Making Power Affordable for Africa and Viable for Its Utilities

WORLD BANK GROUP

Africa Renewable Energy and Access Program (AFREA)

ESMAP
Energy Sector Management Assistance Program

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Masami Kojima and Chris Trimble

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Preface

This report summarizes the findings and recommendations of a study program exploring the financial viability, affordability, and political economy of the electricity sector in Sub-Saharan Africa. It pulls together the findings from three background papers—"Political Economy of Power Sector Subsidies: A Review with Reference to Sub-Saharan Africa," "Financial Viability of Electricity Sectors in Sub-Saharan Africa: Quasi-Fiscal Deficits and Hidden Costs," and "Who Uses Electricity in Sub-Saharan Africa? Findings from Household Surveys"—as well as information drawn from the databases developed in the study program. It complements other analytical work in the Africa Region of the World Bank that is forthcoming or has been recently published, including "Improving the Performance of Sub-Sahara African Electricity Utilities: Lessons Learned," "Independent Power Projects in Sub-Saharan Africa: Lessons from Five Key Countries," "Double Dividend: Power and Agriculture Nexus in Sub-Saharan Africa," and "The Climate Is Right: Scaling Off-Grid Solar Solutions in Sub-Saharan Africa," along with other study programs exploring issues of access in Africa and the governance of state-owned enterprises.

This study program focuses largely on grid electricity and does not cover off-grid rural electrification. Cost calculations are based on current utility assets and do not take into account the cost of system expansion, nor potential cost savings from a least-cost development plan, which would include optimization of cross-border trade and domestic generation mix.

The study team comprised Ines Perez Arroyo, Robert Bacon, Rafael Ben, Joeri Frederik de Wit, David Ganske, Jace Jeesun Han, Masami Kojima (co-task team leader), Farah Mohammadzadeh, Chris Trimble (co-task team leader), and Xin Zhou. Jamal Saghir provided overall guidance for the production of this report. The work was carried out under the guidance of Lucio Monari and Meike van Ginneken. The team gratefully acknowledges review comments received through the course of the study from Pedro Antmann, Sudeshna Banerjee, Malcolm Cosgrove-Davies, Vivien Foster, Wendy Hughes, Gabriela Inchauste, Caterina Laderchi, Elvira Morella, Sameer Shukla, David Vilar, Vladislav Vucetic, Ruslan Yemtsov, all of the World Bank Group. Some reviewers also provided input materials and helped validate the analysis. Nita Congress edited and designed the publication.

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Tariff calculations were validated through local counterparts from each country, typically from the regulator, reference utility, or minister of energy. These include Gbêdonougbo Claude Gbaguidi and Solange Ebo (Benin); Pascal Hema (Burkina Faso); Jérémie Sinzinkayo and Donat Niyonzima (Burundi); Rito Évora (Cabo Verde); Pierre-Marie Cussaguet (Cameroon); Mohamed Moussa Tamou, Claude Buisson, and Laurent Frugier (Comoros); Francis Aka (Côte d'Ivoire); Tigabu Atalo (Ethiopia); Sompo Ceesay (The Gambia); Abdoulaye Kone (Guinea); John M. Mutua and Stanley Kagine Mutwiri (Kenya); Monti Ntlopo (Lesotho); Peter Graham (Liberia); Aimée Andrianasolo (Madagascar); Dennis Reo Mwangonde and Wiseman Kabwazi (Malawi); Fousseynou Bah and Sekou Oumar Traore (Mali); Dah Sidi Bouna (Mauritania); Ahmad Iqbal Dreepaul (Mauritius); Erasmo Biosse (Mozambique); Iyaloo Andre (Namibia); Abdoulkarim Saidou (Niger); Alexis Mutware (Rwanda); Alberto Leal, Posik Espirito Santo, Ligilisio Viana, and Homero Boa Esperança (São Tomé and Príncipe); Alioune Fall (Senegal); Laurent Sam and Guilly Moustache (Seychelles); Maite Pina, Mallay Bangura, and Clive Neel (Sierra Leone); Lorraine Leburu and Melusi Ngobeni (South Africa); Sabelo Dube, James Mabundza, and Edrida Kamugisha (Swaziland); Nzinyangwa Mchany and Anastas Mbawala (Tanzania); Geofrey Okoboi and Vianney Mutyaba (Uganda); Rodgers Muyangwa (Zambia); and Peggy Mhlanga and Gwyneth Ngoma (Zimbabwe).

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Executive Summary

Africa[1] lags all other regions of the world in electricity generation capacity, per capita electricity consumption, and household access to electricity. Only one out of every three Africans has access to electricity. Power shortages are widespread, not least because utilities are cash strapped and have allowed their assets to fall into disrepair.

Two important determinants of whether the region's electricity sector will be able to meet demand and expand access are the financial sustainability of utilities and the ability of households to afford tariffs. This study, using recent data from Africa countries, examines the relationship between costs and revenues of utilities in 39 countries, estimates the scope for reducing utility deficits by lessening operational inefficiencies, collects tariff data in another overlapping set of 39 countries to assess affordability, and analyzes electricity spending data from national household expenditure surveys in 22 countries. The study is confined largely to grid electricity; it does not consider off-grid rural electrification, the cost of system expansion, and possible cost savings from system optimization based on a least-cost development plan and expansion in cross-border electricity trade.

Key issues

Of the 39 countries studied, only the Seychelles and Uganda were fully recovering their operational and capital costs. In only 19 countries did the cash collected by utilities cover operational costs; just 4 of these countries were also covering half or more of capital costs, based on new replacement values of current assets. Such large funding gaps prevent power sectors from delivering reliable electricity to existing customers, let alone expand supply to new consumers at an optimal pace.

External shocks such as changes in oil prices, currency, or rainfall can improve or exacerbate prospects for an electricity sector's financial viability. Quasi-fiscal deficits—the difference between the net revenue of an efficient utility and the net cash it collects—averaged 1.5 percent of gross domestic product (GDP)—or 0.9 percent if South Africa is excluded. The quasi-fiscal deficits in six countries would have been lower by more than 1 percent of GDP had the 2015 oil price been used rather than the price in each country's reference year considered for this study. By contrast, greater use of emergency power due to drought would increase costs: a simulation replacing a 30 percent reduction in hydropower generation with (much more

1 Africa in this report means Sub-Saharan Africa and excludes North Africa and Djibouti.

expensive) leased power generation capacity indicates that utility deficits would increase by more than 1 percent of GDP in six countries.

Many households are unable to afford connection fees and tariffs, thus limiting expansion of access to grid electricity. Some households share electricity meters to offset connection fees, which can exceed monthly income many times over. In Ethiopia, where the lowest connection charge represents 130 percent of average monthly household income, there are two and a half times as many grid-connected households as utility customers. Under current tariff structures, subsistence consumption of 30 kilowatt hours a month is affordable to the vast majority of the population in most countries, including those with low rates of access to electricity. But shared meters deprive low-income electricity users of the benefits of lifeline tariffs, because the combined consumption of multiple households places them in higher-priced tariff brackets.

Policy considerations

Improving operational efficiency should be the first area of policy focus in reducing quasi-fiscal deficits. If utilities could reduce combined transmission, distribution, and bill collection losses to 10 percent of dispatched electricity (the level considered in this study for benchmark utility efficiency) and tackle overstaffing, an additional 11 countries could see their utility deficits disappear, bringing the total number of deficit-free countries to 13. International experience suggests that unmetered consumption is disproportionately concentrated in large consumers and others who are able to pay cost-reflective tariffs. By targeting better-off, large-volume customers first, significant loss reduction is possible with little loss of welfare.

Most countries may need to increase tariffs. In two-thirds of the countries studied, the funding gap cannot be bridged simply by eliminating operational inefficiencies; tariffs will have to be increased even after achieving benchmark operational efficiency. The pressure to increase tariffs could be eased somewhat by optimizing the power generation mix and reducing costs further, but doing so could take many years and require substantial investment.

Political economy considerations can inform the design of tariff increases:

- **Raising tariffs while outages continue unabated is bound to invite a backlash.** Utilities need to focus on achieving an acceptable level of service quality to launch a trajectory toward cost recovery in tariff revenues. They could reduce costs by phasing out operational inefficiencies, implementing short-term measures to reduce the duration (if not the frequency) of outages, and addressing customer service quality in general. Information systems are fundamental to attending to customer complaints, accelerating service restoration after outages, regularly measuring system reliability, and providing better commercial service.

- **Small, frequent tariff increases may find wider acceptance than infrequent large increases.** To eliminate fuel subsidies, India and Thailand raised fuel prices by small fixed amounts every month, announced in advance, until cost-recovery levels were reached. Predictability coupled with small and manageable increases can go a long way toward achieving acceptance.

- **A period of low oil prices may be a good time to introduce an automatic fuel price pass-through mechanism.** An automatic price adjustment mechanism, such as that in place in Kenya, can depoliticize one element of tariff adjustments. The best time to introduce such a mechanism is when input prices are low so consumers do not equate the mechanism with large tariff increases.

- **Targeting tariff increases to customers who account for the bulk of consumption and can afford to pay more would limit adverse effects on the poor.** As with commercial losses, it would make sense to focus tariff increases first on large- and medium-size customers, for whom affordability is not as significant a challenge as for small-consumption households. Although the political sensitivity of tariff increases to better-off consumers cannot be ignored, neither should it be overemphasized. In the face of large utility deficits and low access rates, there is no compelling reason to subsidize those who can afford higher tariffs. Indeed, they could be asked to cross-subsidize low-income consumers more, as long as the latter's total consumption is a small fraction of the total electricity sold. Successful examples of power sector reforms in emerging countries in other regions show that middle- and high-income consumers in all tariff categories usually accept cost-reflective rates, provided the quality of electricity services is good.

Prepaid meters can help both utilities and customers. For low-income households with cash flow constraints, the ability to pay in small increments helps align electricity payments with income flows. Households on prepaid plans do not risk disconnection for failure to pay and avoid reconnection fees, which can be considerable in some countries. But prepaid meters should not be made mandatory if grid electricity is unreliable, lest customers pay cash in advance for electricity they cannot get when they need it. For the utility, prepaid meters improve revenue collection.

The additional subsidies needed over and above current lifeline rates to enable the poor to purchase the subsistence level of electricity are modest. If households can be metered individually and accurately, the additional subsidies needed to make the subsistence level of grid electricity affordable to every urban household in the countries studied would be less than $5 million in 19 countries and less than $1 million in 15 countries. Subsidies needed to make electricity affordable to every rural household will be greater; this topic is outside the scope of this study, because rural electrification will play a considerable role.

Sharper targeting of cross-subsidies for the poor can help increase affordability and speed up access expansion. The first priority in increasing access to electricity is to make the initial connection affordable. Consideration may be given to including assets associated with new connections in utilities' regulatory assets and recovering costs from all customers. A small first block with a lifeline rate can be introduced if the utility has not already done so, its size can be optimized, cross-subsidies can be increased, and a moving average rather than monthly consumption can be used as the basis for the lifeline rate.

Abbreviations

AICD	Africa Infrastructure Country Diagnostic
GDP	gross domestic product
kWh	kilowatt hour(s)
SAIDI	system average interruption duration index
SAIFI	system average interruption frequency index

All dollar amounts are U.S. dollars unless otherwise indicated.

Old Problem, New Context

More than 1 billion people globally still lack access to electricity. For many more, their electricity is unreliable, with blackouts forcing them to turn to expensive self-generation, suffer business losses, make do with inferior lighting from kerosene—or spend hours in darkness.

Access in Africa continues to lag rest of the world

Africa[1] lags all other regions of the world in installed generation capacity, per capita electricity consumption, and household access to electricity. The total electricity generation capacity in the region, which has a total population of nearly 1 billion, is less than 100 gigawatts—less than the total generation capacity in Spain with its population of 46 million—and halved if South Africa is excluded. Fifteen of the countries ranked in the bottom 20 worldwide for per capita consumption of electricity are in Africa (IEA 2016; World Bank 2016a). Moreover, according to the 2015 Global Tracking Framework report (World Bank and IEA 2015), the region has 13 of the top 20 countries in the world with the largest numbers of people without electricity. The proportion of Africans living in households with electricity in 2012 was about 35 percent. However, the disparity between urban and rural areas was stark: 69 percent of urban but only 15 percent of rural residents were estimated to have had access to electricity. South Asia, the region with the second lowest rate of access, had more than double Africa's percentage of people living with electricity (79 percent) and nearly five times the share of rural residents with electricity (70 percent).

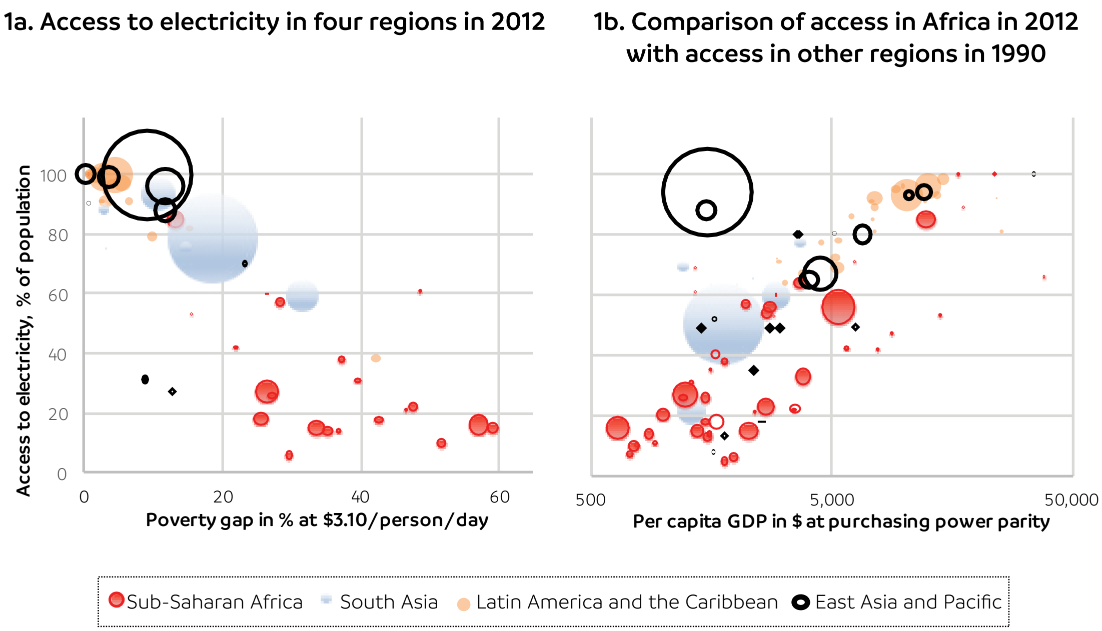
Africa's access lags at the same level of development. Infrastructure development mirrors economic development. Generally, the higher the gross domestic product (GDP) per capita, the better the roads, power system, railways, and telecoms. But when access to electricity is examined at comparable levels on economic and poverty indicators, Africa significantly lags the other regions. Figure 1 illustrates this observation.

Figure 1a plots the rate of access to electricity in four regions in 2012 against the poverty gap.[2] Countries broadly fall along a downward-sloping line, except African countries, many of which lie far below the trend line. As to the poverty gap itself, the situation in many African countries

1 Africa in this report means Sub-Saharan Africa and excludes North Africa and Djibouti.

2 The poverty gap is a measurement of the extent to which individuals fall below the poverty line as a proportion of the poverty line. This illustration uses the poverty line of $3.10 per person per day valued at purchasing power parity in 2011 international dollars.

Figure 1 Comparison of access to electricity in Africa and three other regions



Sources: World Bank staff analysis using data from World Bank 2016 and World Bank and IEA 2015.

Note: Poverty gaps and GDP are calculated at purchasing power parity in 2011 international dollars. The poverty gap data are either for 2012 or as close as possible to 2012, within two years, and are missing for many countries, reducing the sample size in figure 1a. Bubbles are in proportion to population.

in 2012 closely resembled that of the rest of the world in 1990. When the poverty gap and access data from 2012 in Africa are overlaid with those from 1990 in other regions, Africa still falls below the global trend (Kojima et al. 2016). Statistical analysis using these economic parameters shows that, everything else being equal, living in Africa reduces the likelihood of a household having access to electricity.

Figure 1b compares electricity access in Africa in 2012 with that in the other three regions in 1990 as a function of gross domestic product (GDP) per capita. China stands out as a significant (positive) outlier, having achieved an access rate of 94 percent with per capita GDP of $1,500; as does Vietnam, having achieved an 88 percent rate of access with the same per capita GDP. Here again, nearly all countries below the global trend are in Africa.

High costs, low revenues are at the root of the access issue. Serious shortcomings in operational efficiency, high costs of small-scale operation, and overreliance on expensive oil-based electricity generation have increased costs of power supply in Africa, while the inability of many customers to pay for electricity services and underpricing have reduced utility revenues. One consequence of high costs and low revenues is the inability of African utilities to meet demand and deliver reliable electricity—a deficiency exacerbated by years of underspending on maintenance and expansion. Existing customers face frequent power outages, and new connections can barely keep up with population growth. Another consequence is that the access rate in

Africa has been increasing at a mere 5 percentage points every decade—rising from 23 percent in 1990 to 35 percent in 2012. Yet another consequence is that the Doing Business indicator for supply reliability and tariff transparency is, on a scale of 0 to 8, only 0.9 in Africa—by far the lowest in the world and less than half the second lowest, 1.9 in South Asia (World Bank 2016b).

