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Who Uses Electricity in Sub-Saharan Africa?

Findings from Household Surveys

Masami Kojima
Xin Zhou
Jace Jeesun Han
Joeri de Wit
Robert Bacon
Chris Trimble

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Abstract

Analysis of household expenditure surveys since 2008 in 22 Sub-Saharan African countries shows that one-third of all people use electricity. As expected, users are disproportionately urban and rich. In communities with access to electricity, lack of affordability is the greatest barrier to household connection. Lifeline rates enabling the poor to use grid electricity vary in availability, with six countries allowing 30 kilowatt-hours or less of electricity usage a month at low prices. Affordability challenges are aggravated by sharing of meters by several households—denying them access to lifeline rates—and high connection costs in many countries, made worse by demands from utility staff for bribes in some countries. Collection of detailed information on residential schedules enabled calculation of the percentage of total household expenditures needed for electricity at the subsistence and other levels. Affordability varied across countries, with grid electricity even at the subsistence level being out of reach for the poor in half the countries and even more so once connection charges are considered. Examination of the gender of the head of household shows that female-headed households are not disadvantaged in electricity use once income and the place of residence (urban or rural) are taken into account. However, female-headed households tend to be poorer, making it all the more important to focus on helping the poor for the goal of achieving universal access. Installing individual meters and subsidizing installation, encouraging prepaid metering so as to avoid disconnection and reconnection charges, reformulating lifeline blocks and rates as appropriate, and stamping out corruption to eliminate bribe-taking can all help the poor.

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Masami Kojima, Xin Zhou, Jace Jeesun Han, Joeri de Wit, Robert Bacon, and Chris Trimble[1]

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Contents

Abbreviations

GDP	gross domestic product
kWh	kilowatt-hour(s)
VAT	value-added tax

Introduction

Sub-Saharan Africa (Africa hereafter) lags behind all other regions of the world in household access[2] to electricity, per capita power consumption, and installed generation capacity. Africa accounted for 13 out of the top 20 countries in the world with the largest numbers of people without access to electricity identified in the Global Tracking Framework report published in 2015 (World Bank and IEA 2015). The report found that the percentage of people living in households with access to electricity in 2012 was about 35 percent. However, disparity between urban and rural areas was stark—69 percent of urban residents but only 15 percent of rural residents were estimated to have had access to electricity. The region with the second lowest access rate, South Asia, had more than double the percentage of people living with electricity (79 percent), and nearly five times the percentage share of rural residents with electricity (70 percent).

The global initiative, *Sustainable Energy for All*, brings diverse partners together to work toward universal access to electricity by 2030. Africa is likely to be the last region of the world to reach this target. Years of underspending, serious shortcomings in operational efficiency, underpricing, high costs of small-scale operation, over-reliance on expensive oil-based power generation, and the inability of many customers to pay for electricity services have contributed to much lower generation capacity per capita than in other regions. Existing customers face frequent power outages, and new connections in some countries have barely kept with population growth.

Benefits of electrifying households are many. Electric lighting is safer, more convenient, and far more efficient than kerosene lamps. Electricity enables households to use electronic forms of communication, and refrigeration makes food safer as well as reduces the frequency of grocery shopping and cooking. Studies analyzing data from household surveys have found positive effects of electrification on income (Kumar and Rauniyar 2011; Khandker et al. 2012; Khandker, Barnes, and Samead 2013; Van de Walle et al. 2013), employment (Dinkelman 2011; Khandker et al. 2012; Grogan and Sadanad 2013; Van de Walle et al. 2013), and education (Kumar and Rauniyar 2011; Khandker et al. 2012; Khandker, Barnes, and Samead 2013; Van de Walle et al. 2013).

In order to understand better why so many households in Africa do not have access to electricity despite its many benefits, some have studied possible constraints facing households. Komives et al. (2005) analyzed electricity access by quintile and by poverty status. The study covered about 40 countries, and predictably found that access was much lower for poor households. However, only three countries in Africa were included in the study, and most other countries had much higher rates of access. The study assessed the effectiveness of subsidies embedded within the tariff structure and the potential improvements that could be made by redesign of the tariff structure.

Komives et al. broke down access into two factors in assessing whether subsidies could benefit low-income households: the “community access rate” and the “connection rate” for those living in communities with

[2] In international initiatives to achieve universal access, access has come to mean having electricity at home, and this paper uses the word in that sense. However, some literature has defined access to mean availability of electricity in the community and uses the term “coverage” to mean having electricity at home. The difference between percent coverage and percent access is the percentage of people or households who live in communities with electricity but have chosen not to have it at home (for example, have chosen not to connect to the grid), most usually for financial reasons. To the extent that anyone can have a generator at home, private generators are excluded from access in the latter sense.

electricity. Together these factors defined the "access" rate.[3] For example, 88 percent of all households in Cabo Verde lived in communities that had connection to the grid, while 63 percent of these households were actually connected, leading to an overall access rate of 55 percent. The difference between community access and household access was much greater for poor households—72 percent of the poor had community access in Cabo Verde, but only 34 percent was actually connected, giving an access rate of 25 percent. The situations in São Tomé and Príncipe and Rwanda were similar—community access was only slightly lower for the poor, but household connection of those with community access was much lower. The distinction between "community access" and "household access" was shown to be important in the study by Van de Walle et al. (2013). This showed that non-connected households, when their neighbors were connected, may have also received benefits from the electrification. This conclusion suggested that the overall benefits from providing access could be greater than those accruing just to the households connected.

Briceño-Garmendia and Shkaratan (2011) analyzed spending on electricity by quintile in Africa. They found that the share of total household expenditure allocated to electricity was below 3 percent in most countries, and that the share was relatively stable across expenditure quintiles. The authors used this information to check whether households could afford to pay the full economic cost of consumption at the subsistence level. Affordability was defined as spending being in the range of 3–5 percent of total household expenditure, while consumption at the subsistence level was defined as 50 kilowatt-hours (kWh) per month. The study found that on existing tariffs consumption at the subsistence level is affordable for the large majority of those already connected. However, for those not already connected consumption at the subsistence level would be affordable at existing tariffs for only one-quarter of such households. Were tariffs to be raised to cost recovery levels, far fewer of the unconnected would be able to afford to purchase even consumption at the subsistence level. An even larger barrier to access is the existence of a connection charge. Golumbeanu and Barnes (2013) described the way in which connection charges can be so large that they are unaffordable for many low-income households. Evidence from a number of countries indicated that countries with higher connection charges, controlling for the level of gross domestic product (GDP) per capita, tended to have lower access.

Surveys of household access to electricity and its use have highlighted the issue that some households pay nothing or only part of the appropriate charge for the use of electricity. Smith (2004) pointed out that electricity theft could be in the form of fraud (meter tampering), stealing (illegal connections), billing irregularities, and unpaid bills. Calculations based on data from 102 countries showed that average transmission and distribution losses, which include losses from theft, had increased between 1980 and 2000 for all regions except Western Europe and North America. Antmann (2009) provided an analysis of methods of reducing technical and non-technical losses in the power sector drawn from experience in several countries. The use of pre-payment meters has been identified as one way of dealing with delinquent bill payment by households. Tewari and Shah (2003) describe the South African experience, starting in 1989, of the introduction of pre-paid meters and their benefits, costs, and problems. A study by Jack and Smith (2015) of purchasing patterns of electricity in South Africa through pre-payment meters found that the bottom-quintile households tended to buy electricity three times as often but in amounts that are only one-fifth of those households in the top quintile. The pattern of small frequent transactions is consistent with the existence of liquidity constraints and difficulties in smoothing income, suggesting that the pay-as-you-go approach of pre-paid meters is preferable for low-income households to a monthly billing cycle. In Uganda

[3] Komives et al. used the term "access" to denote the fact that households in the neighborhood had an electricity connection and "connection" to indicate that the household was itself connected to the grid. Angel-Urdinola and Wodon (2007) called the former "community access" and the latter "users".

bulk metering was introduced for micro and small enterprises in 2009 and pre-payment meters for households in 2012. An analysis of the bulk metering program by Never (2015) indicated that although this approach improved bill collection, there were still problems of theft and inability to pay.

