the gross domestic product, population, and infrastructure aid flows of Sub-Saharan Africa. The countries are: Benin, Burkina Faso, Cape Verde, Cameroon, Chad, Côte d'Ivoire, the Democratic Republic of Congo, Ethiopia, Ghana, Kenya, Lesotho, Madagascar, Malawi, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, South Africa, Sudan, Tanzania, Uganda, and Zambia. Under a second phase of the project, coverage was expanded to include as many of the remaining African countries as possible.

Consistent with the genesis of the project, the main focus is on the 48 countries south of the Sahara that face the most severe infrastructure challenges. Some components of the study also cover North African countries so as to provide a broader point of reference. Unless otherwise stated, therefore, the term "Africa" is used throughout this report as a shorthand for "Sub-Saharan Africa."

The World Bank has implemented the AICD with the guidance of a steering committee that represents the African Union, the New Partnership for Africa's Development (NEPAD), Africa's regional economic communities, the African Development Bank (AfDB), the Development Bank of Southern Africa (DBSA), and major infrastructure donors.

Financing for the AICD is provided by a multidonor trust fund to which the main contributors are the United Kingdom's Department for International Development (DFID), the Public Private Infrastructure Advisory Facility (PPIAF), Agence Française de Développement (AFD), the European Commission, and Germany's Entwicklungsbank (KfW). A group of distinguished peer reviewers from policy-making and academic circles in Africa and beyond reviewed all of the major outputs of the study to ensure the technical quality of the work. The Sub-Saharan Africa Transport Policy Program and the Water and Sanitation Program provided technical support on data collection and analysis pertaining to their respective sectors.

The data underlying the AICD's reports, as well as the reports themselves, are available to the public through an interactive Web site, www.infrastructureafrica.org, that allows users to download customized data reports and perform various simulations. Many AICD outputs will appear in the World Bank's Policy Research Working Papers series.

Inquiries concerning the availability of data sets should be directed to the volume editors at the World Bank in Washington, DC.