Past data indicate full cost recovery unlikely. These problems were documented in the Africa Infrastructure Country Diagnostic (AICD), a wide-ranging knowledge program that undertook extensive data collection in the 2000s (primarily from 2001 to 2008) in all key infrastructure sectors, including grid electricity. The AICD's analysis of the electricity sector pointed to inadequate generation capacity, stagnant and inequitable access to unreliable electricity services, prevalence of backup generators, increasing use of leased emergency power generation capacity, and concurrently high and inadequate electricity tariffs. External events—drought, oil price shocks, and civil conflict—exacerbated an already precarious situation. The AICD estimated that a total annual investment of $40 billion would be needed in the sector across the region, more than triple the $12 billion a year being spent at the time. Although gross operational inefficiencies in poorly functioning utilities offered scope for cost savings, the funding gap could not be bridged entirely by eliminating the estimated $8 billion a year of inefficiencies (Eberhard et al. 2011). Combined examination of tariff structures in 27 countries and of household survey data found that recovery of historic electricity production costs, tariffs consistent with future electricity production costs, affordability of tariffs to low-income households, and distributional equity of tariff subsidies would be almost impossible to achieve in the context of the high-cost, low-income environment characterizing much of the region in the mid-2000s (Briceño-Garmendia and Shkaratan 2011).

Changed context sharpens the challenge for access

The context for electricity access and utilities' financial performance has changed in important ways since the AICD program was under way.

Global commitment to universal access has strengthened. In 2011, the United Nations launched the Sustainable Energy for All initiative, bringing diverse partners—including 106 governments and the European Union—together to achieve three dimensions of sustainable modern energy by 2030, including universal access to electricity. Africa is likely to be the last region of the world to reach this target, and will benefit from any increase in external assistance to that end. In June 2015, the Sustainable Energy for All initiative proposed a new multitier framework for defining and measuring access to energy in *Beyond Connections: Energy Access Redefined* (World Bank 2015). The underlying premise is that the energy supply supporting access must be adequate in quantity, available when needed, reliable, convenient, affordable, legal, healthy, and safe. Echoing this refined understanding of access, the Sustainable Development Goals adopted by the United Nations in September 2015 specifically call for universal access by 2030 to *reliable* and *affordable* electricity.

Changing oil prices and exchange rates have resulted in a mixed impact on African economies. The oil price movement during the data collection period of the AICD, 2001–08, saw a quadrupling of the prices of both diesel fuel—which Africa increasingly relies on to meet emergency electricity needs—and fuel oil. By contrast, between 2008 and the first half of 2016, the prices for these fuels fell by three-fifths.

Some currencies in Africa appreciated against the U.S. dollar between 2001 and 2008, but no currency appreciated between 2008 and the first half of 2016. The median for the currency movements was a slight appreciation (4 percent) in 2001–08, and a 43 percent depreciation in 2008–16.

Not surprisingly, the combined effect of the oil price and exchange rate movements has been mixed. While there was a universal increase in petroleum product prices in local currency between 2001 and 2008, there has not been a subsequent universal decline. Taking diesel fuel as an example, the price increase in local currency during the first period ranged from 155 percent to nearly 1,400 percent with a median of 300 percent (slightly lower than the increase in U.S. dollars of 320 percent). The median price decrease between 2008 and 2016 is 44 percent, but the price of imported diesel has risen rather than fallen in local currency in Ghana, Malawi, Sudan, and Zambia because of substantial currency depreciation outstripping the fall in the price of oil.[3]

Sharp drop in commodity prices has had significant repercussions for Africa. The prices of commodities crucial to the earnings of many African economies rose between 2001 and 2008, but have fallen sharply since. The oil price collapse that began in 2014 is the largest 20-month drop over the last half century. Unlike previous episodes, the current price decline involves not only oil and gas but also metals, minerals, and agricultural commodities. These price movements on the world market have significantly affected not only the fiscal balance in Africa (2 percentage points lower than otherwise), but the current account (4 percentage points lower), the terms of trade (decline of about 16 percent), and economic activity (0.5 percent lower) (World Bank 2016c).

Fresh look at access issues, focusing on full cost recovery and tariff affordability

Some African governments have attempted to expand access to electricity by subsidizing its use, the cost of connection to grid electricity supply, or both. However, in the face of a falling fiscal balance, there is little room for large-scale government support. This restriction underscores the need to improve utility performance, adjust tariffs to achieve cost recovery, and design subsidy support in a way that maximizes the benefits to the neediest.

The present study draws on more recent data than was available to the AICD to reexamine issues in the African electricity sector. The study looks at the literature on power sector subsidies and their reform with an emphasis on the political economy of such reform, asks about the degree of cost recovery with and without operational inefficiencies, assesses residential tariff

3 Currency changes in Somalia, South Sudan, and Zimbabwe are not available for these two periods.

structures, estimates the affordability to households of the subsistence level of electricity consumption, and computes how much additional assistance might be needed to enable the poor to use electricity. The study's coverage is largely confined to grid electricity, and does not capture the cost of system expansion or potential cost savings from system optimization based on a least-cost development plan and expansion in cross-border electricity trade.

The next section covers issues related to the electricity sector's financial viability; following that is a discussion of affordability issues from the consumer point of view based on household survey data. A brief discussion of reliability is included, because unreliable electricity harms rather than contributes to economic development, and access is increasingly defined as access to reliable electricity. The report's final section summarizes the main findings and policy recommendations emerging from the study. Two appendixes present the sources, methodology, and assumptions underlying the study. For full details, see Trimble et al. (2016); Kojima et al. (2016); Kojima, Bacon, and Trimble (2014); and companion Excel files (www.worldbank.org/affordableviablepowerforafrica).

Sector Financial Viability

Simply put, a utility that does not cover its costs will struggle to deliver reliable electricity in sufficient quantity. To determine the financial viability of Africa's electric utilities, this section explores these questions:

- How much of the total cost of electricity supply does cash collected by the utilities cover?
- How much can revenue shortfalls be reduced if operational efficiencies are increased? What are the priority areas in individual countries for reducing operational inefficiencies?
- How do fluctuations in rainfall and fuel prices affect electric utilities' financial viability?

Broadly, there are two approaches to interpreting cost recovery and financial viability: cash needs and full cost recovery (Kojima, Bacon, and Trimble 2014).

- The cash needs approach concerns the short-term financial viability of a utility and covers all projected cash payments to be made by the utility: the costs of operation and maintenance, power purchases, debt obligations, taxes, insurance, and cash payments for minor capital expenditures. It does not capture input subsidies, subsidized interests (such as concessional financing), and other types of subsidies to cover expenses utilities are not expected to pay.
- The full cost recovery approach covers all cash needs as well as all capital costs—with depreciation and the rate of return on invested capital forming the basis for calculating capital costs—and decommissioning costs where applicable. If all costs are fully recovered from payments by consumers, the utility is financially sustainable over the long run. However, input and other types of subsidies covering unbilled expenditures may not be captured.

The main difference between the two approaches is that full cost recovery includes coverage of future investment projects for significant replacement or upgrading of existing capacity as well as capacity expansion. Essentially, then, the cash needs approach incorporates only known present cash considerations, while full cost recovery includes provisions for future capital costs and adequate returns on investment.

The question of which costs should be recovered through revenue collection influences tariff setting. International experience suggests that the degree of cost recovery from consumer payments depends largely on the level of development of the electricity sector. The electricity sector in Africa is far from mature. The medium- to long-term target is to reach tariff levels that fully cover all reasonably and prudently incurred costs. If, revenues fall far short, the first priority is to meet all cash obligations. The cash needs approach reduces the short-term impact of capital expenditure on tariffs, requiring the utility to seek concessional financing (grants, low-interest loans, long grace periods, partial risk guarantees) for major capital expenditures. The reality is that available concessional financing to meet future demand for electricity is far from sufficient. The hope is that future economic growth will increase consumers' ability to pay and eventually enable full cost recovery.

This study makes use of both approaches but, due to data limitations, with some modification. In using the first approach, this study excludes debt obligations from cash needs and refers to total cash requirements as operating expenditures. In the second approach, capital expenditures are confined to new replacement values of current assets, amortized over the economic life of each asset; capacity expansion is excluded (appendix A). The remainder of this report concerns recovery of operational and capital expenditures as understood in this modified sense.

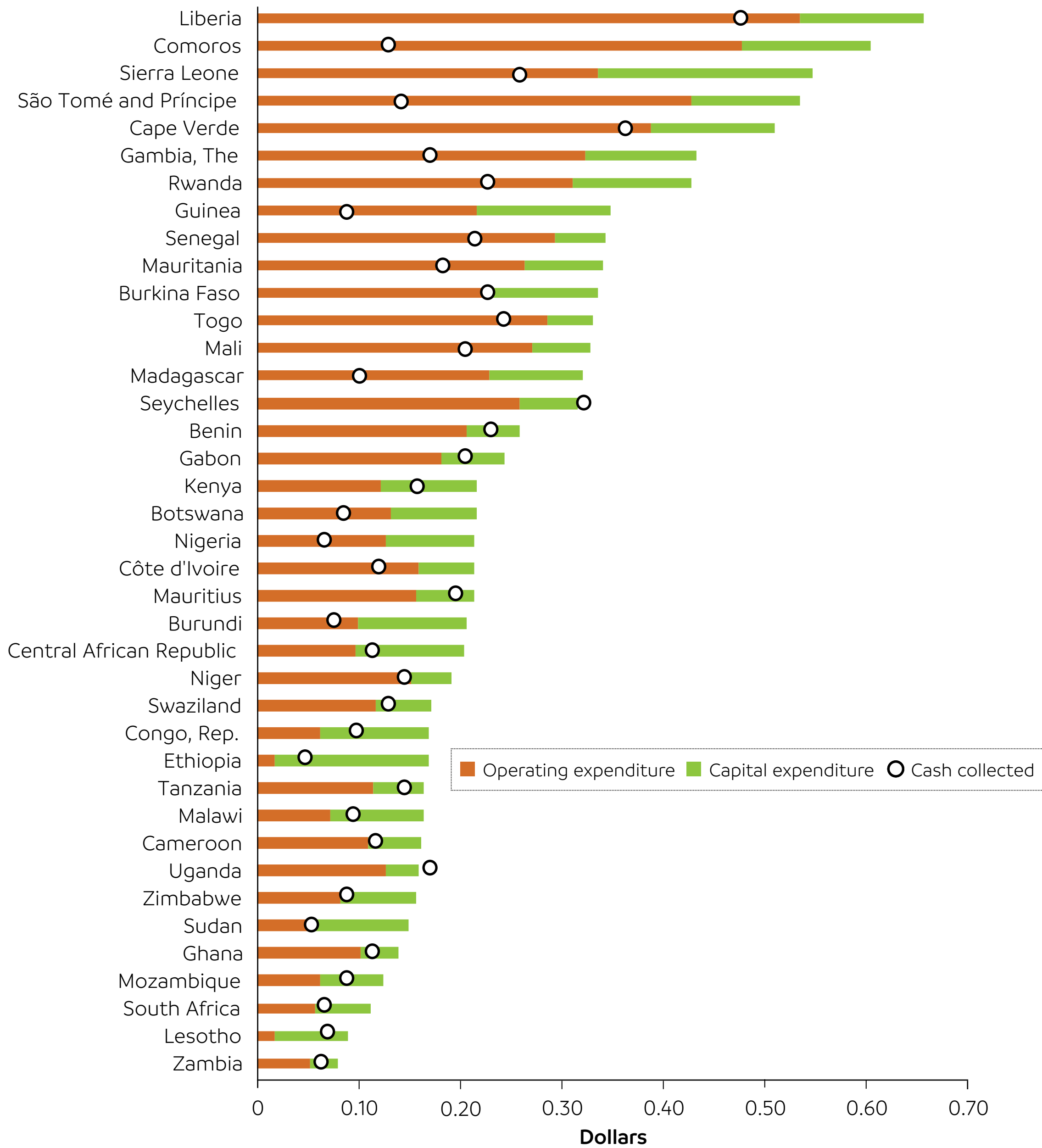
Using utility financial data available in 39 African countries, the following examines in detail the extent of cost recovery and the scope for increasing cost recovery by improving operational performance, and runs several "what-if" scenarios. The most recent year for which data were available ranged from 2010 in Lesotho to the first half of 2015 in Kenya and Zambia, with most data from 2013 and 2014 (table A.1 in appendix A). Data sources and methodology are discussed in appendix A. Because the focus of this section is the financial viability of utilities, taxes rebated to them are here excluded from tariffs, utility revenues, and cash collected.

Current cost recovery

To what extent are costs covered by cash collection? Figure 2 compares the cash collected from bills sent out with the total costs of supply—broken down into operational and capital expenditures—per kilowatt hour (kWh) billed. The findings show that only the Seychelles and Uganda fully covered both operational and capital expenditures. Cash collected in 19 countries covered operational expenditures, leaving 20 with insufficient cash to cover these. Among the top 10 countries with highest unit costs, all but Guinea and Sierra Leone are highly dependent on oil-based generation, which is expensive. Logarithms of unit cost and unit cash collected are statistically significantly correlated, with a correlation coefficient of 0.91, suggesting that utilities with high unit costs tend to have high tariffs and collect a higher share of revenue billed. A study for the AICD by Briceño-Garmendia and Shkaratan (2011) using a smaller set of countries similarly found that no country was covering its total costs of supply.

What is the difference between collections and revenue? The quasi-fiscal deficit is the difference between the net revenue of an efficient electricity sector covering operational and capital costs and the net cash collected by the utilities. The results of this computation are shown in table 1. South Africa had the largest quasi-fiscal deficit in absolute terms, $11 billion. As a proportion of GDP, São Tomé and Príncipe had the highest deficit at 6.1 percent, followed by The Gambia at 5.8 percent and Zimbabwe at 5.2 percent. As a proportion of cash collected, Ethiopia had the largest deficit (408 percent), followed by Comoros (397 percent) and Guinea

Figure 2 Comparison of electric supply costs with cash collected in 2014 U.S. dollars per kWh billed



Source: Trimble et al. 2016.

(354 percent). At the opposite end of the spectrum, the Seychelles and Uganda had no deficit. The quasi-fiscal deficit as a percentage of cash collected is positively correlated with capital cost per kWh billed using a 1 percent significance test (which ensures that the probability of mistakenly concluding that there is a statistically significant non-zero correlation—when there actually is not—is 1 percent or smaller); this suggests that the higher the capital cost, the higher the deficit relative to cash collected.

Table 1 Quasi-fiscal deficits of utilities under current performance in country reference years

Country	$, millions	% of GDP	% of cash collected	Country	$, millions	% of GDP	% of cash collected
Benin	26	0.3	13	Mali	155	1.3	63
Botswana	487	3.4	176	Mauritania	78	1.5	90
Burkina Faso	125	1.0	49	Mauritius	51	0.4	12
Burundi	29	1.0	208	Mozambique	157	0.9	49
Cabo Verde	28	1.6	39	Niger	39	0.5	36
Cameroon	214	0.7	43	Nigeria	2,928	0.5	264
Central African Republic	7	0.4	87	Rwanda	78	1.0	86
Comoros	23	4.1	397	São Tomé and Príncipe	21	6.1	293
Congo, Rep.	76	0.6	96	Senegal	325	2.2	59
Côte d'Ivoire	654	1.9	89	Seychelles	−4	−0.3	−4
Ethiopia	636	1.7	408	Sierra Leone	33	0.9	123
Gabon	66	0.4	19	South Africa	11,329	3.4	92
Gambia, The	52	5.8	158	Sudan	1,024	1.4	233
Ghana	205	0.5	23	Swaziland	52	1.2	40
Guinea	129	2.1	354	Tanzania	193	0.3	19
Kenya	486	0.8	41	Togo	70	1.6	36
Lesotho	11	0.5	24	Uganda	−19	−0.1	−5
Liberia	7	0.4	36	Zambia	317	1.2	49
Madagascar	229	2.2	243	Zimbabwe	643	5.2	94
Malawi	111	2.5	88	Median	78	1.0	63

Source: Trimble et al. 2016.

Note: Quasi-fiscal deficits are in current U.S. dollars in the reference year.

Data available from 16 countries enabled estimation of how quasi-fiscal deficits were distributed among different customer classes using simplifying assumptions. Each consumer category's share of the quasi-fiscal deficits broadly tracks kWh of electricity consumed, except for households and industry. Households consumed 38 percent of the total volume of electricity billed but accounted for 42 percent of the deficits, whereas industry consumed 33 percent of electricity billed but accounted for 26 percent of the deficits; this suggests marginal cross-subsidization of households by industry.