This paper is part of a broader study examining the financial viability and related aspects of the power sector in Africa. The broader study focuses primarily on grid electricity for reasons of data availability at the regional level. The study examines quasi-fiscal deficits—difference between the total cost of providing electricity and total cash collected by utilities—in 39 countries (Trimble et al. 2016), tariff structures in 39, and household use of electricity in 22.[4] The component on household use of electricity, which is the subject of this paper, takes household expenditure surveys to gain a better understanding of who uses electricity, what type of electricity, and how much. It asks the following questions:

- How widely is electricity used?
- What are the barriers to making electricity the main source of energy in Africa for lighting and powering appliances?
- Is electricity affordable?
- Is there potential evidence suggesting that female-headed households are disadvantaged in some ways with respect to electricity use?

Although household expenditure surveys capture spending on all forms of electricity, as with the broader study, detailed analysis is carried out primarily on issues associated with grid connection.

Scope and Methodology

The household expenditure surveys analyzed in this paper were carried out in 2008 or later. The survey period and the sample size are summarized in Table A.1 in the annex. This paper reports results calculated using household weights or population weights, depending on whether percentages of households or people are being examined. The only exception is when the sample size is discussed, primarily to point out that the number of households being interviewed was too small for meaningful results (for example, the number of rural households in the bottom 40 percent connected to the grid). In each country, people are divided into quintiles based on per capita expenditures, with quintile 1 being the poorest and quintile 5 being the richest. Per capita expenditures are derived from consumption aggregates used to construct official poverty measures.[5] Poverty measurements are based on real expenditures, either per capita or per adult equivalent, except in Botswana where nominal values are used. Each quintile has the same number of people, not households. Because household size typically declines with increasing wealth, and because the rich tend to be concentrated in urban areas, upper quintiles have more households than lower quintiles and are more urban than rural. The results are analyzed by consumption quintile, households' poverty status (poor or non-poor based on the official poverty measures), location (urban or rural), and gender of the head of household. Where official poverty is based on per capita expenditure, the bottom quintile is always poor, but where poverty is based on expenditure per adult equivalent, the overlap between the poor and the bottom quintile

[4] The 39 countries are not identical. Non-overlapping countries between the components are Angola, Chad, and Namibia in the tariff analysis and the Central Africa Republic, the Republic of Congo, and Sudan in the analysis of quasi-fiscal deficits. Of the 22 countries with household surveys, all but Angola were analyzed for quasi-fiscal deficits.

[5] The methodology for consumption aggregation for the purpose of defining poverty varies from government to government, and therefore quintiles are not strictly comparable across countries because what is included in consumption aggregates is not the same.

is not complete. Households that had spent more than 30 percent of their total expenditures on electricity are considered outliners and dropped.

All questionnaires except the one in South Africa asked for the primary sources of energy for lighting and cooking; the South African survey asked if the household was connected to the grid, and the response to that question substitutes the question about the primary energy source for lighting in the rest of this paper.

Some surveys listed off-grid electricity separately (typically solar and backup generators), while some had only one category called electricity. "Solar energy"—the term used in Botswana, Burkina Faso, Ethiopia, Ghana, Senegal, Swaziland, and Uganda—could mean solar home systems only or could include solar lanterns. This lack of distinction is unfortunate because solar lamps would not fall under the category of electricity access, whereas solar home systems would. Mali, Mozambique, Rwanda, Sierra Leone, Tanzania, and Zambia asked specifically about solar panels. Seventeen surveys asked specifically about grid electricity, of which sixteen asked if the household was connected to the grid, and Togo asked about paying electricity bills over the previous two months (thereby excluding those connected to the grid but had not made payments during the recall period); several asked respondents if they had their own meters or were sharing meters with others.

Spending on electricity in this paper excludes expenditures on items not considered as part of access to electricity: batteries, candles, kerosene, and liquefied petroleum gas. While fuels for generators would be part of spending on electricity, only Rwanda and Zambia enabled isolation of spending on fuel for generators; all other countries bundled spending on gasoline and diesel for vehicles or lawn mowers with spending on either fuel for generators. For consistency across countries, spending on diesel used in generators in these countries was excluded from expenditure on electricity.

The surveys did not enable systematic analysis of access at different levels according to the recently formulated multi-tier access framework for the Sustainable Energy for All initiative. The framework defines energy access as the ability to obtain energy that is adequate, available when needed, reliable, affordable, legal, convenient, healthy, and safe for all required energy applications (World Bank 2015). For household connection to electricity, there are five tiers in the framework, with grid electricity corresponding to tiers 3–5 depending on appliances being used and kWh consumed per year and per day. Information on appliance use was not available in any survey, and plausible data on kWh consumed were available in only two to three surveys. In the face of these data limitations, this paper instead examined access at five different levels:

1. People living in households that reported connection to the grid
2. Adding to 1 people 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. Adding to 2 people living in households that reported using generators or diesel as the primary source of energy for lighting, cooking, or both, or reported owning generators
4. Adding to 3 people living households that reported using solar panels as the primary source of energy for lighting, cooking, or both, or reported owning solar panels; or solar energy in the place of solar panels if only information on solar energy was available
5. Adding to 4 people who reported non-zero expenditures on electricity.

Definition 2 is the same as definitions 3 and 4 in Malawi and São Tomé and Príncipe where the survey did not specifically asked about use of generators and solar panels or solar energy. Access to solar panels is preferred

whenever information is available so as to avoid including people living in households using one or two solar lanterns. In countries where survey questionnaires asked only about solar energy (Botswana, Burkina Faso, Ethiopia, Ghana, Senegal, South Africa, Swaziland, Togo, and Uganda), definition 4 could well over-estimate the number of people with access, if households with solar lanterns had replied that they were using solar energy for lighting.

All surveys asked about spending on electricity, most commonly in the last 30 days. There are limitations with this approach. Payment arrears may be common, but no household surveys in this paper probed this point. By contrast, the 2012 National Survey of Household Income and Expenditures in Mexico asked a series of questions to understand arrears, including when the last payment for electricity had been made, while the 2005 Integrated Sample Household Budget and Labor Survey in the Kyrgyz Republic asked for kWh of electricity consumed, the amount billed, and the amount paid for three successive months as well as the amount of subsidy received. Most household surveys, however, simply ask how much the household paid last month for electricity. Asking just one question about how much the household paid over a fixed period of time could under- or over-estimate (the latter if past debts are being repaid to utilities) monthly expenditures on electricity. Cross-checking household survey data against data from the utilities could indicate the magnitude of these problems and ways of adjusting data for a more accurate picture. Lampietti and Junge (2006) combined billing and payment records from the utility and merged them with household survey data to address recall errors, under- and over-reporting, and the presence of arrears, which enabled more accurate estimation of current and historical electricity consumption as a function of household income and other characteristics. However, obtaining utility data for such cross-checking was outside the scope of the study.

The survey in Senegal asked if the household had spent anything on electricity over the last 12 months, which would more likely capture whether the household was paying something for electricity. If the question is about spending only in the last month only, no payment might have been made for a variety of reasons and the household would be registered as having zero expenditure. Similarly, some households did not answer the question (they might have found it difficult to recall the amount in the short time given to answer this question during the interview), and all missing responses were recorded as zero in the analysis. In all 22 countries, not all who cited electricity as the primary source of energy for lighting reported positive expenditures in electricity. Legitimate reasons for having no expenditures for grid electricity, the focus of this study, include electricity included as part of the rent, bundling of utility services (such as combined water and electricity bills), or free electricity being part of the compensation package for employment. It is also possible that the household happened not to have made payments during the recall period—for example, the household could have missed one bill payment, making up for it later.

Examination of spending on electricity was necessarily confined to those who reported positive expenditures on electricity. Among those who did, spending on electricity was computed as a share of total household expenditures as one measure of affordability. Because power tariffs in many countries are pan-territorial and do not have large regional differences that are observed with food and other items, nominal expenditures on electricity and nominal total household expenditures were used to compute expenditure shares, except in Angola and Mozambique where nominal expenditures were not available and where regionally adjusted expenditures were used.

Where enough information was available on how consumption aggregates were derived for official poverty statistics, expenditures on food were disaggregated into those paid for by cash and freely acquired food that had been assigned imputed values. The purpose of doing so was to estimate the total amount of cash

available to pay for electricity. Imputed values are also assigned to items other than food, such as collected firewood. However, separating cash expenditure on food from imputed values was considered adequate for the purpose of assessing affordability of electricity among low-income households, because by far the greatest share of non-cash expenditures is food consumption, the share of which increases with decreasing income.

To examine the affordability of grid electricity, monthly consumption corresponding to tiers 3–5 in the multi-tier matrix for access to household electricity supply was taken—30 kWh, 100 kWh, and 250 kWh, respectively—and corresponding electricity bills were computed. The bills are inclusive of energy charges, fixed charges, other charges (such as a rural electrification fund fee), and applicable value-added tax (VAT) and any other tax. They do not include charges unrelated to electricity use (specifically public television and radio license fee) even if they are always added to every residential electricity bill. In addition, 50 kWh a month was considered for comparison with the AICD and because several countries set 50 kWh as the cap on highly subsidized lifeline rates.

The monthly electricity bills for these amounts were then expressed as shares of total household expenditures for all households, whether or not they were connected to the grid. The multi-tier access framework defines electricity as being affordable if households spend less than 5 percent of total expenditures on monthly consumption of 30 kWh. This paper similarly considers grid electricity to be unaffordable if a household has to spend more than 5 percent of its total expenditures on electricity. As part of the broader study, detailed information on the tariff schedule in effect in July 2014 was collected in 39 countries, including all the 22 countries with household survey data. In many countries, more than one schedule existed, and the least-cost option was taken for the purpose of examining affordability. If the survey was undertaken when a different tariff schedule was in effect, then monthly nominal per capita expenditures were 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 and total household expenditures were then computed from the adjusted per capita expenditure. If the tariff schedule in effect in July 2014 had been first introduced before the survey date, no adjustment of expenditure was necessary—Burkina Faso, Ethiopia, Mali, Mozambique, Senegal, Sierra Leone, and Togo fell under this category and did not require any adjustment to total household expenditures. Connection charges were available for all but Mali and São Tomé and Príncipe. They were computed as multiples of total monthly household expenditures. If information on when the connection charges came into effect was not available, the dates of effectiveness were assumed to be the same as those for tariff schedules (see Table A.8 in the annex for more detail).

This paper computes the poverty gap for grid electricity in the same way the poverty gap is defined in economics as follows:

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

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 their 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, and 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 (multi-tier framework tier 4), and 250 kWh (multi-tier framework tier 5) a month to see how many people can afford higher consumption. For these

calculations, the lowest-cost tariff schedule for each consumption level is taken where there are two or more possible schedules. This paper 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 its total household expenditure.

In addition to the poverty gap, this paper also computes the poverty headcount for grid electricity. The poverty gap takes account of the depth of poverty and is 100 percent only if every person has zero total household expenditure. The poverty headcount, by contrast, is simply the percentage of people who find consumption of a certain amount of electricity unaffordable according to the household-expenditure-share threshold of 5 percent. If every person has to spend 5.05 rather than 5.00 percent of total household expenditures to purchase electricity, the poverty headcount would be 100 percent but the poverty gap would be 1 percent, which is the difference between 5.05 and 5.00 divided by 5.00.

Lastly, in additional to analysis of supplementary questions related to grid electricity, the study also investigated differences in electricity use between female- and male-headed households. Simplified regression analysis was carried out country by country to see if, after accounting for total expenditures and location (urban or rural), female-headed households were any more likely to use electricity than male-headed households, and whether spending on electricity showed differences. Probit regressions (for the first three below) and ordinary least squares (for the last) were carried out on the following dependent variables:

- 1/0 “expenditure dummy” for having positive expenditures on electricity (1 if positive, 0 if zero or missing)
- 1/0 “electricity dummy” for citing electricity of all forms, including generators and solar, as the primary source of energy for lighting or cooking (1 if electricity was used for lighting or cooking, 0 otherwise)
- 1/0 “grid dummy” for connection to the grid, or if that information was not available, for citing electricity excluding generators and solar as the primary source of energy for lighting or cooking where generators, solar, or both were separately listed
- logarithm of expenditures (“log expenditure”) on electricity for those households that reported positive expenditure, and in addition repeating the regression confining the sample only to those connected to the grid

The following explanatory variables were tried and their statistical significance was tested using at 5-percent significance test[6] (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 total household expenditures
- logarithm of per capita expenditure and logarithm of household size as an alternative to the above
- 1/0 dummy for female- and male-headed households (1 for female, 0 for male)
- 1/0 dummy for urban and rural (1 for urban, 0 for rural)

The dummy for urban/rural may be viewed as a proxy for the level of infrastructure development, and more specifically a crude proxy for the availability of grid electricity. This variable was always statistically

[6] This paper uses a 5-percent significance test, or a 1-percent test when results are highly implausible were the true coefficient zero.

significant, raising the question of whether the independent variable of interest, female/male dummy, may be correlated with it. To examine this question, another probit was tested with the urban/rural dummy as the dependent variable and the logarithms of per capita expenditure and household size and the female/male dummy as explanatory variables. With the exception of Angola, the female/male dummy was always statistically significant. Therefore, the sample was split into urban and rural in every country, and regressions were run separately, eliminating the urban/rural dummy as an explanatory variable.[7]

In every case where the coefficient for female/male dummy was statistically significant, the probability of increasing the dependent variable by switching from male- to female-headed households was computed. For that purpose, the values of the remaining two variables assumed the weighted averages in urban and rural areas, respectively. For ordinary least squares, which drops all households with zero expenditure on electricity and regresses the logarithm of spending on electricity on the three explanatory variables, the percent increase in spending on electricity (not logarithm) was computed, again setting the values of the two remaining variables at average values of the households in the sample.

For cross-regional comparison of household access to electricity, presented first, access rates in 1990 and 2012 in different regions from the 2015 Global Tracking Framework report (World Bank and IEA 2015) were compared as a function of two measures of the poverty gap ($3.10 and $1.90 per day per person at purchasing power parity in 2011 international dollars) and of logarithms of per capita GDP (at the market exchange rate in 2005 U.S. dollars and at purchasing power parity in 2011 international dollars). 2012 was selected because it is the last year for which access rates are available in the Global Tracking Framework report, three other years being 1990, 2000, and 2010. 1990 was selected as an alternative because the poverty gap in South Asia, the region with the second lowest rate of access to electricity, was close to that in Africa in 2012. Unlike GDP, the availability of the poverty gap data is sporadic, reducing the sample size by more than half. For access in 2012, corresponding poverty gap data were taken from 2012 whenever they were available, and otherwise from 2011 or 2013, and if the data were not available from any of these years, they were taken from 2010 (the poverty gap in 2014 was not available for any country). For 1990, in order to capture India, which had the poverty gap data in 1987 and 1993 but no other year in between, the range of years was extended to 1987–1992. For regression equations, in addition to access, per capita GDP, and the poverty gap, 1/0 regional dummies for Africa, South Asia, East Asia and Pacific, Latin American and the Caribbean, and “other” for the countries in the remaining regions were also used.

The next section entitled “Cross-Regional Perspective” is the only one that does not use data from recent household surveys in the 22 countries covered in the rest of the paper. It is also the only section that defines the poverty gap according to the poverty lines of $3.10 and $1.90 per person per day. Elsewhere, the poverty gap refers to the grid-electricity poverty gap defined in the equation above. To distinguish different measures of the poverty gap, “poverty gap” is followed by threshold values: $3.10, $1.90, 30 kWh, 50 kWh, 100 kWh, and 250 kWh.