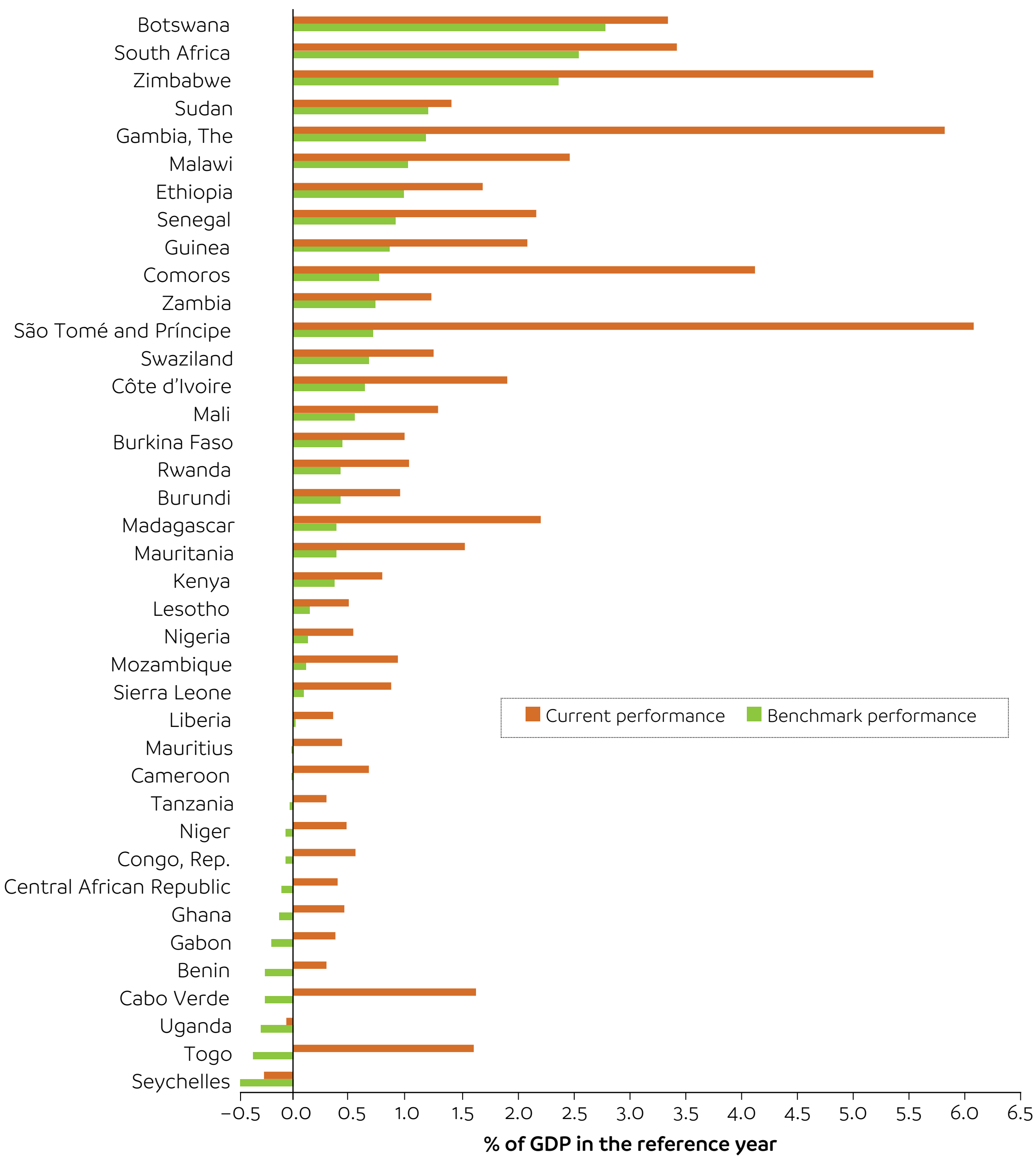
Cost recovery at benchmark performance

To understand what benefits can be achieved through improvements in operational performance, quasi-fiscal deficits were also estimated at efficient operation. Efficient operation—also referred to as benchmark performance—is defined here as follows:

- Transmission and distribution losses (both technical and commercial) of 10 percent of dispatched electricity or lower
- 100 percent bill collection
- The same staffing level as in well-performing, comparable utilities in Latin America

Conversely, inefficient utilities are said to suffer from transmission and distribution losses, bill collection losses, and overstaffing. The deficit at benchmark performance is identical to the magnitude of underpricing in the absence of generation mix optimization and other cost-reduction measures such as greater imports of cheaper electricity (appendix A). Figure 3 shows how much quasi-fiscal deficits can be reduced by achieving benchmark performance.

Figure 3 Comparison of quasi-fiscal deficits of utilities at current and benchmark performance in country reference years



Source: Trimble et al. 2016.

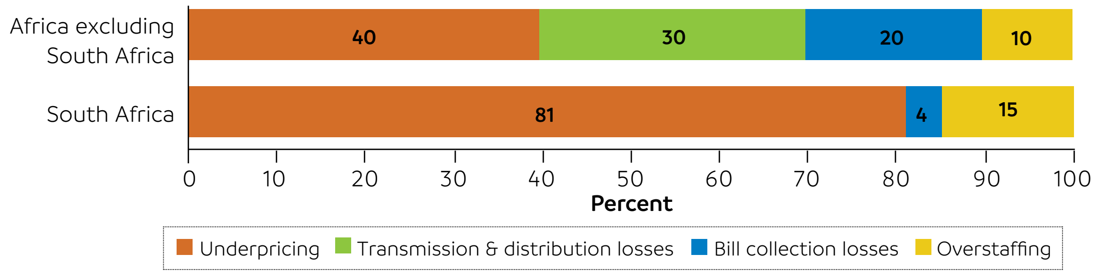
The results are shown as percentages of GDP in the reference year. An additional 11 countries, besides the Seychelles and Uganda, eliminate quasi-fiscal deficits altogether, bringing the total number of countries at full cost recovery to 13. It does not, however, automatically follow that these countries can lower tariffs upon achieving benchmark performance, because losses and overstaffing cannot be eliminated at no additional cost.

What drives each country's quasi-fiscal deficit? Large differences in the quasi-fiscal deficit are found between current and benchmark performance. To understand the drivers of the quasi-fiscal deficit in each country, the deficit is decomposed into four components or hidden costs. Three are losses arising from operational inefficiencies: transmission and distribution losses, bill collection losses, and overstaffing. The fourth component is underpricing (appendix A). The existence of underpricing does not necessarily call for tariff increases over the long run, as there can be other reasons that lead to costs being too high. Absent execution of long-term, sectorwide optimization and a least-cost development plan, the generation mix may be suboptimal, relying too heavily on expensive domestic generation sources. Optimizing the generation mix combined with cross-border trade would require capital expenditure and could take many years before new plants and associated transmission and distribution infrastructure are commissioned. Calculation of cost savings from implementing a least-cost development plan is beyond the scope of this study.

Across the region, underpricing (which is identical to the quasi-fiscal deficit at benchmark performance in figure 3) was the largest component of quasi-fiscal deficits in 19 countries. Outside of South Africa, transmission and distribution losses ranked second, followed by bill collection losses (figure 4).

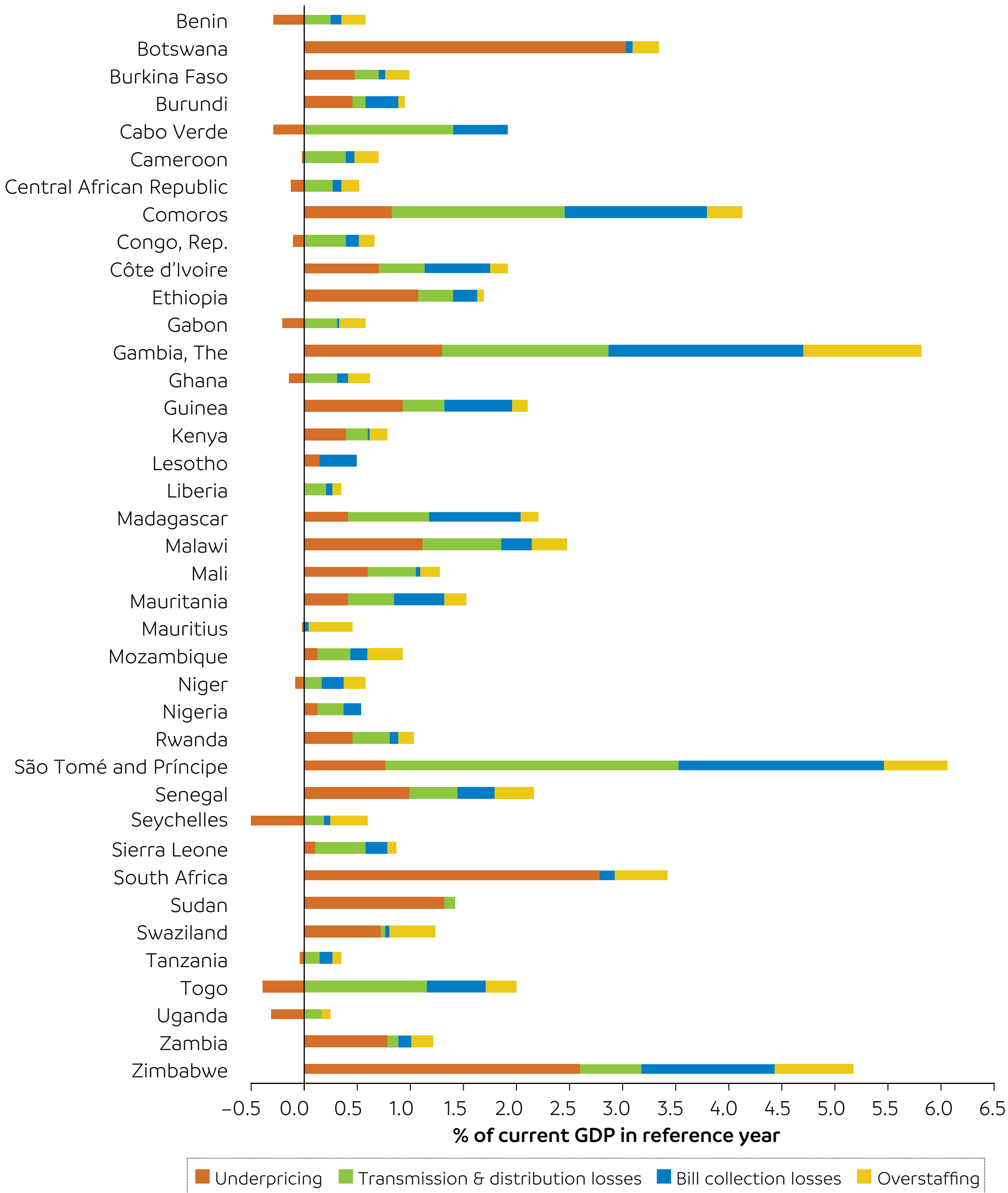
Figure 5 shows the results of decomposition analysis by country. The three components other than underpricing are largely under utilities' control. Of these, transmission and distribution losses in excess of 10 percent accounted for the largest share in 14 countries. While 4 countries had losses lower than 10 percent, losses were larger than 20 percent in 24 countries, larger than 30 percent in 8 countries, and exceeded 40 percent in 4 countries. The highest losses were 48 percent in the Central African Republic. Perhaps not surprisingly, utilities that had high transmission and distribution losses tended to have high bill collection losses, suggesting that poor management tends to lead to high losses across the supply chain. Of the 39 countries, 13 had

Figure 4 Breakdown of hidden costs in Africa



Source: Trimble et al. 2016.

Figure 5 **Decomposition of quasi-fiscal deficits in Africa for the reference year**



Source: Trimble et al. 2016.

Note: Lesotho, Nigeria, and Sudan lacked data for staff-level analysis.

bill collection rates in excess of 95 percent and 10 had collection rates lower than 80 percent; Comoros, with a 58 percent bill collection rate, ranked lowest.

Is there a trade-off between quasi-fiscal deficits and access? Would countries with ambitious electrification programs run large deficits? Do poorer countries tend to have high deficits because they lack funds, or do they tend to have low deficits because they cannot afford high quasi-fiscal deficits in the first place? To probe these questions, six measures of quasi-fiscal deficits—deficits at current and benchmark performance as percentages of GDP, revenue, and cash collected—were examined with respect to their relationships to GDP per capita, access rates, and the poverty gap.[1] None of the latter variables was statistically correlated with any measure of quasi-fiscal deficits using a 5 percent significance test. There is thus little indication of a trade-off between quasi-fiscal deficits and access, or a relationship between the level of economic development or the depth of poverty and deficits.

Impact of oil price and drought

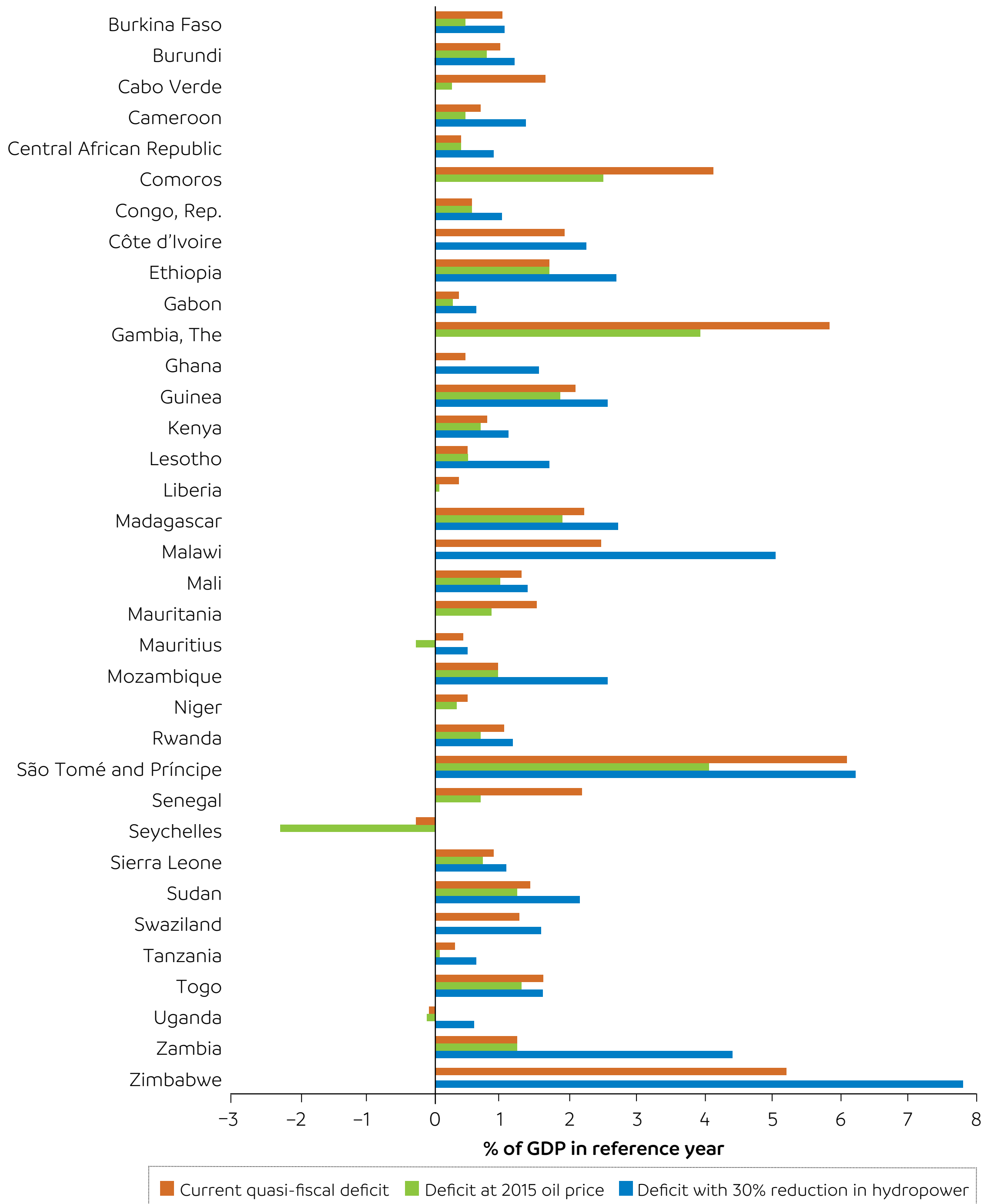
Recent trends in oil prices and rainfall have the potential to improve or further harm utilities' financial viability. The study looked at the potential effects of these phenomena on quasi-fiscal deficits. The effect of oil price on quasi-fiscal deficits depends on the price of oil in the reference year and how much electricity generation is sourced from oil. What would have been the magnitude of savings possible if the collapse of the world oil price since the end of 2014 had occurred in the reference year of analysis? As to rainfall, not every country has hydropower in its power mix. The effect of drought is a function of the share of electricity generated from hydropower, and how the loss will be replaced. For simplicity, this study assumes that the electricity loss from drought would be replaced with emergency leased power generation capacity at a cost of $0.20 per kWh. This assumption is similar to conditions in southern Africa in 2015 and 2016, where drought forced Zambia and Zimbabwe to resort to expensive short-term leased electricity generation capacity to make up for loss of hydropower. How much more cash will utilities need if increasing climate variability leads to more drought?