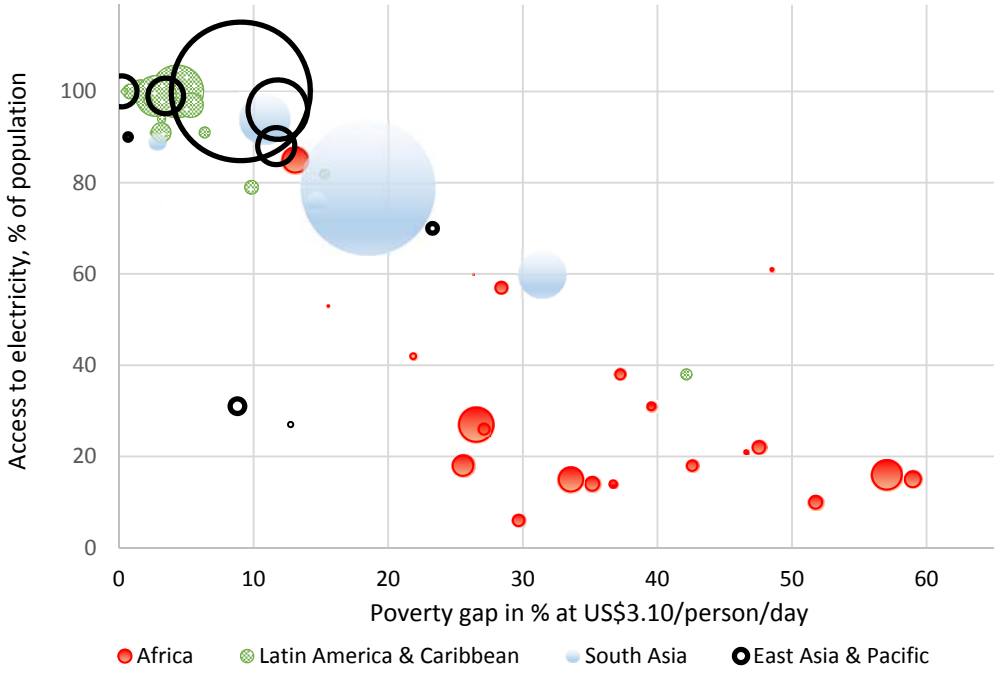
[7] For the probit for the dependent variable that excludes generators and solar, ideally the sample should be restricted to those who could potentially have connected to the grid. Only Malawi and Nigeria asked that question of each household and the main reason for choosing not to connect. One approach is to assume that if there was at least one household citing electricity use in a sampling unit, the entire sampling unit was electrified. In the context of Africa, such an assumption may be too sweeping, and was not examined in this study.

Cross-Regional Perspective

Broadly, access expansion mirrors economic development. Does access in Africa as a function of income or depth of poverty fall in line with the rest of the world? To answer this question, access in different countries was compared as a function of the poverty gap at $3.10 and $1.90 and per capita GDP. Correlation coefficients between access and the two measures of the poverty gap and per capita GDP are statistically significant at 1 percent, with correlation coefficients ranging from -0.72 for the logarithm of GDP per capita at the market exchange rate to -0.89 for the poverty gap at $3.10.

Figure 1 plots the relationship between access and the poverty headcount at $3.10 for 2012. There is a downward sloping line on which most countries in regions other than Africa lie, whereas several countries in Africa lie markedly below, as do Cambodia and Vanuatu. When access is regressed on any one of the measures of the poverty gap or per capita GDP together with 1/0 regional dummies, Africa is the only region for which the coefficient for the regional dummy is consistently negative and statistically significant at 1 percent. The predictive power of the poverty gap at $3.10 was the highest, followed by the poverty gap at $1.90, the logarithm of per capita GDP at purchasing power parity, and finally the logarithm of per capita GDP at the market exchange rate.

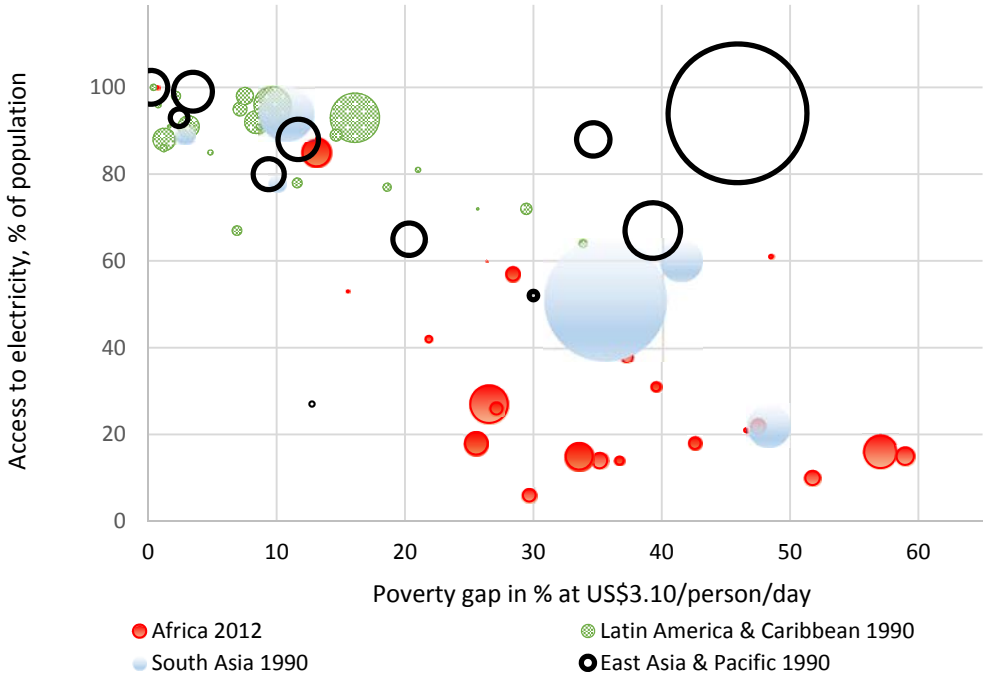
Figure 1: Relationship between poverty gap and electricity access in 2012



Source: World Bank staff analysis using data from World Bank 2016 and World Bank and IEA 2015.
Note: Bubbles are in proportion to population.

Figure 2 compares access and the poverty gap in Africa in 2012 with corresponding values in three other regions in 1990. China stands out as a (positive) outliner, with the access rate far above that of other countries at similar levels of the poverty gap. Several countries in Africa again lie below the global trend line. When access (in 2012 in Africa and in 1990 elsewhere) is regressed on the poverty gap at $3.10 (in 2012 in Africa and in 1990 elsewhere) together with regional dummies as dependent variables, the Africa dummy is again negative and statistically significant at 1 percent. While these are simplified analyses, these findings point to the special challenges facing Africa in expanding household access.

Figure 2: Comparison of Africa in 2012 with other regions in 1990



Source: World Bank staff analysis using data from World Bank 2016 and World Bank and IEA 2015.
Note: Bubbles are in proportion to population.

Descriptive Statistics

Household surveys in the 22 countries show that, on average, two-thirds of all people lived in rural areas (see Table A.2 in the annex). In terms of numbers of households, one-third of households lived in rural areas in South Africa, but in all other countries the percentage was 42 or higher. In 16 countries, the average per capita expenditure in every rural quintile (calculated using population weights) was lower than in the corresponding urban quintile, and in seven countries household expenditure in every rural quintile (calculated using household weights) was similarly lower. The median for the percentage of people who were officially classified poor across the 22 countries was 46 percent. In rural areas, the poor constituted a majority, with a median of 56 percent of all people and a weighted average of 50 percent. About one-fifth of all people lived in households headed by a woman. The median of the percentage of people living in female-headed households was 23 in urban areas, 20 in rural areas, and 21 percent of the total population. At the highest end of the spectrum, Botswana stands out with half of all people living in female-headed households; at the opposite end is Mali with only 4 percent reporting living in female-headed households. Across the 22 countries studied, the median monthly per capita expenditure in 2014 U.S. dollars[8] was $73 in urban areas and $37 in rural areas, giving a national median of $49 per capita per month.