The results in countries where respective effects of drought and the oil price collapse are more than 10 percent of the current quasi-fiscal deficits are shown in figure 6. The average petroleum product prices in 2015 and a 30 percent reduction in hydropower generation were selected for this illustration and applied to each country's reference year. All utilities were assumed to have been paying for diesel and fuel oil at prices linked to those on the world market. Had any utility been benefiting from fuel price subsidies, the savings accruing to it would be smaller.

The fall in the price of oil eliminates the quasi-fiscal deficit altogether in Mauritius (where the reference year is calendar year 2013), while the deficit is reduced by 84 percent in Cabo Verde (calendar year 2012) and 82 percent in Liberia (July 2013–June 2014). The quasi-fiscal deficit is

1 GDP per capita is evaluated at both the market exchange rate and purchasing power parity. The poverty gap is at $3.10 per person per day. A lack of data reduces the sample from 39 to 18 countries when the poverty gap is considered.

Figure 6 Impact of lowering oil price to the 2015 level and 30 percent reduction in hydropower on quasi-fiscal deficit in country reference years



Source: Trimble et al. 2016.

Note: The bars shown are the quasi-fiscal deficit at current performance, the deficit re-evaluated at the 2015 oil price, and the deficit re-evaluated assuming a 30 percent reduction in hydropower generation, all in each country's reference year. Where both oil and hydropower effects are considered, the impact of oil is evaluated first, and the effect of lower hydropower generation is added on next. The difference in quasi-fiscal deficits as a percentage of GDP between hydropower and oil is the isolated effect of hydropower reduction alone on the deficit. Data on oil-based generation in Madagascar were not available.

more than doubled if 30 percent of hydropower is replaced with leased electricity generation in the Central African Republic, Ghana, Lesotho, Mozambique, Uganda, and Zambia.

Overall trends in quasi-fiscal deficits

Data for three or more years are available in 23 countries. In general, quasi-fiscal deficits follow consistent patterns over time in individual countries (improving, worsening, or remaining steady). Most of the countries with low quasi-fiscal deficits see them decline or stabilize over time; most of those with high quasi-fiscal deficits see them remain steadily high. Tariff increases combined with performance improvement helped reduce quasi-fiscal deficits in the Seychelles, Tanzania, and Uganda. Comparison across countries does not suggest declining quasi-fiscal deficits overall in the region.

In summary, only two countries were covering all costs in the electricity sector in the reference year of the analysis, and many were not even able to cover operational expenditure. Absent improvement in financial performance, the utilities cannot afford to maintain or introduce subsidies to make electricity affordable to the poor unless they significantly restructure subsidies for much sharper targeting, increase cross-subsidization for the poor, increase quasi-fiscal deficits, or implement some combination of these measures. Against the backdrop of rising demand, loss reduction alone is unlikely to eliminate outages in many countries, but a lack of generation capacity calls for investment in new capacity; capital spending would be difficult for utilities running such large deficits. In particular, the high risks associated with the financial activities of these utilities would result in a very high cost of capital. Outages caused by the inability to pay for fuels—as in Ghana and Nigeria for natural gas—would be similarly difficult to resolve as long as cash collected is not sufficient to cover fuel bill payments.

Household Use of Electricity

Household use of electricity in Africa mirrors low consumption of electricity in the economy. Access rates are low for a variety of reasons—households find the initial connection costs, if not monthly bill payments, too expensive; poor reliability makes grid electricity unattractive; and many live in areas where there is no grid electricity. To overcome the challenge of affordability, more subsidies may be needed, raising in turn the question of the affordability of such subsidies to utilities. To quantify these issues, this section addresses the following:

- How is access to electricity affected by income and location of residence?
- How affordable are grid electricity tariffs to households? Are affordability and access strongly correlated? Are there factors that make affordability calculations based on tariff schedules misleading? What does it take to make grid electricity affordable to all households?
- How do the observed spending patterns compare to monthly bills for subsistence consumption of electricity?
- Is there evidence that female-headed households are more or less likely to use electricity than male-headed households?

To answer these questions, this study uses tariff schedules in effect as of July 2014 in 39 countries (33 of which were examined in the quasi-fiscal deficit analysis) and national household expenditure surveys undertaken since 2008 in 22 countries. Data sources and methodology are discussed in appendix B.

Access and affordability

Survey questionnaires vary from country to country, as does the level of detail available from which to draw conclusions about the type of electricity (grid-connected, self-generation, solar panels) used by surveyed households. Rates of access by location, income quintile, and poverty status are shown in table 2, using the most expansive definition of access (level 5; see appendix B). Because income data are lacking, total household expenditure, which is used to calculate official poverty statistics, serves as a proxy for income in this study. The findings about access are consistent with widely accepted observations: the percentage of the population using

Table 2 Percentage of people with access to electricity using the most expansive definition of access

Country	All people					People classified as poor		
	Urban	Rural	Total	Bottom 20%	Top 20%	Urban	Rural	Total
Angola	75	14	47	8	85	40	6	16
Botswana	63	23	46	15	79	42	11	25
Burkina Faso	47	3	13	2	38	14	2	3
Côte d'Ivoire	88	31	57	41	38	14	2	3
Ethiopia	96	12	22	7	45	86	6	10
Ghana	89	47	68	37	91	74	32	41
Madagascar	38	6	12	1	44	12	3	4
Malawi	38	4	9	1	31	8	0	1
Mali	92	57	65	49	80	86	50	52
Mozambique	47	2	16	1	51	11	1	2
Niger	61	6	15	2	47	20	3	4
Nigeria	93	48	64	33	88	88	38	48
Rwanda	48	6	12	1	46	6	1	1
São Tomé and Príncipe	69	48	59	49	72	62	44	53
Senegal	93	32	59	36	84	84	26	44
Sierra Leone	42	2	17	3	43	25	1	8
South Africa	94	81	89	78	99	87	77	81
Swaziland	70	30	40	4	83	45	16	19
Tanzania	52	9	20	4	58	7	4	4
Togo	80	10	37	6	76	65	6	19
Uganda	39	7	15	3	42	6	4	4
Zambia	59	16	31	8	78	19	11	12
Median	66	13	34	7	65	33	6	11

Source: World Bank staff analysis of household surveys.

Note: Bottom and top 20 percent refer to the bottom and top income quintiles. Access to electricity as defined here includes those reporting grid connection; those using electricity from the grid, generators, solar panels, or solar energy as their primary energy source for lighting or cooking; those owning generators or solar panels; and those reporting non-zero expenditures on electricity.

electricity remains low in Africa, electricity use is far more prevalent in urban than rural areas, and adoption of electricity and quantities consumed rise sharply with income.

How much would it cost to make electricity affordable to all people? The answer to this question depends on how much electricity and what is considered affordable. This study bases affordability of electricity on having to spend no more than 5 percent of household income on 30 kWh a month, which is considered the subsistence level (box 1).

Table 3 shows the results of calculations estimating the amount of subsidies required to enable every household in the country to spend no more than 5 percent of income to purchase 30 kWh a month. These hypothetical subsidies assume a perfect world in which precise targeting of subsidies individually tailored to each household is possible. The countries are listed in order of decreasing grid-electricity poverty gap.

Box 1 Subsistence consumption and grid-electricity poverty

The framework developed by the Sustainable Energy for All initiative to define and measure access to energy considers 30 kWh a month to be the subsistence level for grid electricity; the framework considers the electricity affordable if a household does not have to spend any more than 5 percent of its total monthly income to purchase it (World Bank and IEA 2015). Accordingly, this study defines the grid-electricity poor as those who live in households that find monthly consumption of 30 kWh unaffordable. For example, if it costs $5 to buy 30 kWh, then the minimal monthly household income needed to afford electricity is $100, and all people living in households with a combined income of less than $100 are classified as electricity poor.

The grid-electricity poverty headcount is the proportion of a country's population that is grid-electricity poor. The headcount tells who is poor but not how poor they are. To determine depth of poverty, the grid-electricity poverty gap is calculated: it measures the extent to which 5 percent of household income falls below the monthly bill for electricity as a proportion of that bill. The sum of the grid-electricity poverty gaps across all households (multiplied by the monthly bill for 30 kWh) is the subsidy needed to enable everyone to consume the subsistence level of electricity, if subsidy transfers could be perfectly targeted.

So, for example, if every household in a country earns $60 a month, a $5 monthly expenditure on electricity would not be considered affordable (5 percent of $60 is $3). Everyone is electricity poor, and the poverty headcount is 100 percent. But the poverty gap is 40 percent, obtained by dividing $2 (the difference between $5 and $3) by $5, the monthly bill for 30 kWh. The poverty gap would be 100 percent only if every person had no household income. The hypothetical subsidy needed to make electricity affordable to the entire population would be $2 per household, multiplied by the total number of households in the country.

Predictably, the ranking of the grid-electricity poverty gap and the grid-electricity poverty headcount are similar. Access tends to increase with decreasing grid-electricity poverty metrics, but the relationship is not strong; it is weak at low levels of the grid-electricity poverty gap and headcount. Taking the bottom 10 countries in the table as an example, monthly bills for 30 kWh are affordable for more than 97 percent of all people, but some countries—Ethiopia, Malawi, Mali, and Tanzania—have low rates of access, ranging from 22 percent down to 9 percent of the population.

The additional subsidies needed to make the subsistence level of electricity affordable to every household in the country are surprisingly small at the current applicable tariffs. They are no more than 6 percent of utilities' cash collections. In practice, current tariffs are almost certain to be too low to extend grid electricity to every rural household. The costs per kWh delivered would be much higher than in the current system, and could also be higher than minigrids and other off-grid arrangements. In Africa, where 63 percent of the total population is estimated to be rural, the customer base needed to cross-subsidize rural households is not sufficiently large. For these reasons, grid-electricity poverty indicators and subsidy estimations based on current tariffs are less likely to be applicable to rural areas, many of which are better suited for off-grid

Table 3 Grid-electricity poverty, access, and subsidy statistics for monthly consumption of 30 kWh

Country	% Poverty		Access (%)	30 kWh as % of HH income	Subsidy required as % of			Subsidy[a] ($, millions)	
	Gap	Head-count			QFD	Cash collected	GDP	Urban	Rural
Madagascar	30	71	11	9.6	2.6	6.4	0.06	0	0
Rwanda	27	63	11	8.9	7.3	6.3	0.08	0	1
Burkina Faso	24	60	11	8.8	7.2	3.5	0.07	14	58
Togo	15	39	34	6.9	2.6	0.9	0.04	1	2
Sierra Leone	9	33	13	5.1	2.7	3.4	0.02	0	1
Zambia	7	24	22	4.1	0.3	0.2	0.00	0	1
Uganda	7	22	9	4.4	-2.1	0.1	0.02	10	60
Botswana	5	12	43	3.7	0.0	0.0	0.00	0	1
Senegal	2	8	53	2.9	0.1	0.1	0.00	0	0
Niger	2	10	10	3.6	1.8	0.7	0.01	0	1
Swaziland	2	3.2	38	1.9	0.0	0.0	0.00	0	7
Mozambique	1.4	4.6	15	2.3	0.1	0.1	0.00	0	0
Côte d'Ivoire	0.9	2.5	57	1.8	0.0	0.0	0.00	5	61
Malawi	0.6	2.9	9	2.2	0.1	0.1	0.00	0	0
Tanzania	0.6	2.5	16	1.9	0.2	0.0	0.00	1	4
Ghana	0.3	1.1	66	1.4	0.1	0.0	0.00	2	10
South Africa	0.2	0.9	87	1.2	0.0	0.0	0.00	1	1
Ethiopia	0.2	0.8	19	1.3	0.0	0.0	0.00	0	0
São Tomé and Príncipe	0.2	0.9	56	1.7	0.0	0.0	0.00	0	0
Mali	0.1	0.4	22	1.4	0.0	0.0	0.00	4	15
Nigeria	0.0	0.0	56	0.3	0.0	0.0	0.00	6	44
Angola	0.0	0.0	41	0.1	—	—	—	1	12

Source: Kojima et al. 2016.

Note: Population weights are used for grid-electricity poverty metrics and access, and household weights for the remaining variables. Subsidies are the amounts needed to make up the difference between the monthly bill for 30 kWh and 5 percent of total household income for every household where the difference is positive. Where there are several tariff schedules applicable to 30 kWh, the lowest possible monthly bill—inclusive of all taxes and applicable charges—is selected. Access is the rate of household access to grid electricity or, where information on grid connection is not available, to electricity excluding batteries, solar energy, and standby generators (if separately accounted for in the survey). HH = household; QFD = quasi-fiscal deficit; — = not available.

a. Annual subsidy required in current $ million in the survey year, or if the tariffs came into effect later, the first year of tariff implementation.

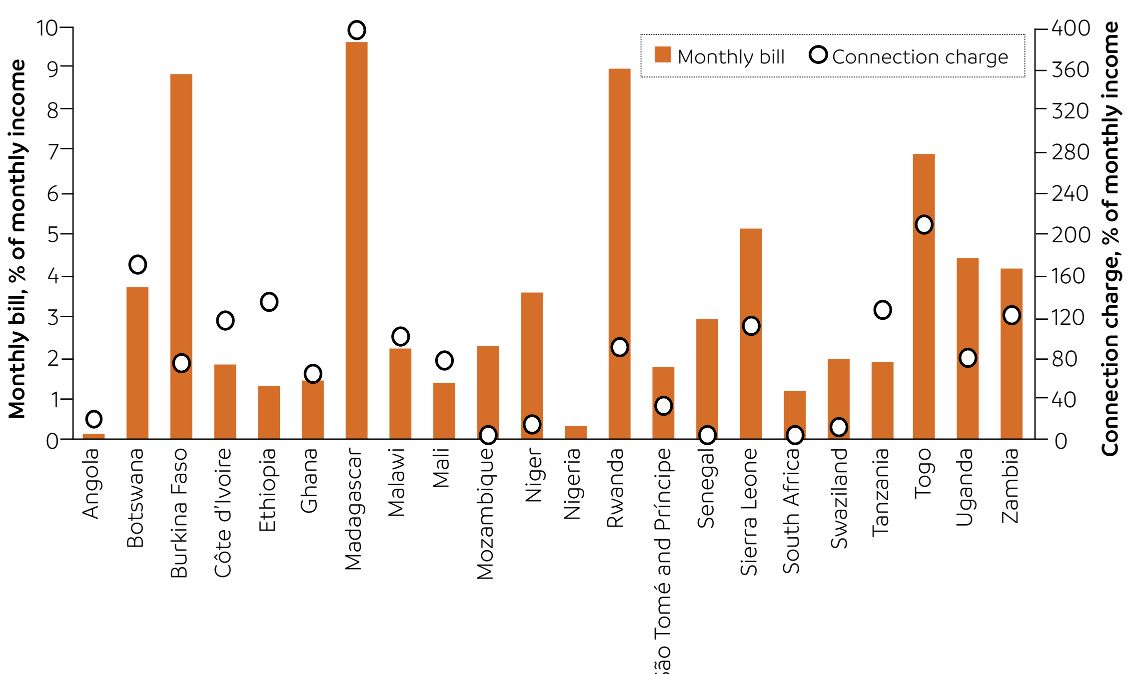
electrification (although the level of service is much lower in off-grid systems than in grid networks). Once the fact that many households will be served by off-grid electrification is taken into account, the subsidy requirements for grid electrification would decline further, although the subsidies needed for off-grid electrification can be substantial. A lower bound on subsidies is that needed to make grid electricity affordable to every urban household. The additional annual subsidies to that end would be less than $1 million in 15 countries and less than $5 million in 19. Even the maximum is less than 1 percent of the cash collected by utilities.

In the top 10 countries in table 3, only Niger, Togo, and Uganda do not suffer from underpricing—in other words, they have the fiscal space to charge better-off, large-consumption customers more and cross-subsidize needy households. All other countries will continue to experience underpricing even after attaining benchmark performance in operational efficiency. The current quasi-fiscal deficits are not small in the top three countries: 2.2 percent of GDP in Madagascar, and 1.0 percent in Burkina Faso and Rwanda. These findings highlight the challenges facing countries with high grid-electricity poverty gaps and low access rates.

What does it cost to be connected to the grid? An equally important consideration in affordability is the cost charged to households for initial connection to the grid. Figure 7 provides a comparison of the lowest monthly bill for 30 kWh and the lowest available connection charges, expressed as percentages of monthly household income. The countries in which monthly consumption of 30 kWh is already unaffordable to the poor tend to have high connection charges—the correlation coefficient between the expenditure shares of monthly electricity consumption and of the lowest connection costs is 0.58 (which is statistically significant using a 5 percent significance test). Madagascar, where the lowest connection charge is $165 and the bill for 30 kWh is $3.70, leads in every respect: grid-electricity poverty gap, grid-electricity poverty headcount, and shares of household income for monthly bill and connection charge.

Although the subsistence level of 30 kWh a month is used to define affordability, grid-electricity poverty metrics can be computed for any monthly consumption. The results of such

Figure 7 Monthly bill for 30 kWh and connection charge as percentage of monthly household income



Source: Kojima et al. 2016.

Note: Household weights are used for the calculations. Nigeria charges households for the cost of materials needed. In South Africa, both the connection fee and the monthly bill may be waived for households according to different eligibility criteria depending on the municipality.

computations give an idea of how many people can afford to buy varying amounts of electricity and the subsidies needed to make these amounts affordable to all households if perfect targeting is possible.

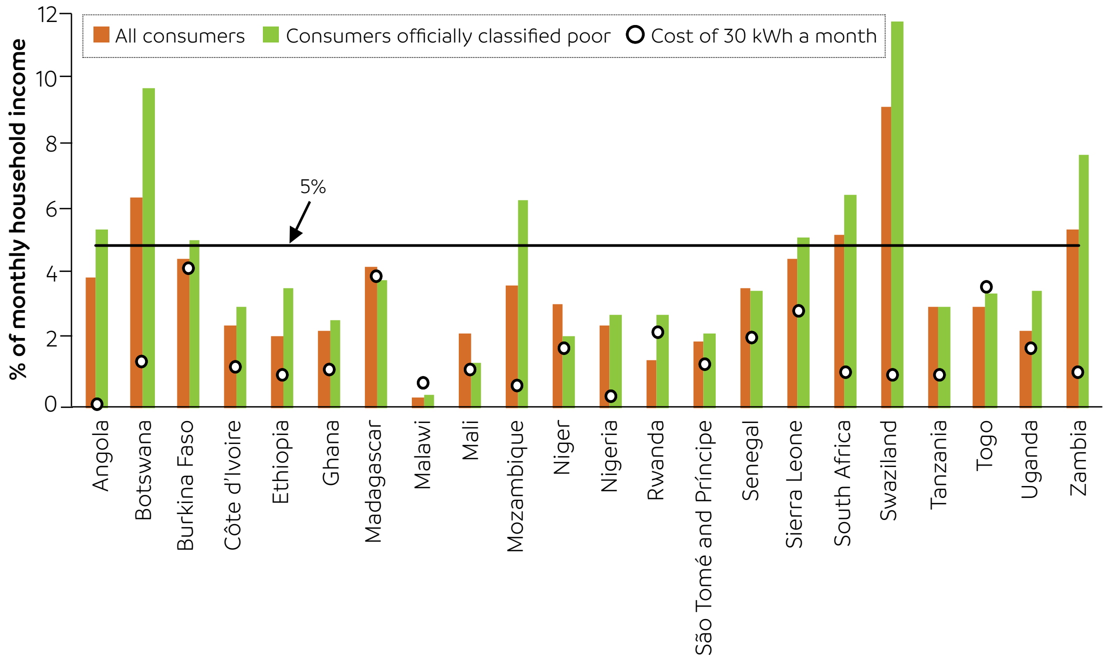
Which measure of grid-electricity poverty, if any, is best correlated with access? While grid-electricity poverty metrics at 30 kWh a month might be expected to address affordability most directly, the considerable variance in access rates at low grid-electricity poverty levels suggests otherwise. Access rates range from 9 percent to 87 percent at grid-electricity poverty indicators below 3 percent, making a meaningful relationship between the two unlikely. Examination of the relationships between access and the two measures of poverty shows that the poverty gap for 250 kWh and the poverty headcount for 100 kWh are the best predictors of access. Even so, the predictive power is not anywhere near that of the poverty gap measured at $3.10 per person per day.

High grid-electricity poverty indicators signal income being too low relative to the tariffs in effect. In the face of the inability of so many households to pay for electricity, could regulatory authorities keep tariffs relatively low compared to where they should be, even if so doing increases quasi-fiscal deficits? One way of probing this question is to examine the relationships between grid-electricity poverty indicators and quasi-fiscal deficits. Correlation statistics show that the grid-electricity poverty indicators for 30 kWh are not well correlated with quasi-fiscal deficits, suggesting that making the subsistence level of electricity affordable does not drive deficits. Underpricing of tariffs (quasi-fiscal deficits at benchmark performance) had the highest correlation coefficients with grid-electricity poverty indicators, but at consumption volumes far above the subsistence level: the highest correlation coefficients are for the grid-electricity poverty headcount for 250 kWh, followed by the grid-electricity poverty gap for 250 kWh and the grid-electricity poverty headcount for 100 kWh. In every case, the sign was negative, as expected: the smaller the degree of underpricing relative to GDP, bills sent out, or cash collected, the more unaffordable electricity becomes with increasing consumption.

How do monthly bills for 30 kWh compare to actual household spending? Figure 8 compares actual spending on electricity with the cost of consuming 30 kWh a month. The statistics are confined to those reporting positive expenditures on electricity; the expenditure shares of actual spending on electricity would be much smaller if averaged over all households, because many were not using electricity and reported no expenditures.

For several reasons, the amount by which the actual expenditure share exceeds the expenditure share of 30 kWh is not necessarily an indication of how much more electricity households are consuming. Aside from recall problems—in a survey with hundreds of questions, only one of which is about spending on electricity, the response provided has a wide margin of error—many poor households do not have access to the lowest possible tariff rate for 30 kWh. As an extreme case, half the consumers in Nigeria are not metered and few households can take advantage of the exceptionally low lifeline rate for the poor. As discussed below, multiple connections to a single meter are prevalent in many African countries, depriving them of the benefits of progressive tariffs. Botswana, Swaziland, and Zambia stand out for average electricity expenditure shares exceeding 5 percent by a large margin. The statistics for the poor are not

Figure 8 **Spending on electricity as percentage of monthly household income**



Source: Kojima et al. 2016.

Note: Household weights are used in the calculations. The three sets of data are confined to those households that reported positive expenditures on electricity, including solar and standby generators but excluding batteries or lamps fueled by kerosene or liquefied petroleum gas. Those reporting values for free electricity are excluded. The poor are those classified as officially poor by the respective government.

necessarily representative, because so few were using electricity and the total sample size of those reporting positive expenditures was very small in a number of countries.

Female-headed households

The share of female-headed households in Africa has been rising over the last two decades (Milazzo and van de Walle 2015). If female-headed households face unmeasured economic disadvantages—such as having greater difficulties accessing credit or not having title to land—their ability to spend cash at the same total household spending as defined in this study will be constrained. Is there evidence that female-headed households face greater challenges in gaining access to electricity, or that they use less of it once they have access? To investigate this question, the study looked at access to and spending on electricity for male- versus female-headed households.

Regression analysis shows that once income (per capita and household) and place of residence (urban and rural) are separately accounted for, female-headed households were not any less likely to connect to electricity than their male counterparts; they tended, in fact, to be more likely to do so. The results on spending on electricity similarly point to no apparent disadvantage for female-headed households. However, female-headed households tended to be poorer.

These findings suggest that focusing on making electricity affordable for the poor will go a long way in increasing electricity use among female-headed households.

Tariff schedules and multiple connections

This study collected information on the residential tariff schedules in effect as of July 2014 in 39 countries. Their characteristics for single-phase connections, or single- and three-phase connections where no distinction is made in the tariff schedules, are provided in table 4.

Of the 37 countries where information on tariff type is available (last column), 17 have only increasing block tariffs; 10 have only single blocks; 3 have only volume-differentiated tariffs; 3 have volume-differentiated tariffs for the first two blocks followed by increasing block tariffs; 3 have a combination of single blocks and increasing block tariffs for two or more blocks; and 1 has increasing, decreasing, and single-block tariffs depending on the schedule. Where there are multiple blocks, in all cases except one schedule in Côte d'Ivoire, energy charges per kWh increase with increasing consumption. Costs of supply, by contrast, decrease with increasing consumption.

Many countries have lifeline rates—discounted rates based on household consumption of electricity intended to help the poor by cross-subsidizing low-consumption households. In the 39 African countries studied, the most common lifeline block size is 50 kWh a month (8 countries), followed by 25, 75, and 100 kWh (3 countries each). Eight countries have lifeline blocks up to 40 kWh, and five are 25 kWh or smaller—that is, below the monthly subsistence level of 30 kWh. All five of these latter countries except Benin have increasing block tariffs. South Africa (more specifically, Johannesburg) may appear to have an exceptionally large first block, followed by The Gambia. However, there are special provisions in South Africa that allow the poor to receive free grid electricity for the first so many kWh—including 25, 50, 60, 100, and 150 kWh a month—depending on eligibility criteria (for example, prepaid customers consuming less than so many kWh a month based on the average over the last 12 months), which in turn differ by municipality. Fixed charges punish low-consumption households. For example, unit tariffs (price per kWh) are higher for monthly consumption of 30 kWh than 50 kWh in 15 countries due solely to fixed charges.

Subsidized lifeline rates are limited only to those consuming less than the cap in nine countries (Benin, Cabo Verde, Cameroon, Gabon, Ghana, Mozambique, Nigeria, São Tomé and Príncipe, and Togo), shifting households to higher tariffs in the next tier for the entire consumption if the cap is exceeded. This has the same effect as volume-differentiated tariffs in Gabon, Mozambique, and Nigeria. Not having access to the lifeline rate by exceeding the limit by even 1 kWh makes it more difficult for the poor when the block size is relatively small (for example, less than 50 kWh). The median increase in the effective unit energy charge for consuming more than the limit on the first block is 65 percent. There is large variation across countries, however: the increase ranges from 4 percent in The Gambia and 7 percent in Senegal to 340 percent in Madagascar and 450 percent in Kenya and Zimbabwe.

Table 4 **Residential tariff schedules in effect in July 2014**

Country	kWh[a]	Ratio[b]	No. of schedules	No. of blocks[c]	Tariff type
Angola	50	3.19	2	2/1	IBT
Benin	20	1.65	1	3	VDT/IBT[d]
Botswana	200	1.31	1	2	—
Burkina Faso	75	1.71	7	3	IBT
Burundi	50	2.03	1	3	IBT
Cabo Verde	60	1.23	2	2	VDT
Cameroon	110	1.72	1	5	VDT
Chad	150	1.47	1	2	—
Comoros	n.a.	n.a.	2	1	n.a.
Côte d'Ivoire	40	2.05	3	2/1/2	IBT/n.a./DBT
Ethiopia	25	1.31	1	9	IBT
Gabon	120	1.62	9	1	n.a.
Gambia, The	300	1.04	2	4/1	IBT/n.a.
Ghana	50	2.01	1	4	VDT/IBT[d]
Guinea	60	2.58	1	3	IBT
Kenya	50	5.47	1	3	IBT
Lesotho	n.a.	n.a.	1	1	n.a.
Liberia	n.a.	n.a.	1	1	n.a.
Madagascar	25	4.4	2	2	IBT
Malawi	n.a.	n.a.	2	1	n.a.
Mali	50	1.58	17	4 for prepaid social, 2 otherwise	IBT
Mauritania	n.a.	1.92	8	1	n.a.
Mauritius	25	1.39	1	8	IBT
Mozambique	100	2.34	3	1/3/1	n.a./IBT/n.a.
Namibia	n.a.	n.a.	4	1	n.a.
Niger	50	1.33	1	2	IBT
Nigeria	50	3.68	2	1	n.a.
Rwanda	n.a.	n.a.	1	1	n.a.
São Tomé and Príncipe	100	1.47	2	3	VDT
Senegal	75	1.07	2	3/1	IBT/n.a.
Seychelles	200	1.19	2	5	IBT
Sierra Leone	30	1.43	1	3	IBT
South Africa[e]	500	1.14	7	5 or TOU seasonal	IBT
Swaziland	n.a.	n.a.	2	1	n.a.
Tanzania	75	3.5	2	2/1	IBT/n.a.
Togo	40	1.57	1	4	VDT/IBT[d]
Uganda	15	3.45	1	2	IBT
Zambia	100	2.07	2	3/1	IBT/n.a.
Zimbabwe	50	5.5	3	3/1/3	IBT/n.a./IBT

Source: Kojima et al. 2016.

Note: The names of the countries with household survey data are shown in bold. DBT = decreasing block tariff; IBT = increasing block tariff; VDT = volume-differentiated tariff; TOU = time of use; — = not available (information could not be obtained); n.a. = not applicable (there is only one block).

a. The monthly size of a tariff subject to a lifeline rate, or the size of the first block when there are two or more blocks. Some countries have multiple schedules, each of which has a single block. The sizes of the consumption blocks in Senegal are defined over two months and are divided by 2.

b. The ratio of the effective energy charge, inclusive of ad valorem tax such as value-added tax but exclusive of fixed charges, between the second block (or the second level of service, if there are several schedules of a single block each with increasing installed capacity) and the first block.

c. Where there are multiple schedules but only one number for the number of blocks, every schedule has the same number of blocks.

d. Volume differentiated for block 2, increasing thereafter.

e. These numbers are for Johannesburg. Depending on eligibility, poor households are provided with 50, 100, or 150 kWh of free electricity a month in that municipality.

How widespread are multiple connections? Progressive tariffs are effective only if each customer is individually and accurately metered so as to determine in which block household consumption falls. In the six countries where data from household surveys and utilities were available to estimate whether households had their own meters—Côte d'Ivoire, Ethiopia, Malawi (although it has unit tariffs independent of consumption), Mali, Senegal, and Sierra Leone—multiple connections were widespread. In Côte d'Ivoire, Ethiopia, and Sierra Leone, less than half of all households had their own meters. Ethiopia possibly had the highest percentage of households with shared meters: the number of households reporting connection to the grid in the household survey exceeded the number of residential customers reported by the utility by 150 percent. Meter-sharing practices vary: in Senegal and Sierra Leone, meter sharing was more common among the poor; in Côte d'Ivoire, sharing did not vary much with household income; in Ethiopia, meter sharing appeared more common among the rich than the poor.

Extensive meter sharing defeats the purpose of designing progressive tariffs. Undoubtedly the dominant reason for sharing meters is to defray the high cost of the initial connection. Not surprisingly, the country with the least degree of meter sharing is Senegal, which does not charge for connection if a household is within 40 meters of the nearest power line. Information on the connection charge is not available in Mali, but in all other countries it costs on average at least one month's worth of household expenditures to connect to the grid (figure 7). "Informal fees" for the initial connection add to the affordability challenge (box 2).

What scope exists for further cross-subsidizing low-income households? To achieve universal access in Africa, the poor will have to be cross-subsidized for the foreseeable future to make the connection fee and subsistence consumption of electricity affordable. Cross-subsidies are easier to implement if utilities are not suffering from serious underpricing, and consumption by poor households makes up only a small fraction of total consumption. Of the 39 countries in which this study collected information from utilities, 11 provided information by consumer category, isolating residential consumers from others. Another five isolated low-voltage from higher-voltage consumers. The ratios of residential tariffs to other tariffs—and, in the absence of information about residential customers, of low-voltage to higher-voltage tariffs—give an indication of how much residential tariffs are already cross-subsidized.

Box 2 Bribery for connection to grid electricity

Corruption in the form of bribes adds to the cost of using electricity. Malawi and Nigeria asked households connected to the grid if they had to pay an "informal fee" over and above the official connection charge to get the connection. Bribery was more prevalent in Nigeria, where more than half of the households reported having paid a bribe. In Malawi, there were too few households in the bottom half of income groups for meaningful statistics, but in Nigeria there were enough households connected to the grid across all income groups. The percentage of households reporting informal payments was lowest in the bottom 40 percent and highest in the top 40 percent—that is, those who had greater financial means were also more likely to be approached for a bribe and to pay it.

The share of total kWh billed to residential customers is another indication of the room available for further cross-subsidization. The residential share of electricity consumption in Africa tends to be high. For comparison with a mature electricity sector with detailed information and a relatively high share of residential consumption, the United States was selected for comparison. Table 5 summarizes the findings.