Measuring Access in Household Surveys

What information about access do household surveys provide? How many surveys provide enough information about kWh of electricity consumed by each household—essential information for designing targeted subsidies? How do access rates differ by income, between urban and rural, between the poor and

[8] Expenditures were adjusted for inflation to 2014 and converted to U.S. dollars using the exchange rate in 2014.

non-poor? As explained on page 6, this paper uses five measures to calculate access. Access statistics by location, quintile, and poverty status using the most expansive definition (definition 5) are shown in Table 1; the statistics using the first definition (grid connection) are reported in Table A.3 in the annex. The results are consistent with the general observations made elsewhere that access rates in rural Africa are significantly lower than in urban areas, the poor are far less likely to have access to electricity than the rich, and in some countries access of the rural poor to electricity is essentially non-existent. Overall, the poor in nine out of 22 countries had an access rate of less than 5 percent.

Table 1: Percentage of people with access to electricity according to definition 5

	All people					People classified poor		
Country	Urban	Rural	Total	Q1	Q5	Urban	Rural	Total
Angola	75	14	47	8	85	40	6	16
Botswana	63	23	46	15	79	42	10	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	23	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[a]	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

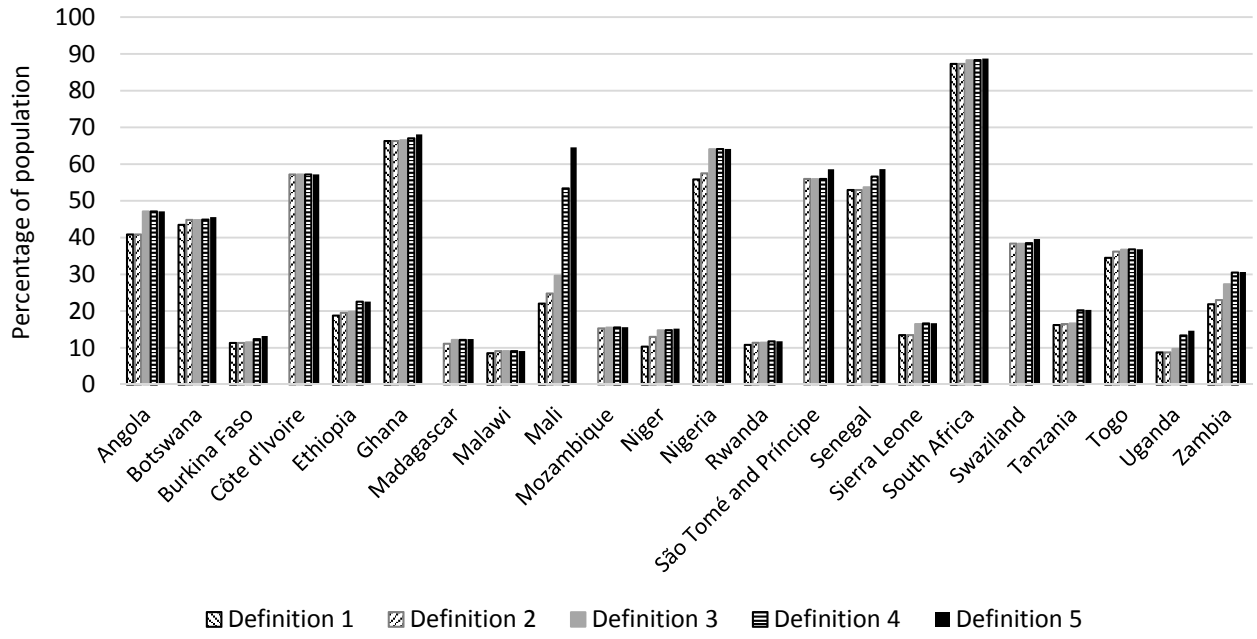
Source: World Bank staff analysis of household surveys

a. The statistics for Togo are not for those who are connected to the grid because that question was not asked, but for those who reported positive expenditures on electricity utility bills.

Differences in access rates according to the metrics as defined on page 6 are shown in Figure 3. The difference in the rate of access between definition 1 and definition 5 represents largely people who use electricity other than grid electricity and people who failed to report grid connection (possibly those connected to neighbors' grid and did not consider themselves connected to the grid). The difference was striking in Mali, especially in rural areas and among the poor where the differences reached 50 percentage points. Two factors accounted for this difference. For rural residents, the most important cause of the difference was extensive use of solar panels. For the urban poor, it was non-zero expenditures on electricity by those who did not cite electricity as the main source of lighting or cooking. These expenditures were small in urban areas. However, in rural areas, spending on electricity by those who did not cite electricity as the main source of lighting or cooking, did not indicate connection to the grid, or did not own a generator or a solar panel was much higher when expressed as a share of total household expenditures, and significantly

higher among the rural poor. It was not possible to infer from the questionnaire what explains this odd result. The second largest difference was found in Zambia, where the difference was due largely to use of generators in rural areas. Lastly, in Niger the difference in access between definitions 1 and 5 was larger than 10 percentage points for urban households as well as for the urban poor. The greatest contributing factor was use of electricity as the primary source of energy by those who did not report connection to the grid, followed by use of generators (even among the urban poor); the survey did not ask questions about solar energy. The difference also exceeded 10 percentage points in rural Nigeria and rural Ghana. In rural Nigeria, it was due to generator ownership: nearly one-fifth of all rural households own generators; the questionnaire did not ask about solar energy. In rural Zambia, the difference was due three-fifths to generator use and two-fifths to solar panels.

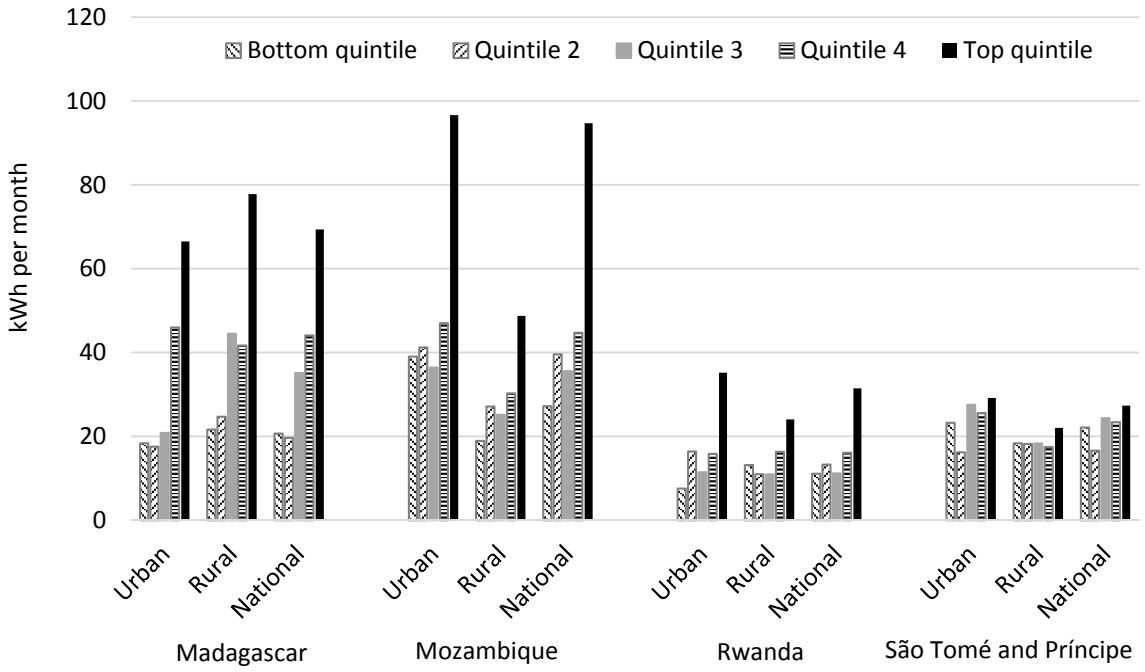
Figure 3: Percentage of people using electricity according to different definitions of access



Source: World Bank staff calculations using household survey data.
Note: For a descriptions of the five definitions of access, see page 6.

Only four surveys—Madagascar, Mozambique, São Tomé and Príncipe, and Togo—asked about quantities of electricity consumed. Recalling quantities of electricity consumed is even more challenging than recalling the amount spent, and the evidence of this challenge was clear in São Tomé and Príncipe, where 15 surveyed households reported electricity consumption of 1 kWh *a year*, 11 of them in the top quintile. The results were even more striking in Togo, where average monthly consumption was only 5 kWh, reaching only 6 kWh even in the top urban quintile. Such a consumption pattern seems more indicative of a lack of understanding of kWh as a unit of electricity than actual consumption. In addition, there was one country—Rwanda—that enabled back-calculation of kWh consumed from spending on electricity because the tariff schedule consisted of a single block with a unit charge applicable to all residential consumers and no fixed charges, and the survey asked about the last electricity bill. Taking the tariff schedule in effect at the time of the survey, kWh consumed was calculated. The results for those reporting non-zero quantities (and non-zero spending on grid electricity in the case of Rwanda) are presented in Figure 4 for all these countries other than Togo.

Figure 4: kWh of electricity consumed per month by expenditure quintile and location



Source: World Bank staff calculations using household survey data.
Note: The survey in São Tomé and Príncipe had many households reporting exceptionally low monthly consumption, including those in the top quintile. They are reported to illustrate difficulties encountered in obtaining information on electricity consumption. Rwandan consumption is calculated from expenditures and the unit price in effect at the time of the survey.

The results show the predictable pattern of increasing consumption with increasing quintile, and significantly higher consumption by the top quintile in the first three countries where the results seem more plausible than in São Tomé and Príncipe or Togo. Rwanda, the only country in which kWh consumed was calculated from reported billed amounts, shows low consumption compared to Madagascar or Mozambique. In addition to seeming confusion about units for electricity consumption, another reason for caution in interpreting the results is the very small sample size in lower quintiles, especially in rural areas, leading to results that are not meaningful. For example, the bottom three quintiles in rural Mozambique had a total of only 11 households reporting kWh consumed. The bottom two quintiles in Rwanda similarly had only 7 and 12 households, respectively, connected to the grid with positive expenditures.

Spending on Electricity

The share of household expenditures spent on electricity among those with non-zero spending on electricity provides an indication of how much households are willing to spend, balancing affordability with the perceived value of electricity. The results are summarized in Table 2 for the share of household expenditures that include imputed values of freely acquired items, largely home-grown food. The corresponding results by quintile are given in Table A.4 in the annex. The median expenditure share is about 3 percent, and not markedly higher among the poor. The findings are consistent with households not spending much more than 5 percent of their total expenditures on electricity. However, there was considerable variation across the countries, ranging from a mere 0.3 percent in Malawi to 9.3 percent in Swaziland. Notable exceptions include the poor in Botswana and Swaziland. Urban households spent a larger share in 13 out of 22 countries.

However, Sierra Leone stands out with the average rural expenditure share being twice as high. Among the poor, urban expenditure shares were higher in 15 countries, although the numbers of households in the sample are too small for meaningful results in many countries. Expenditure shares were higher for female-headed households in 19 out of 22 countries. Uganda was exceptional in that there were no households among the urban poor who had purchased electricity; 0.8 percent of the urban poor reported receiving free electricity.

Table 2: Share of total household expenditures spent on electricity

	All households			Poor			Household head	
Country	Urban	Rural	Total	Urban	Rural	Total	Female	Male
Angola	4.0	2.9	4.0	5.6	4.2	5.5	3.1	4.2
Botswana	6.2	7.6	6.5	9.5	11.1	9.8	6.8	6.2
Burkina Faso	4.6	4.1	4.5	6.2	3.3	5.2	4.6	4.5
Cote d'Ivoire	2.5	2.4	2.5	3.1	3.0	3.1	2.5	2.5
Ethiopia	2.8	1.3	2.2	4.6	2.4	3.7	2.8	2.0
Ghana	2.6	2.0	2.4	3.1	2.4	2.7	2.5	2.4
Madagascar	4.4	4.1	4.3	4.1	3.7	3.9	4.6	4.3
Malawi	0.3	0.3	0.3	0.4	0.4	0.4	0.3	0.3
Mali	2.9	1.4	2.2	2.4	1.2	1.4	2.6	2.2
Mozambique	3.7	4.0	3.7	6.1	7.5	6.4	4.2	3.6
Niger	3.4	2.4	3.2	2.8	1.9	2.2	3.6	3.1
Nigeria	2.6	2.3	2.5	3.1	2.7	2.9	2.8	2.4
Rwanda	1.4	1.6	1.5	2.3	3.3	2.9	1.6	1.4
São Tomé and Príncipe	2.0	1.9	2.0	2.3	2.1	2.2	1.9	2.1
Senegal	3.7	3.6	3.7	3.7	3.5	3.6	3.7	3.7
Sierra Leone	4.5	9.1	4.6	4.9	13.2	5.2	4.5	4.6
South Africa	5.3	5.2	5.3	7.3	6.0	6.6	5.5	5.1
Swaziland	9.5	9.1	9.3	13.9	10.9	11.9	9.7	9.0
Tanzania	3.0	3.3	3.1	1.9	5.8	3.1	3.4	2.9
Togo	3.1	3.1	3.1	3.6	3.3	3.5	3.1	3.1
Uganda	2.4	1.9	2.4	—	3.6	3.6	2.6	2.3
Zambia	5.4	6.3	5.5	8.3	5.4	7.8	5.7	5.4
Median	3.3	3.0	3.1	3.7	3.4	3.6	3.3	3.1

Source: World Bank staff calculations using household survey data.
Note: Only households with positive expenditures on electricity are analyzed. In Ghana, South Africa, Uganda, and Zambia, freely provided electricity is excluded.
— = No households with positive cash expenditures on electricity.

Because the amount of cash available is an important determinant of the household's ability to pay for electricity, Table 3 re-computes the shares by excluding these imputed values from household expenditures in the 18 countries where cash expenditures were computed. The corresponding results by quintile are given in Table A.5 in the annex. As an indication of how much rural households rely on freely acquired food, the urban expenditure share was larger in only 5 out of 13 countries (38 percent), in contrast to 59 percent found in Table 2. Sierra Leone and Uganda stand out with rural expenditure shares being about two-and-a-half times higher. Among the poor, in addition to these two countries, the rural expenditure share is three-and-a-half times higher in Tanzania. In absolute terms, the expenditure share appears exceptionally high in rural Sierra Leone, Botswana, and Swaziland, but this is in part because of the small sample sizes reducing representativeness of the households reporting positive expenditures. The pattern with respect to the

gender of the head of household remains the same, with female-headed households showing higher expenditure shares.