Cabo Verde, Gabon, Liberia, Niger, and Uganda have no or negative underpricing (figure 5), suggesting some scope for cross-subsidizing the poor. However, the high share of total kWh billed to residential (Niger) and low-voltage (Gabon) customers increases the unit cost of supply and poses a challenge to adding more low-tariff, low-volume residential consumers, who are costly to connect because of lack of economies of scale. In Malawi and Guinea, both of which suffer from significant underpricing, residential (Malawi) and low-voltage (Guinea) consumers are already heavily subsidized. Not surprisingly, Malawi has a high grid-electricity poverty gap and headcount (table 3). In such cases, the electricity sector might consider targeting access expansion first to those able to afford higher tariffs. Guinea faces the additional challenge of three-quarters of all consumers belonging to the low-voltage category. Mali and Mauritania are two other countries with low rates of access and low-voltage consumers accounting for

Table 5 Comparison of residential or low-voltage tariffs and consumption with other categories

Country	Tariff ratio					R or LV	Access in 2012
	R/C	R/I	R/NR	LV/MV	LV/HV	(% of total kWh)	(% of population)
Botswana	0.8	1.1	n.a.	n.a.	n.a.	27	53
Burundi	1.3	1.3	n.a.	n.a.	n.a.	50	7
Kenya	0.8	1.3	n.a.	n.a.	n.a.	24	23
Lesotho	1.3	1.6	n.a.	n.a.	n.a.	32	17[a]
Malawi	0.6	0.8	n.a.	n.a.	n.a.	42	10
Mauritius	0.8	1.6	n.a.	n.a.	n.a.	33	100
São Tomé and Príncipe	0.4	0.7	n.a.	n.a.	n.a.	49	60
Uganda	1.0	1.3	n.a.	n.a.	n.a.	24	18
Cabo Verde	n.a.	n.a.	1.2	n.a.	n.a.	47	71
Liberia	n.a.	n.a.	1.0	n.a.	n.a.	41	10
Niger	n.a.	n.a.	1.0	n.a.	n.a.	65	14
Gabon	n.a.	n.a.	n.a.	1.3	n.a.	64	89
Guinea	n.a.	n.a.	n.a.	0.2	n.a.	78	26
Mali	n.a.	n.a.	n.a.	1.3	n.a.	62	26
Mauritania	n.a.	n.a.	n.a.	1.0	n.a.	57	22
Senegal	n.a.	n.a.	n.a.	1.2	1.8	61	57
Median	0.8	1.3	1.0	1.2	n.a.	41[b]	18
United States	1.2	1.8	n.a.	n.a.	n.a.	37	100

Source: IEA and World Bank 2015 for access; World Bank staff calculations using utility data and U.S. EIA 2016 for all others.

Note: Calculations are based on values and kWh billed. R = residential; C = commercial; I = industrial; NR = non-residential; LV = low voltage; MV = medium voltage; HV = high voltage; n.a. = not applicable.

a. The access rate in Lesotho is for 2010, the year of utility data.

b. The median is that for the first 11 countries reporting residential consumption separately.

more than half of total consumption. In at least Niger and Mauritania, these small customers are already well cross-subsidized. At the opposite end of the spectrum is Lesotho, where the statistics are comparable to those of the U.S. electricity sector. However, Lesotho suffers from some underpricing (0.15 percent of GDP), suggesting that the tariff levels need to be raised across all consumer categories. The median statistics in table 5 suggest that in general residential customers tend to be cross-subsidized more in Africa than in the United States and in other high-income countries, leaving less room for cross-subsidization.

Reliability

Poor reliability of electricity services is arguably as serious a problem in Africa as low rates of access and per capita consumption. The issues are ultimately interlinked, signaling serious power shortages. Seven household surveys—for Ethiopia, Madagascar, Malawi, Mali, Niger, Nigeria, and Senegal—asked questions about the frequency, duration, or both of blackouts. Power outages were common in all seven countries, and serious in Malawi (where six out of every seven households reported daily blackouts over the previous 12 months), Niger, Nigeria, and Senegal. In Nigeria, where 57 percent of households reported daily blackouts, some cited poor reliability as their reason for not connecting to the grid, and all but one had their own generator.

Despite the severity of service interruptions, very few utilities in the region seem to be measuring the quality of service according to the two internationally accepted metrics: system average interruption duration index (SAIDI) and system average interruption frequency index (SAIFI). Of the 39 countries with utility annual reports, only 16 reported any measure of system interruptions; of these, only Cameroon, Liberia, Mozambique, and South Africa reported SAIDI and SAIFI. The utilities in the remaining 12 countries reported the average duration of an outage, the total number of hours of outages, or the total number of system interruptions (for example, Guinea reported 1,962 outages due to breakdowns per year). The most commonly reported metric for reliability was average outage duration. Utilities in five countries specified where outages were occurring—such as medium-voltage lines in Mauritania and Sierra Leone and the transmission system in Zimbabwe—while the remaining seven provided no further information. Even the four countries that reported SAIDI and SAIFI cited national statistics but not the measurements in low-voltage segments at the end-user level. Without knowing the duration and frequency of service interruptions for individual customers, it is difficult to assess utility performance.

Improving reliability is one of the most critical complements to tariff reform, because no customer wants to be asked to pay more for continuing bad service. The pervasive lack of measurement of SAIDI and SAIFI is itself an indication of how far there is to go in tackling poor reliability. Without systematic monitoring, it will be difficult to measure progress and the effectiveness of steps taken to improve reliability.

Conclusions and Implications

It is useful to highlight the limitations of this study—in terms of scope and data availability—before summarizing its key findings and potential policy implications.

- **The study does not cover off-grid rural electrification.** More than three-fifths of the population in Africa is still rural. Universal access through grid expansion alone would be too costly and impractical, because of the low density of customers coupled with the low consumption of electricity in many rural areas. Off-grid electricity, especially from renewable sources, would be cheaper than grid expansion, although still costly. The net cost to the electricity sector of reaching rural areas—not captured in this report—will be substantial.
- **The study does not consider system expansion, costs of unreported input subsidies, costs of improving operational performance, and fixing problems created by delayed investments in maintenance.** The marginal cost of expanding the transmission system is likely to be higher as lines are extended to less densely populated areas. The unit cost of expanding generation capacity may be higher or lower depending on the type and size of generation capacity. For example, exploiting economies of scale can lower unit costs, while adding gas-based power generation in a sector dominated by coal-based generation could increase costs. All other factors will increase quasi-fiscal deficits relative to those reported here.
- **The study does not consider potential cost savings from optimization of the power generation mix or expansion of cross-border electricity trade.** System optimization is a long-term process that needs to start today. Over the long run, it offers great potential for decreasing unit costs of electricity delivery to end users and helping reduce quasi-fiscal deficits and the magnitude of tariff increases required for the electricity sector's financial sustainability. Similarly, cross-border trade can lower costs for all parties by exploiting economies of scale and the lowest-cost sources of electricity.
- **No information exists about the distance to the nearest distribution line for household access to grid electricity.** Connection charges tend to increase rapidly with increasing distance from the power line, and yet information on distance to the nearest grid is not available. Grid connection may not be a practical option even for many living in electrified communities. On the demand side, information on income as well as disposable cash income is not available and is substituted by household expenditures used for official poverty statistics.

These exclusions are all important areas for future study and more in-depth country-level analysis. It is important to bear these limitations in mind in interpreting the following findings and policy implications; these are summarized in the following table.

The key findings of the study and policy implications are summarized below.

Issue	Key finding	Policy implication and response option	Anticipated benefit
Cost recovery and utilities' financial sustainability	• Absent systemwide optimization, very few African countries have full cost recovery.	• Give high priority to systemwide optimization through a least-cost development plan.	• Future costs are minimized.
	• Eliminating operational inefficiencies can potentially achieve cost recovery in about one-third of African countries.	• Reduce network and bill collection losses as top priority in all countries. • Install prepaid meters as a way of improving revenue collection.	• Costs are lowered with little welfare loss. • Utility revenue is increased.
	• In the remaining two-thirds, both system optimization and tariff increases are needed in addition to eliminating operational inefficiencies.	• Focus tariff increases first on the better-off accounting for large shares of total consumption. • Consider small, frequent tariff increases instead of large, rare ones. • Communicate clearly and transparently in advance the timetable for tariff increases, and implement according to announced timetable.	• Tariff increases generate revenue with minimal loss of welfare. • There is wider public acceptance of tariff increases. • Utilities are held accountable more.
	• External events outside electricity sector's control—oil price and exchange rate volatility, rainfall variability—have large effects on financial sustainability.	• Take advantage of low world oil prices today to introduce automatic pass-through of fuel price and exchange rate fluctuations. • Plan ahead for long periods of drought by optimizing generation mix.	• Automatic pass-through is not equated with price shocks, making it more acceptable to the public. • Reliance on expensive emergency leased power is minimized, lowering costs.
Improved utility management	• Network system and bill collection losses account for a majority of utility quasi-fiscal deficits in half of African countries.	• Give high priority to reducing unmetered consumption and bill collection losses among medium- and large-size consumers. • Reduce technical losses. • Install commercial information management systems.	• Revenue is increased with minimal loss of welfare. • Metering, billing, bill collection, connection, and disconnection are all improved, as is customer service quality.
	• Service reliability is poor, and seldom measured systematically.	• Reduce service interruption duration and improve customer service for bill payment first.	• These short-term measures "buy time" for longer-term steps to improve service quality. • Public support is won for other reform measures.

Issue	Key finding	Policy implication and response option	Anticipated benefit
Improved utility manage-ment		• Measure service reliability statistics systematically at end-user level.	• Service reliability is improved because where to take corrective steps becomes clearer.
		• Consider pros and cons of mandating prepaid meters if service quality is poor.	• Not mandating until service quality is improved may mean customers do not pay in advance for electricity not delivered when needed. • Where billing is based on estimated consumption and there is overbilling for undelivered electricity due to frequent outages, prepaid meters reduce payments.
Afford-ability of grid electricity	• Connection costs are not affordable in many countries.	• Optimize technical and financial arrangements for all aspects of electrifica-tion and move away from charging customers sepa-rately for new connection.	• Connection charges can be tailored to customers' ability to pay; connection fees col-lected may be transferred to a ring-fenced electrification fund and used to accelerate electrification.
	• Practice of multiple household connections to a single meter is widespread.	• Benefits of lifeline tariffs for the poor are negated. • Eliminate practice of multi-ple household connections, replacing them with individ-ual meters.	• Service quality is improved. • The poor benefit fully from lifeline rates.
	• About half of African countries have small first blocks with low lifeline rates. • Monthly electricity bills are unaffordable for some in the current setup.	• Sharpen progressive tariffs to increase affordability, and concurrently develop more targeted social protection measures.	• Subsidies become more efficient.
		• Install prepaid meters.	• Poor customers can pay when disposable cash becomes available, not when they are billed monthly. • Poor customers do not risk disconnection.
	• In most countries, only small additional subsidies are needed to make grid electricity affordable to every urban household.	• Install more meters; afford-ability depends critically on metering each household individually accurately.	• Electricity is affordable to more people and subsidies needed are reduced.
	• Poor financial state of many utilities makes it difficult to cross-subsi-dize the poor further.	• A financially viable, well-op-erating electricity sector is essential for making elec-tricity affordable to more people.	• Universal access is achieved earlier.

Key findings

Africa lags all other regions with respect to household access to electricity, even after taking into account its level of economic development. At the same income level, South Asia had much higher rates of access. At present, the likelihood of having access to electricity is reduced simply by living in Africa.

Utility management

Poor management plagues the electricity sector in many countries. Where transmission and distribution losses are high, bill collection losses also tend to be high, suggesting that operational inefficiencies are not confined to isolated segments of the supply chain but permeate the sector. Transmission, distribution, and bill collection losses combined accounted for more than half of the quasi-fiscal deficits in 21 countries, and more than three-quarters in 13.

Service reliability is poor, and seldom measured systematically. In some countries, households interviewed for national expenditure surveys reported daily blackouts, and poor reliability is supported by Doing Business indicators. Aside from inconvenience and discomfort, the cost to the economy of unreliable electricity service is significant—sometimes even driving investment in the economy away to other countries or regions. Indeed, two out of every five firms surveyed in Africa cites electricity as a major or severe constraint to doing business (World Bank 2016d). And yet few utilities are systematically measuring reliability using internationally accepted metrics: SAIDI and SAIFI statistics could be found in the annual reports of only four utilities; even in these cases, only national averages were reported. National averages by definition do not distinguish between areas with high reliability and those suffering frequent outages, making it difficult to assess utility performance. Nor are SAIDI and SAIFI measured at the level of individual customers. The absence of such statistics in itself could indicate to investors that the sector is not yet at a stage where even basic statistics are being collected, further discouraging investment in the economy.

Utilities' financial sustainability

The financial sustainability of electric utilities in many African countries is precarious. Of the 39 countries studied, only the Seychelles and Uganda were fully recovering their costs of supply, before taking system expansion into account. Quasi-fiscal deficits exceeded 100 percent of the cash collected by the utilities in 11 countries. Twenty countries were not even covering operational expenses; of the remaining 19, only 5 were covering half or more of their capital expenditures.

Improving operational efficiencies can potentially put the electricity sector on a sustainable path in about one-third of African countries. If transmission, distribution, and bill collection losses combined could be reduced to 10 percent (the level considered for benchmark utility efficiency) and overstaffing could be addressed, an additional 11 countries might see their quasi-fiscal deficits disappear, bringing the total at full cost recovery to 13. In practice, achieving loss requires both time and financial resources, leaving the possibility of residual quasi-fiscal deficits even as losses are being reduced to benchmark levels.

In the remaining two-thirds of African countries, system optimization, tariff increases, or—most likely—both are needed for financial sustainability. Just as did the AICD, this study finds that the funding gap cannot be bridged entirely by eliminating operational inefficiencies in the remaining 26 countries. The median of the quasi-fiscal deficits at benchmark performance in these countries is 0.7 percent of GDP, which is not small. Among the highest such deficits is 2.8 percent of GDP in South Africa, which also happens to be the only country in the sample that provides free electricity and free connection to those meeting eligibility criteria. In all these countries, absent optimization of generation mix and cross-border trade, tariffs will need to be raised.

External events can improve or exacerbate prospects for financial sustainability. While operational efficiency is completely under the control of the electricity sector—and tariff adjustments are too, to varying degrees—other events are not. Volatility in currency, rainfall, and the price of oil are three external developments that can increase or threaten the electricity sector's financial sustainability. A 30 percent reduction in hydropower can increase quasi-fiscal deficits by more than 2 percent of GDP in three countries. For countries highly reliant on oil-based electricity generation, absent a matching currency collapse, the current low oil price frees up some budget to improve operational efficiency while easing the pressure to correct underpricing.

Affordability of grid electricity to households

About half of African countries have small first blocks with low lifeline rates. Of the 39 countries for which this study obtained detailed information on tariffs, six have lifeline blocks of 30 kWh a month (the subsistence level of electricity used in the Sustainable Energy for All initiative) or less, with the smallest being 15 kWh in Uganda. The corresponding numbers of countries for 50, 75, and 100 kWh are 16, 21, and 24. Of the 24 countries with the first block size at or below 100 kWh, 17 have increasing block tariffs; the remaining 7 have volume-differentiated tariffs or their equivalent. The increase in unit tariff for exceeding the first volume ranged from 4 percent in The Gambia to 450 percent in Kenya and Zimbabwe in July 2014.

Sharing connections among several households is a widespread practice. The evidence from national household surveys combined with utility data shows that sharing of meters is common and even widespread among households in Africa. In Ethiopia, where the lowest connection fee of $76 represents 130 percent of monthly household income, the number of grid-connected households outnumbers utility customers two and half times over. Not surprisingly, Senegal—where the connection fee is waived if the household is within 40 meters of the power line—has the lowest degree of shared connections. Shared connections defeat the purpose of progressive tariffs.

The subsistence level of grid electricity is affordable on paper to the vast majority of the population in many countries with low rates of access. Electricity is affordable if 30 kWh a month costs no more than 5 percent of household income. If the tariffs in effect could be perfectly enforced (which means accurate metering of each house connected to the grid) and perfect targeting is possible, the grid-electricity poverty headcount and poverty gaps would be less than 5 percent in more than half of the 22 countries for which household survey data are available. Bridging the gap between the monthly bill for 30 kWh and 5 percent of household income for every urban household—for which grid extension would likely be the least-cost option—would cost less than $1 million annually in 15 countries and less than $5 million in 19, and be no more than 1 percent of the cash collected by utilities in all 22 countries. More detailed country-specific analysis of this aspect of affordability would be useful.

High connection charges and informal payments for connection are further barriers to increasing household access to electricity. Connection is free for some households in Mozambique, Senegal, and South Africa, but can be multiples of household monthly income in others. High connection charges lead to households choosing not to connect as well as to shared connections. Seeking connection to the grid also provides an opportunity for unscrupulous utility staff to demand informal payments (bribes) for timely or even not-so-timely connection. For the poor, such malpractice reduces the affordability of electricity further.

Policy implications

Within the electricity sector, political economy considerations point to the importance of prioritizing reform steps according to political risk. Measures that reduce the magnitude of requisite tariff increases, noticeably improve the quality of customer service, and avoid undue hardships on those with affordability challenges can help win public acceptance and expand access while moving the sector toward greater financial sustainability. In interpreting what follows, it is important to bear in mind that the exact sequence of steps and the design of a roadmap in each country will be guided by the specific circumstances of the electricity sector, government ownership and interest, the public's experience with the sector, and other country-specific factors.

Improving utility management

There are measures that can improve service quality in the short run. Improving the quality of service requires time and investment, but experience in other regions shows that early gains are possible by diligently attending to customers' complaints for outages and other incidents, restoring electricity supply in the shortest possible time, and making it easy to pay bills (through mobile phones, automatic teller machines, supermarkets, and other easily accessible locations with extended hours of service). Outage (or incident) management systems help deal with customer complaints about incidents related to the quality of supply; and commercial information management systems help improve metering, billing, bill collection, connection, and disconnection, and enable utilities to give full attention to customers. Service quality improvement does not call for significant investment, but requires incorporation of these information systems together with organizational arrangements for their proper use—for example, creation of call centers and use of a website and social networks to receive complaints and respond to them—and a more customer-oriented mindset (Antmann 2009). Global experience shows that, through such initial improvements, utilities can buy time (say two to three years) to achieve longer-lasting solutions through execution of investment projects to rehabilitate, upgrade, and expand the electricity infrastructure.