Table 3: Share of total household cash expenditures spent on electricity

	All households			Poor			Household head	
Country	Urban	Rural	Total	Urban	Rural	Total	Female	Male
Botswana	6.3	7.9	6.6	9.6	13.3	10.4	7.0	6.3
Burkina Faso	5.4	5.0	5.3	6.8	5.1	6.2	5.4	5.3
Cote d'Ivoire	2.6	2.9	2.7	3.3	3.8	3.5	2.7	2.6
Ethiopia	3.1	2.1	2.7	4.9	3.2	4.2	3.4	2.4
Ghana	2.6	2.3	2.5	3.3	2.9	3.1	2.6	2.5
Malawi	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.3
Mali	2.9	1.7	2.4	2.4	1.6	1.8	2.7	2.4
Niger	3.4	2.8	3.3	3.1	2.2	2.5	3.7	3.2
Nigeria	3.7	3.9	3.8	4.7	4.6	4.7	4.4	3.7
Rwanda	1.4	1.8	1.6	2.4	4.3	3.5	1.7	1.5
São Tomé and Príncipe	2.0	2.0	2.0	2.3	2.2	2.3	1.9	2.1
Senegal	3.8	3.8	3.8	3.7	3.9	3.7	3.8	3.8
Sierra Leone	4.5	10.7	4.6	4.9	15.5	5.3	4.5	4.6
Swaziland	9.8	9.9	9.8	14.3	12.1	12.8	10.4	9.4
Tanzania	3.4	4.3	3.5	2.0	7.2	3.7	4.0	3.4
Togo	3.2	3.5	3.2	3.7	4.0	3.8	3.1	3.2
Uganda	2.6	2.2	2.5	—	4.8	4.8	2.8	2.4
Zambia	5.7	7.0	5.8	8.8	7.9	8.7	6.1	5.7
Median	3.3	3.2	3.3	3.7	4.2	3.8	3.6	3.2

Source: World Bank staff calculations using household survey data.
Note: Only households with positive expenditures on electricity are analyzed. Total household expenditures exclude imputed values of freely acquired items, largely food.
— = no households with positive cash expenditures on electricity.

When the shares in Table 2 and Table 3 are compared, they increase more in rural areas than in urban areas when imputed values are excluded from household expenditures. The differences also predictably decrease with increasing quintile. Both demonstrate greater reliance on home-grown food by the poor and rural households. Nationally, the largest increase was found in Nigeria (53 percent increase), followed by Ethiopia (21 percent), and Burkina Faso (18 percent). There was little difference between female- and male-headed households, indicating comparable dependence on home-grown food.

Charges for Grid Electricity Use and Connection

How expensive is it to buy electricity? Are tariffs designed to make electricity affordable to the poor? Do connection charges take the ability to pay into account, or is every residential customer charged the same?

This study collected information on residential tariffs for grid electricity in effect in July 2014 in 39 countries, including the 22 countries with household survey data. Table 4 summarizes tariff concessions available to those consuming little electricity in the 39 countries. The column labeled kWh shows the size of the lifeline block (the first block in a tariff schedule with a low price per kWh, intended to help the poor consume electricity) or, in the absence of an explicit lifeline block, the first block if there are two or more blocks. The column labeled “ratio” calculates the ratio of the unit energy charge (price per kWh) in the second block to that in the first block, or if there are two or more schedules of a single block each with increasing levels of

installed capacity, the ratio of the second level of service to the schedule corresponding to the lowest unit energy charge. The unit energy charges used in computing the ratio include ad valorem taxes but exclude fixed charges, which are spread over the entire consumption and the unit values of which vary with consumption. If the first block is exempt from fixed charges and higher blocks are not, the ratio will be larger what the table shows, but if all blocks are subject to the same fixed charge, the ratio will be smaller. The comment column describes concessions offered to the lifeline rate or the first block, such as exemption from tax and fixed charges. The comment column also indicates whether increasing block tariffs apply in going from the first to the second block (different unit energy charges are applied to corresponding segments of consumption, with the unit price for the first block applying to kWh consumed up to the limit of the first block, the unit price for the second block applying to kWh above the limit of the first block up to the limit of the second block, and so on) or if volume-differentiated tariffs apply (a single unit charge, determined only by the total consumption, is applied to the entire consumption).

Table 4: Summary of residential tariff information related to lifeline rates

Country	kWh[a]	Ratio[b]	Comments
Angola	50	3.19	Increasing block tariff to 200 kWh in the social tariff schedule
Benin	20	1.65	Tax exempt but cannot exceed 20 kWh a month
Botswana	200	1.31	Information not available on whether increasing or volume-differentiated
Burkina Faso	75	1.71	75 is for 1–3 amperes and has no fixed premium; increasing block tariff
Burundi	50	2.03	Increasing block tariff; no fixed charge up to 150 kWh
Cabo Verde	60	1.23	Cannot exceed 60 kWh a month
Cameroon	110	1.72	Cannot exceed 110 kWh a month, but 110 kWh is exempt from VAT for all consumption levels; only first block is not explicitly subsidized
Chad	150	1.47	Information not available on whether increasing or volume- differentiated
Comoros	n.a.	n.a.	Single block
Côte d'Ivoire	40	2.05	First 40 kWh is VAT-exempt; increasing block tariff
Ethiopia	25	1.31	Same low energy charge for the first 50 kWh but the first 25 kWh has a lower service charge; increasing block tariff
Gabon	120	1.62	There are two schedules for social tariff 1 (capped at 120 kWh) but one (prepaid) is exempt from the fee for contribution to special electricity; tax is halved for social tariffs 1 and 2 (240 kWh)
Gambia, The	300	1.04	Increasing block tariff; prepaid energy charge is the same as that for the 1st block but with no kWh limit
Ghana	50	2.01	Lower monthly service charge, but cannot exceed 50 kWh a month
Guinea	60	2.58	Increasing block tariff
Kenya	50	5.47	Increasing block tariff
Lesotho	n.a.	n.a.	Single schedule, single block
Liberia	n.a.	n.a.	Single schedule, single block
Madagascar	25	4.40	Tariffs change by region; increasing block tariff; first 25 kWh exempt from the National Electricity Fund fee; 1st 100 kWh is exempt from VAT
Malawi	n.a.	n.a.	1 block each for prepaid (much cheaper for low consumption) and postpaid
Mali	50	1.58	Increasing block tariff; 1st two blocks exempt from VAT; access to the low rates for the first 2 blocks (50 and 100 kWh) is retained for prepaid customers if monthly consumption exceeds 100 kWh, but if post-paid exceedance automatically switches the customer to the normal tariff schedule, with a higher unit price subject to 18% VAT
Mauritania	n.a.	1.92	There are 8 schedules of single block each, and low tariffs are charged for low subscribed kVA. The monthly fixed charge increases nearly six-fold between the lowest and the second-lowest subscribed kVA.

Country	kWh[a]	Ratio[b]	Comments
Mauritius	25	1.39	Increasing block tariff
Mozambique	100	2.34	Cannot exceed 100 kWh a month; no fixed charge
Namibia	n.a.	n.a.	There are 5 schedules of a single block each with no limits on consumption.
Niger	50	1.33	Increasing block tariff
Nigeria	50	3.68	Cannot exceed 50 kWh a month
Rwanda	n.a.	n.a.	Single schedule, single block
São Tomé and Príncipe	100	1.47	volume-differentiated tariff
Senegal	75	1.07	Increasing block tariff
Seychelles	200	1.19	Increasing block tariff
Sierra Leone	30	1.43	Increasing block tariff
South Africa[c]	500	1.14	Increasing block tariff
Swaziland	n.a.	n.a.	2 schedules of single block each
Tanzania	75	3.50	Increasing block tariff
Togo	40	1.57	Exceeding 40 kWh a month moves the consumer to another schedule subject to 18% VAT
Uganda	15	3.45	Increasing block tariff
Zambia	100	2.07	Increasing block tariff
Zimbabwe	50	5.50	Increasing block tariff

Source: Utility and regulator websites and reports, and World Bank staff calculations.
Note: Names of countries with household survey data are shown in bold. "Cannot exceed so many kWh a month" means that the lifeline rate does not apply if monthly consumption exceeds the limit, and the entire consumption is charged a higher tariff, instead of increasing block tariffs. n.a. = not applicable.
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. Senegal defines the size of the consumption blocks over two months. The first block is 150 kWh over two months, shown here as 75 kWh a month.
b. The ratio of the effective energy charge, inclusive of ad valorem tax such as VAT but exclusive of fixed charges and taxes applied to 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).
c. These numbers are for Johannesburg. Depending on eligibility, poor households are provided with 50, 100, or 150 kWh of free electricity a month in Johannesburg.

To the extent that subsidies for the poor are offered, all countries use some measure of consumption (kWh a month, amperage, or kilovolt-amperes) as a proxy for income. One exception is Johannesburg in South Africa, where the city calculates a poverty index for each household based on income and other indicators and offers three different levels of free electricity—currently 50, 100, and 150 kWh a month—depending on the poverty index.