Loss reduction merits high priority. Reducing losses from unmetered consumption and inefficient bill collection—and sustaining such loss reduction over time—is much more important than addressing overstaffing, particularly against a backdrop of increasing demand and the need for rapid capacity expansion in every country.

Reliability statistics need to be measured at the end-user level. Few utilities report SAIDI and SAIFI, and those that do record incidents only in the high- and medium-voltage segments, ignoring what happens in low-voltage connections and computing SAIDI and SAIFI accordingly. But interruptions experienced by customers matter. If properly measured, SAIDI and SAIFI values would be much higher, because low-voltage segments are a significant source of interruptions. In the absence of systematic measurement of service quality, it is not possible to assess utility performance or compare tariffs across countries in a meaningful way.

Shared connections degrade the quality of service to the multiply connected. Multiple connections to a single meter with low capacity can mean demand rising above the design value of the installed capacity, worsening the quality of service to those so connected. This is another reason to tackle the widespread practice of shared meters.

Accurately metering each individual customer can bring double dividends. Accurate metering of all customers—and especially medium- and large-size customers—is an integral component of any revenue protection program for a utility. Utilities with progressive tariffs will lose some revenue if meter sharing is eliminated, but that small loss of revenue is unlikely to be an important consideration. A lack of individual metering and tolerance of widespread (illegal) connections creates a more permissive environment for other malpractices, such as electricity theft and bribes demanded by utility staff. Individual metering means low-income customers can benefit fully from progressive tariffs, while offering the utility a chance to increase the efficiency of progressive tariffs further.

Winning support for cost recovery

Sequencing is important in setting the electricity sector on a more financially sustainable path. Raising tariffs while outages continue unabated is bound to invite a backlash. Any perception that the better-off are unfairly benefiting—through large price subsidies offered to "strategic" industries or, worse, exploiting informal discretionary power of corrupt utility employees or executives who collude with large customers to reduce their bills—should be addressed as a matter of urgency. A revenue protection program should first focus on sales to large- and medium-size customers, who usually account for the bulk of commercial and bill collection losses. Cost reduction helps limit the tariff increases needed to attain cost recovery. The first step is to eliminate unnecessary losses. The public may be more willing to accept tariff increases if priority is given in the near term to improving service quality and billing and collection efficiency. Reducing reliance on diesel-based electricity generation—including emergency leased power—and shifting to less expensive forms of generation overall could ease the pressure on tariff increases. The pursuit of sectorwide long-term optimization is crucial.

Low access rates may make it easier to address underpricing, provided the quality of service is improved. The bulk of total sales and revenues comes from those who can afford electricity—industries, businesses, and middle- and upper-income households. In most African countries, access rates among the poor are low; to the extent the poor are connected to the grid, they consume little. The financial viability of utilities therefore depends on charging tariff rates that would enable recovery of costs of efficient service delivery to better-off consumers accounting for the bulk of electricity sold. Although the political sensitivity of tariff increases to these consumers cannot be ignored, neither should it be overestimated. In the face of large quasi-fiscal deficits and low access rates, there is no compelling reason to subsidize those who can afford to pay more. If anything, they could be asked to cross-subsidize low-income consumers more, as long as the latter's total consumption is only a small fraction of the total electricity sold. Successful examples of power sector reforms in emerging countries in other regions show that middle- and high-income consumers in all tariff categories usually accept cost-reflective rates, provided the quality of electricity services is good. Therefore, in addition to reducing transmission, distribution, and bill collection losses, utilities' top priority should be to achieve an acceptable level of service quality to enable a trajectory toward cost recovery in tariff revenues.

Small, frequent increases may find wider acceptance than large price shocks. Quite a few countries freeze tariffs for years on end, only to find mounting deficits unsustainable and are thus forced to implement large, one-off tariff increases, followed by another long period of tariff freezes. One option for avoiding such large increases is to allow small, frequent tariff adjustments. Indeed, several African countries conduct regular and frequent tariff reviews, although adjustments are not necessarily implemented due to professed socioeconomic considerations. A useful analogy is how India and Thailand handled fuel price subsidies: increase prices by small fixed amounts every month, announced in advance, until cost recovery levels are reached (Kojima 2016). It is important to communicate clearly and transparently in advance all the steps and the timetable for tariff increases toward cost recovery, and implement the steps according to the announced timetable. Predictability coupled with small and manageable increases could go a long way in finding greater public acceptance than rare, large, ad hoc tariff hikes.

Prepaid meters can help both utilities and customers. For low-income households with cash flow constraints, the ability to pay in small increments overcomes the classic problem of indivisibility of electricity bill payments: making relatively large payments once a month can be far more challenging than making several small payments during the month. By not risking disconnection for payment failure, prepaid meters also help households avoid reconnection fees, which can be considerable in some countries. For the utility, prepaid meters improve revenue collection. On the downside, depending on how unreliable electricity service is and how customers are billed, prepaid metering could mean customers pay in advance for electricity that is not delivered when needed. It may be unfair to consumers to make prepaid metering mandatory in the face of unreliable electricity service. However, if monthly bills for some customers are based on estimated consumption and there is frequent overbilling for electricity not delivered due to widespread power outages, prepaid meters help reduce payments. For the utility, prepaid meters do not guarantee payment for electricity consumed, in that they can be bypassed by those determined to steal electricity.

Governments could take advantage of current low world oil prices and introduce automatic pass-through of fuel price changes. Government control of energy prices—and passing through of input cost increases in particular—is politically sensitive. For diesel and fuel oil prices, low world prices offer a good opportunity to introduce an automatic price adjustment mechanism without provoking large tariff increases. As an example, the tariff structure in Kenya allows automatic transmission of oil price and currency fluctuations. There is no better time than now to take this step.

System optimization through a least-cost development plan becomes all the more important in the face of large quasi-fiscal deficits. Although not covered in this study, system optimization can substantially reduce costs compared to uncoordinated infrastructure investments. In a region where investment needs have far exceeded available funding and cost recovery is a long-term goal for many, maximizing technical and cost efficiency is crucial. Cost reduction will make it easier to achieve financial viability. A financially viable, well-operating electricity sector in turn is essential for a successful grid-based access expansion program.

Making grid electricity affordable for the poor

The widespread practice of multiple household connections to a single meter decreases affordability. Progressive tariffs are intended to require the rich to pay more. In the absence of information about each customer's household income, the standard practice in developing countries is to use monthly consumption as a proxy for income. When several low-income households connect to a single meter, they appear to the utility as a single "rich" household consuming a lot of electricity. The average unit tariff of multiple connected households could be considerably higher than if each household was individually metered, and poor households could end up paying much more for consuming the subsistence level of electricity. On the one hand, multiple connections mean that limited financial resources can be pooled to enable connection to the grid; also, if one household cannot pay one month, others may compensate to avoid disconnection, assuming their eventual reimbursement. On the other hand, if the officially registered household fails to pay—for whatever reason—everyone could be disconnected, including those who have been paying promptly and fully. And the difficulty of determining who consumed how much may create a free-rider problem, whereby some households pay less than they should at the expense of others.

The approach to setting connection fees merits further examination. High connection fees contribute to the practice of multiple connections. Isolating installation of new connections from other components of an electrification project (low-, medium-, and high-voltage networks) is economically inefficient. There is no compelling argument for separating network assets and service connections. It is much more efficient to build all infrastructure needed to connect new users in a single project, optimizing technical and financial arrangements. Doing so still offers the option of collecting connection fees from users in installments according to their ability to pay, and the proceeds can be transferred to a ring-fenced fund for the specific purpose of accelerating electrification programs. If the user pays fully for the assets associated with connection (as in urban Peru, where asset ownership is assigned to the user), these assets should be excluded from the regulatory asset base of the utility for tariff determination.

Refining progressive tariffs, and concurrently developing more targeted social protection measures, can deliver more efficient results. The additional subsidies needed to make the subsistence level of electricity affordable to all households living in areas that can be potentially connected to the grid are not large. Findings suggest that it may be possible to achieve tariff affordability by refining lifeline rates and cross-subsidies. There are trade-offs in setting the lifeline tariff and block size. Increasing block tariffs benefits the rich and the poor alike, making the subsidies inefficient. Aside from problems associated with shared meters, volume-differentiated tariffs can be punishing for the poor because exceeding the block size by even 1 kWh would catapult the household into the next block, which could have a much higher unit tariff. One option is to apply the block size to moving averages over the previous several months, but that would require modernization of metering and billing. Keeping the block size small—say 30–50 kWh a month—will ensure that the rich do not benefit disproportionately from heavily subsidized unit tariffs. To protect low-income families from unexpectedly high electricity bills, there could be a buffer in the form of a small second block that does not entail a large increase in unit tariff. Volume-differentiated tariffs in particular may merit such consideration. However well designed, consumption is not necessarily an effective proxy for income. Over the medium to long run, shifting subsidies to a comprehensive and integrated social protection program delivering cash to meet the basic needs of the poor—of which electricity is but one component—is the goal.

Technological advances present an opportunity and a challenge to the poor. Thanks to recent advances, the subsistence level of electricity consumption has been falling. The AICD considered 50 kWh a month a reasonable level; a decade later, it is 30 kWh. Using the most efficient appliances, even 15 kWh a month may be sufficient to burn four light-emitting-diode bulbs for four hours every night, charge a cell phone, and power a small efficient television and a large fan. However, efficient appliances are more expensive, and cash to pay the higher upfront costs is precisely what the poor lack. This is yet another dimension of affordability, and the resources needed to address this challenge arguably extend beyond the electricity sector.

Off-grid electrification is a crucial element in achieving universal access in Africa. Technical advances have slashed costs of solar energy in recent years, expanding the scope for its adoption. While the upfront cost of installing solar panels remains a challenge, solar energy use requires no fuel purchases, making it a very attractive option in terms of avoided operational costs. In Mali, one-quarter of all rural households reported relying on solar energy for lighting. While solar home systems and certainly solar lanterns cannot deliver the same level of service as grid electricity, they are an important first rung on the electricity access ladder, meeting the immediate needs of those currently without access.

Appendix A:
Data Sources and Methodology for Quasi-Fiscal Deficit Calculations

This appendix provides an overview of data sources, utility characteristics, and methodology used. See Trimble et al. (2016) for further detail.

Data sources

This study captures more than 300 indicators related to the financial, commercial, and technical aspects of power sectors in Africa. The primary sources of data are utility financial statements and annual reports, supplemented by data collected directly from utilities or taken from available references (such as cost-of-service studies, tariff studies, power sector reports, industry sources, regulatory documents, project documents, and locally available data provided by World Bank specialists working in the sector). Where data are inconsistent between sources, priority is generally given to utility data.

The 39 countries included in this study accounted for 95 percent of installed power generation capacity, 86 percent of the population, and 85 percent of GDP in all of Africa's 48 countries in 2014. These remaining nine countries were excluded from the analysis because of insufficient data: Angola, Chad, the Democratic Republic of Congo, Equatorial Guinea, Eritrea, Guinea Bissau, Namibia, Somalia, and South Sudan.

The reference year of analysis is defined as the most recent year for which a full set of critical data is available (financial statements, electricity sales, and power mix in installed capacity). Utilities report by fiscal year. If a fiscal year covers 12 months straddling two calendar years, the reference year is designated by the calendar year with a larger share of months in the fiscal year. If there are six months in two successive calendar years, the second calendar year is taken as the reference year. Therefore, the reference year for fiscal year July 2011–June 2012 is 2012, but the reference year for fiscal year April 2011–March 2012 is 2011. With the exception of Lesotho (2010), and Kenya (2015), the reference year for most countries is between 2012 and 2014, with 2014 being the reference year for a majority (table A.1).

Table A.1 Distribution of reference years

Reference year	2010	2011	2012	2013	2014	2015	Total
Number of countries	1	0	6	9	22	1	39

Source: Trimble et al. 2016.

Utility characteristics

Table A.2 provides utility data characteristics by country. Figure A.1 shows how utilities and other actors are positioned in the electricity sector of each country.

Table A.2 Utility data characteristics

Country	Reference year	Reference utility	FY end	Utility service coverage	Financial statements published	Audited statements available
Benin	2013	SBEE (Société Béninoise d'Energie Electrique)	31-Dec	Electricity only	No	No
Botswana	2013	BPC (Botswana Power Company)	31-Mar	Electricity only	Yes	Yes
Burkina Faso	2014	Sonabel (Société Nationale d'Électriité du Burkina)	31-Dec	Electricity only	No	No
Burundi	2014	Regideso	31-Dec	Electricity & water	No	No
Cabo Verde	2012	ELECTRA (Empresa de Electricidade e Água)	31-Dec	Electricity & water	Yes	Yes
Cameroon	2014	Energy of Cameroon	31-Dec	Electricity only	Yes	No
Central African Republic	2014	Enerca (Energie centrafricaine)	31-Dec	Electricity only	No	No
Comoros	2012	MAMWE (Madji na Mwendje ya Komori)	31-Dec	Electricity & water	No	No
Congo, Rep.	2012	SNE (Société Nationale d'Électricité)	31-Dec	Electricity only	No	No
Côte d'Ivoire	2014	CIE (Compagnie Ivoirienne d'Électricité)	31-Dec	Electricity only	No	No
Ethiopia	2012	Ethiopia Electric Power Company	30-Jun	Electricity only	No	No
Gabon	2014	SEEG (Société d'Energie Electrique du Gabon)	31-Dec	Electricity & water	Yes	Yes
Gambia, The	2014	NAWEC (National Water and Electricity Company)	31-Dec	Electricity, water & sewerage	No	Yes
Ghana	2013	ECG (Electricity Company of Ghana)	31-Dec	Electricity only	Yes	Yes
Guinea	2013	Électricité de Guinée	31-Dec	Electricity only	No	No
Kenya	2015	Kenya Power Limited Company	30-Jun	Electricity only	Yes	Yes
Lesotho	2010	Lesotho Electricity Company	31-Mar	Electricity only	Yes	Yes
Liberia	2014	Liberia Electricity Company	30-Jun	Electricity only	No	No
Madagascar	2014	JIRAMA (Jiro Sy Rano Malagasy)	31-Dec	Electricity & water	Yes	Yes

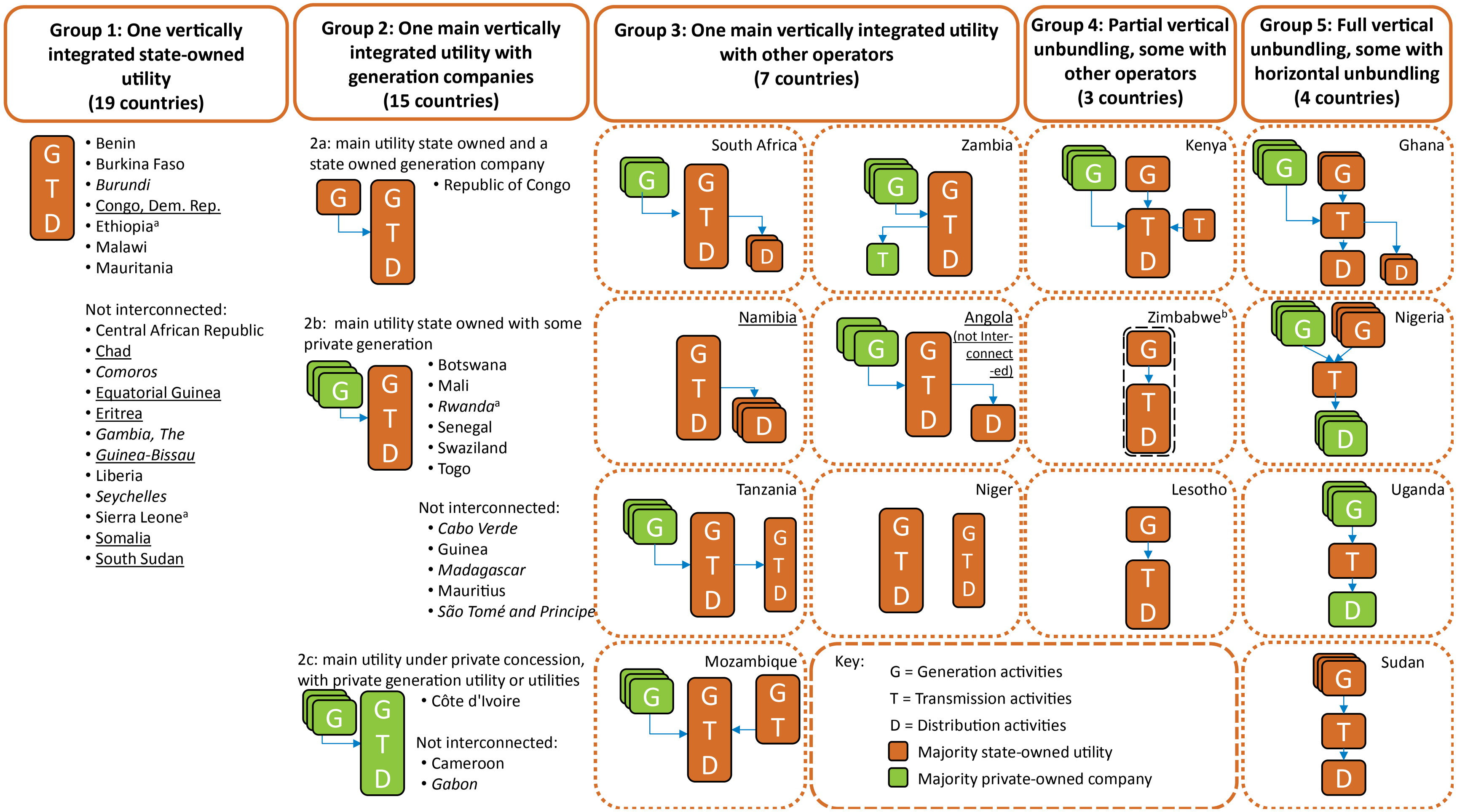
Country	Reference year	Reference utility	FY end	Utility service coverage	Financial statements published	Audited statements available
Malawi	2014	Escom (Electricity Supply Corporation of Malawi)	30-Jun	Electricity only	Yes	Yes
Mali	2014	Energie du Mali	31-Dec	Electricity only	Yes	Yes
Mauritania	2013	SOMELEC (Société Mauritanienne d'Électricité)	31-Dec	Electricity only	No	Yes
Mauritius	2013	CEB (Central Electricity Board)	31-Dec	Electricity only	Yes	Yes
Mozambique	2014	EDM (Electricidade de Moçambique)	31-Dec	Electricity only	Yes	Yes
Niger	2014	Nigelec (Société Nigerienne d'Électricité)	31-Dec	Electricity only	Yes	No
Nigeria	2014	MYTO model	31-Dec	Electricity only	No	No
Rwanda	2013	EWSA (Electricity, Water and Sanitation Authority)	30-Jun	Electricity & water	No	Yes
São Tomé and Príncipe	2014	EMAE (Empresa de Água e Electricidade)	31-Dec	Electricity & water	No	No
Senegal	2013	SENELEC (Société Nationale d'Électricité du Sénégal)	31-Dec	Electricity only	No	Yes
Seychelles	2014	PUC (Public Utilities Corporation)	31-Dec	Electricity, water & sewerage	Yes	Yes
Sierra Leone	2012	NPA (National Power Authority)	31-Dec	Electricity only	No	No
South Africa	2014	Eskom	31-Mar	Electricity only	Yes	Yes
Sudan	2014	Sudan Electricity Distribution Company	31-Dec	Electricity only	No	No
Swaziland	2014	Swaziland Electricity Company	31-Mar	Electricity only	Yes	Yes
Tanzania[a]	2014	TANESCO (Tanzania Electricity Supply Company)	30-Jun	Electricity only	Yes	Yes
Togo	2013	CEET (Compagnie Energie Electrique du Togo)	31-Dec	Electricity only	No	No
Uganda	2014	Umeme	31-Dec	Electricity only	Yes	Yes
Zambia	2014	ZESCO (Zambia Electricity Supply Company)	31-Dec	Electricity only	No	Yes
Zimbabwe	2012	Zimbabwe Transmission and Distribution Company	31-Dec	Electricity only	No	Yes

Source: World Bank staff's review of utility data and publications.

Note: FY = fiscal year; financial statements published = financial statements publicly available; MYTO = Multi-Year Tariff Order (not a utility).

a. Tanzania's reference year is January 2014–June 2015.

Figure A.1 Electricity sector structures in Africa



Note: Countries underlined are excluded in the main analysis presented in this paper because of insufficient data. *Utilities of countries in italics* provide other services such as water and sewerage. Countries are interconnected with one or more other countries unless otherwise indicated. Interconnection refers to high-voltage infrastructure to facilitate power imports and exports, and excludes medium- and low-voltage cross-border sales to local communities on the border. The study excludes 75 state-owned generation companies operating a small plant (less than 15 megawatts) that typically serve isolated rural electrification systems or specific government entities, and distribution companies that account for less than 5 percent of end-user sales, both grid-connected (for example, Senegal, Uganda, Zambia) and off-grid.

a. Sectors in Ethiopia, Rwanda, and Sierra Leone have undergone sector reform subsequent to the reference year, and sector structures have evolved from those illustrated.

b. The dotted line represents the parent company that owns the two companies in the sector.

Methodology

A quasi-fiscal deficit is the difference between the net revenue of an efficient utility ($R_{benchmark}$) and the net current revenue ($R_{current}$). Let *capex* designate benchmark capital expenditure, *opex* designate benchmark operating expenditure, and *Q* designate dispatched kWh. The tariff at benchmark performance, $tariff_{benchmark}$, in this study is (*capex* + *opex*)/0.9*Q* and the revenue of an efficient utility is $tariff_{benchmark}$x0.9*Q*, where 0.9 accounts for combined transmission, distribution, and billing losses of 10 percent (the level considered for benchmark performance). The net revenue of an efficient utility is $R_{benchmark}$ – cost = $R_{benchmark}$ – (*capex* + *opex*) = 0, signaling that the revenue fully covers cost. The revenue at current performance by contrast is $tariff_{current}$x*Q*x(0.9 – *TDL*)x(1 – *BL*), where *TDL* is transmission and distribution losses in excess of 10 percent and *BL* is bill collection losses, while the current cost is *capex* + *opex* + overstaffing cost.

Using Δ to designate unit underpricing ($tariff_{benchmark}$ – $tariff_{current}$), the quasi-fiscal deficit becomes

$$R_{benchmark} - (capex + opex) - (R_{current} - capex - opex - \text{overstaffing}) =$$
$$\text{Overstaffing} + tariff_{benchmark} \times 0.9Q - tariff_{current} \times Q \times (0.9 - TDL) \times (1 - BL) =$$
$$\text{Overstaffing} + tariff_{benchmark} \times 0.9Q - (tariff_{benchmark} - \Delta) \times Q \times (0.9 - TDL) \times (1 - BL).$$

The quasi-fiscal deficit can be decomposed into four hidden-cost components as

$$\underbrace{\Delta \times Q \times (0.9 - TDL) \times (1 - BL)}_{\text{Underpricing}} + \underbrace{tariff_{benchmark} \times Q \times TDL}_{\text{Transmission \& distribution losses}} + \underbrace{tariff_{benchmark} \times Q \times (0.9 - TDL) \times BL}_{\text{Bill collection losses}} + \text{Overstaffing.}$$

At benchmark performance, the last three terms are zero, leaving only underpricing.
This study estimates operating costs using the financial statement of the main utility listed in table A.2, and capital costs are based on the existing state-owned assets in the reference year. This methodology means that the sector structure has a significant effect on the computation of capital and operating costs. Figure A.1 shows how the structures are categorized into five groups. Various parameters used in the analysis are explained below.

- **Revenues** (amounts billed) are taken from utility financial statements and comprise only those directly related to electricity sales that are retained by electric utilities. Subsidies in the form of direct transfers from the government or international donors are excluded. Revenues not directly related to the sale of electricity are excluded, such as those earned from the sale of water for utilities that provide both services.

- **Operational expenditures** include all fixed and variable operational and maintenance costs, and taxes that are not rebated such as corporate income tax. All costs deemed to be related to capital costs are excluded because they are replaced by calculated annualized capital costs for existing assets. All loan repayments—interest payments typically recorded on income statements and principal payments typically recorded on cash flow statements—are considered to be for capital costs. Other exclusions include depreciation, losses on foreign-denominated debt, costs not directly related to electricity sales (such as for providing water services), and costs from extraordinary activities.

Capital expenditures are computed as new replacement values of state-owned generation, transmission, and distribution assets reported in utility annual reports, amortized over the economic life of the assets. Unbundled sectors (Groups 2–5 in figure A.1) require a slightly different approach. With the exception of Nigeria, which was unbundled recently and where the data from the 2015 Multi-Year Tariff Order substituted utility financial statements, the dominant state-owned distribution utility is the primary source of information. To capture all loan payments in the value chain, particularly for generation investments which typically constitute the major outlays, loan payments recorded in the financial statements of state-owned utilities upstream of distribution are identified and included. The cost of power purchases for the distribution company are reduced by the same amount to avoid double counting. No utility had reliable information on distribution lines below 1 kilovolt. The capital costs of such low-voltage lines are based on analysis of costs assumed for setting tariffs for the five-year period 2013–17 in Peru, a useful comparator with readily available data, split into urban and rural areas and increased by 25 percent to reflect higher costs in Africa.

Average tariffs are calculated by dividing the amount billed by kWh billed as reported by the utilities in the reference year.

- **Overstaffing** is estimated using benchmark employment in generation, transmission, and distribution separately. The most extensive analysis is carried out for generation based on the type and size of generation plant. The benchmark number of employees for transmission and distribution lines is set by the length of the power lines with voltage greater than 1 kilovolt and the number of customers. The total numbers of employees reported in the utilities' annual reports are compared with the staff complement in three clusters of electric utilities in Latin America with a similar number of customers and length of transmission and distribution lines.

Appendix B:
Data Sources and Methodology for Household Survey Analysis

This study uses national household expenditure surveys conducted since 2008 in 22 countries; it makes use of tariff schedules in effect as of July 2014 in 39 countries, including all of the 22 countries with household surveys. Tariff schedules include fixed charges and all taxes. For full details, see Kojima et al. (2016).

Monthly payments and connection charges

To assess affordability, bills to be paid by households for monthly consumption of 30, 50, 100, and 250 kWh are based on the lowest tariffs possible for each given consumption level where more than one tariff schedule exists. Similarly, initial connection costs are the lowest possible charges where more than one charge exists. If the survey was undertaken when a different tariff schedule was in effect, monthly nominal per capita expenditures are increased at the same rate as nominal per capita GDP in local currency to the year when the tariffs prevailing in July 2014 first came into effect. Total household expenditures are computed by multiplying the adjusted per capita expenditure by household size. If the tariff schedule in effect in July 2014 had been introduced before the survey date, household expenditures are not adjusted because the tariffs in the year of the survey are known. The timing of when the connection fees came into effect in July 2014 may be different, in which case different adjustment factors for total household expenditures are used. Connection charges were available for all but Mali, Nigeria (where the connection fee is zero but new customers have to buy the materials needed for the initial connection), and São Tomé and Príncipe. If information on when the connection charges came into effect was not available, the dates of effectiveness are assumed to be the same as those for tariff schedules. Table B.1 summarizes monthly payments, connection charges, and adjustment factors by country.

Defining access

The household expenditure surveys do not enable systematic analysis of access because the questions asked are not uniform. All but one survey (South Africa) asked about the primary source of energy for lighting. Sixteen asked about connection to the grid, and Togo's survey asked whether the household had spent money on grid electricity in the previous two months.

Table B.1 Costs of monthly consumption of 30–250 kWh and initial connection charges, and expenditure adjustment factors

Country	Survey	Tariff	Adjustment factor for tariff	Monthly spending on electricity (2014 $)				Connection fee (2014 $)	Adjustment factor for connection
				30 kWh	50 kWh	100 kWh	250 kWh		
Angola	2008	2012	1.84	0.36	0.59	2.32	9.48	52	2.02
Botswana	2009	2014	1.52	4.76[a]	6.28[a]	10.07[a]	22.53[a]	679/141[a]	1.00
Burkina Faso	2009	2008	1.00	8.46	12.26	25.47	70.71	270 capital city/ 70 provinces	1.37
Côte d'Ivoire	2008	2012	1.12	3.15	5.57	13.80	42.25	212	1.38
Ethiopia	2013	2006	1.00	0.66	0.94	2.19	6.39	76	1.13
Ghana	2013	2014	1.23	2.07	3.19	12.31	29.20	87	1.21
Madagascar	2010	2012	1.13	3.67	9.84	17.18	42.06	166	1.25
Malawi	2013	2014	1.30	2.28	3.81	7.61	19.04	101	1.30
Mali	2014	2014	1.00	3.65	6.09	15.79	59.47	Not available	
Mozambique	2009	2009	1.00	1.03	1.72	3.44	22.83	0	1.50
Niger	2011	2012	1.03	5.54	8.20	16.89	46.09	19	1.19
Nigeria	2013	2014	1.09	0.78	1.30	14.06	28.34	0	1.09
Rwanda	2010	2012	1.21	6.93	11.55	23.11	57.77	82	1.46
São Tomé and Príncipe	2010	2012	1.32	2.83	4.68	9.28	33.95	53	1.30
Senegal	2011	2009	1.00	6.76	11.26	23.34	64.71	0	1.05
Sierra Leone	2011	2008	1.00	5.62[b]	9.33[b]	18.59[b]	52.47[b]	233/118[b]	1.00
South Africa	2011	2014	1.23	3.02	5.03	10.07	25.17	107	1.00
Swaziland	2009	2014	1.26	2.63	4.38	8.75	21.88	13	1.63
Tanzania	2013	2014	1.12	2.20	3.67	11.93	50.46	197 urban/ 110 rural	1.00
Togo	2011	2011	1.00	6.54	13.99	24.32	58.97	244	1.26
Uganda	2012	2014	1.27	6.00	10.64	22.26	57.10	101	1.22
Zambia	2010	2014	1.66	4.41	4.99	6.44	15.45	125	1.66

Source: World Bank staff calculations based on utility data.

a. $141 is the first payment in an installment plan of 18, 60, or 180 months. For the 180-month plan, monthly spending increases by $4.98 in the remaining 179 months. $141 is used for the connection charge in figure 7.

b. $118 is the first payment in an 18-month installment plan, with monthly spending increasing by $6.72 in the remaining 17 months. $118 is for the connection charge used in figure 7.

Consequently, the definition of access used in this report includes all households that cited using electricity as the primary source of energy for lighting or cooking, reported positive expenditures on electricity, and reported ownership of generators or solar panels. Depending on the survey, one or more of the following levels of access to electricity can be identified:

1. People living in households that reported connection to the grid

2. People at level 1 access plus those living in households that reported using electricity—excluding generators and solar energy if they are separately counted—as the primary source of energy for lighting, cooking, or both

3. People at level 2 plus those living in households that reported using generators or diesel as the primary source of energy for lighting or cooking, or reported owning generators

4. People at level 3 plus those living in households that reported using solar panels as the primary source of energy for lighting or cooking; or reported owning solar panels; or reported using solar energy as the primary source of energy if only information on solar energy was available

5. People at level 4 plus those who reported non-zero expenditures on electricity

Level 5 is the broadest definition of access, and was used to create table 2.

Grid-electricity poverty gap and subsidies

The poverty gap for grid electricity is computed as

$$\sum_{i=1}^{i=p} \frac{\text{Required monthly payment} - 5\% \text{ of monthly expenditure for household } i}{\text{Required monthly payment}} /N,$$

where the required monthly payment is the monthly bill inclusive of taxes and other charges that a household has to pay to consume the corresponding amount of electricity, P is the total population living in households for whom the monthly payment exceeds 5 percent of total monthly household expenditures (inclusive of freely acquired food and other items), and N is the total population of the country. Where the monthly electricity bill exceeds the 5 percent share, electricity is deemed unaffordable; the degree of unaffordability for a household is the size of the gap between the bill and the 5 percent share when this is positive, zero otherwise. Although monthly consumption of 30 kWh is the basis for defining affordability, the poverty gap is also computed for 50, 100 (multitier framework tier 4), and 250 kWh (multitier framework tier 5) a month to see how many people can afford higher consumption. This study also takes the numerator in the above equation and aggregates the affordability gap (where it is positive) across all households using household weights. The sum is the amount of subsidy needed to enable every household to keep spending on electricity at or below 5 percent of total household expenditure.

Female-headed households

This study carries out simplified regression analysis to see if, after accounting for total expenditures and location (urban or rural), female-headed households are any more likely to use electricity than male-headed households, and whether spending on electricity shows any differences. Probit regressions (for the first three variables listed below) and ordinary least squares (for the last) are carried out for urban and rural households separately on the following dependent variables:

- Expenditure dummy for positive expenditures on electricity (1 if positive, 0 if zero or missing)

- Electricity dummy for citing electricity of all forms, including generators and solar energy, as the primary source of energy for lighting or cooking (1 if electricity was used for lighting or cooking, 0 otherwise)

- Grid dummy (1 if the household has access according to levels 1 or 2, 0 otherwise)

- Logarithm of expenditures (log expenditure) on electricity for those households that reported positive expenditure, and repeating the regression with the sample confined only to those connected to the grid according to level 1

The following explanatory variables are tested using a 5 percent significance test (that is, the probability that the coefficient for the independent variable is actually zero when the regression shows a non-zero value is less than 5 percent):

- Logarithm of household expenditures per capita
- Logarithm of household size
- Dummy for female- and male-headed households (1 for female, 0 for male)

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