The most common lifeline block size is 50 kWh (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. In these five countries, the lifeline block is not sufficient to meet the daily electricity need in tier 3 of the multi-tier access framework; all five except Benin have increasing block tariffs. Increasing block tariffs at least allow poor households to enjoy a large price subsidy for the first block. South Africa, represented by the tariff schedule in Johannesburg, may appear as having an exceptionally large first block, followed by The Gambia. However, many municipalities in South Africa offer free electricity to the poor—such as 25, 50, 60, 100, and 150 kWh a month—depending on eligibility criteria (for example, prepaid lifeline customers consuming less than 250 kWh a month based on a 12-month average can receive 60 kWh of free electricity a month in Cape Town, falling to 25 kWh for consumption of up to 450 kWh a month on average), which differ by municipality. An interesting case is Cameroon, which has increasing block tariffs but where the unit energy charge in the

upper four of the five blocks are explicitly subsidized, the largest unit subsidy reserved for the block covering 801 to 2,000 kWh a month.

Subsidized lifeline rates are limited only to those consuming less than the cap in nine countries (Benin, Cameroon, Cabo Verde, Gabon, Ghana, Mozambique, Nigeria, São Tomé and Príncipe, and Togo), shifting households to tariffs for 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 subsidy by exceeding the limit by even 1 kWh makes it more difficult for the poor when the size of the block size is relatively small (say less than 50 kWh). The median increase in the effective unit energy charge for consuming more than the limit on the first block is 68 percent. There is large variation across countries, however, ranging from 4 percent in The Gambia and 7 percent in Senegal to 340 percent in Madagascar to 450 percent in Kenya and Zimbabwe. In Mali, pre-paid customers do not lose access to the low rates for the first two blocks and tax exemption even if they consume more than 100 kWh, but post-paid customers lose both benefits if 100 kWh is exceeded.

Table A.6 in the annex provides additional information, including the number of schedules and blocks and the type of tariffs (increasing block or volume-differentiated) in each of the 39 countries. Among the 22 countries with household survey data, only Rwanda had a single tariff schedule with one block and no fixed charges. All other countries had more than one schedule, more than one block, or both, making back-calculation of kWh consumed from spending on electricity not possible.[9] Increasing block tariffs were the most common tariff type, but there are several with volume-differentiated tariffs, of which three have volume-differentiated tariffs only between the first and second blocks, with increasing block tariffs above the second block. In countries with volume-differentiated tariffs, exceeding the lifeline block increases the unit cost of the lifeline volume by at least 47 percent (São Tomé and Príncipe), and as much as 268 percent in Nigeria, although many customers falling in the lifeline category are not being metered there. Eleven countries list separate schedules for prepaid customers.

Table A.7 compares effective unit charges (US$/kWh) for consuming 30, 50, 100, and 250 kWh a month, inclusive of taxes and all fixed charges. 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 14 countries due solely to fixed charges. The median rises from US$0.12/kWh for 30 and 50 kWh to US$0.14 for 100 kWh and US$0.17 for 250 kWh, reflecting generally progressive tariff schedules. The table also shows the payment that needs to be made to connect to grid electricity for the first time. Some countries do not charge for connection or charge very little (US$2 in Cabo Verde, US$13 in Swaziland, and US$31 in Mauritius), but others have high fees, the highest of which is $680 in Botswana. Botswana gives an option of paying over 18, 60, or 180 months, but the first payment is the same irrespective of the payment period and is high at US$140. The household survey data show that about two-fifths of customers select 18 months (no interest charged), one-quarter settle the connection charge in a single payment, one-fifth pay over 60 months (prime interest rate minus 0.5 percent), and one-tenth pay over 180 months (prime interest rate). The percentage of households in each quintile selecting a particular payment plan is surprisingly independent of quintile for the one-off payment. The share is twice in the bottom two quintiles as in the top quintile for the 18-month option and about the same difference for the 60-month option. The largest difference is seen with the 180-month option, selected by 13 percent of the households in the bottom quintile but only 5 percent of those in

[9] If there is only one schedule with multiple blocks, as in Benin, Botswana, Burundi, Cameroon, Chad, Ghana, Kenya, Niger, Sierra Leone, and Uganda, back-calculation from monthly spending on electricity is possible if there is no sharing of meters. However, as will be seen later, meter-sharing is widespread in Africa.

the top quintile. In Angola and Cabo Verde, the cost of reconnection after disconnection following non-payment is much higher than the initial connection cost.

To the extent that subsidized connection is offered to the poor, consumption is used as a proxy for income. An example is South Africa, where connection is free for 20 amperage but there is a fee for 60 amperage. In Mauritania, there are six connection fees for residential customers depending on kilo-volt amperes subscribed, ranging from US$128 to US$950. There is one country that takes the ability to pay into account: The Gambia, where the connection fee is twice as high in the Greater Banjul area because of higher income in the capital than in the rest of the country. However, this segmentation does not target the poor specifically.

Affordability of Electricity

How affordable is electricity to households? More specifically, what proportion of households would not be able to afford the subsistence level of electricity, having to spend more than 5 percent of total household expenditures? Among those who cannot afford 30 kWh, what is the gap between the percentage of household expenditures and the affordability threshold of 5 percent? How big a subsidy would it take to make monthly consumption of 30 kWh affordable to every household in each country? How do the calculated subsidies compare to utilities' quasi-fiscal deficits? What if, instead of 30 kWh (tier 3), monthly consumption is 50, or 100 (tier 4), or 250 (tier 5) kWh? How well are the measures of "affordability" at different consumption levels correlated with access? This section probes these questions. Because it is much more costly to connect rural households to the grid, it is most unlikely that current tariffs can be maintained for large-scale grid electrification in rural areas without adversely affecting quasi-fiscal deficits. The results related to rural areas should therefore be treated with caution.

Grid-electricity affordability at the subsistence level of consumption

Using tariff schedules from the utilities, this paper calculated hypothetical expenditure shares of grid electricity when consuming varying amounts, starting at 30 kWh a month, for all households, whether or not households were connected to the grid. Table 5 presents the results. On average, this share exceeds 5 percent in five out of 22 countries, but varies markedly both within and across countries. Electricity consumption at this level is least affordable in Madagascar, followed by Rwanda, Burkina Faso, Togo, and Sierra Leone. Barring provision of free electricity in South Africa, the amount of which varies by municipality and total monthly consumption, grid electricity is most affordable in Angola, with an exceptionally low lifeline rate, followed by Nigeria.[10] Electricity consumption at the subsistence level is not affordable to the poor on average in seven countries, nor to the bottom 20 percent in ten countries. Burkina Faso and Madagascar stand out for grid electricity being marginally unaffordable even to the top quintile. The result from Madagascar may at first seem inconsistent with Figure 4. However, large bill collection losses may explain in part why households in the top quintile reported monthly consumption of 70 kWh: the utility fails to collect 40 percent of the billed amounts (Trimble et al. 2016). Senegal is the only country where the electricity share

[10] A customer is placed in R1, the social tariff category capped at 50 kWh a month, by the distribution company based on its assessment of the customer's likely demand, which in turn is based on the company's estimation of the customer's income, likely ownership of electric appliances, and the neighborhood. Most customers in R1 are not metered and are billed based on the distribution company's estimation. The customer may be moved to R2 if the distribution company concludes that the consumption in the area has increased significantly; metered customers may be moved to R2 sooner if consumption exceeds 50 kWh. In practice, there are few R1 customers in the entire network and they are mostly in rural areas where consumption is minimal.

of household expenditures is smaller for female-headed households; in all other countries, the share is the same or greater than for male-headed households. Lastly, the expenditure share is greater in every country in rural areas than in urban areas.

Table 5: Expenditure share of monthly consumption of 30 kWh by location, quintile, poverty status, and gender of household head

	All households					Poor households			Household head	
Country	Urban	Rural	Total	Q1	Q5	Urban	Rural	Total	Female	Male
Angola	0.1	0.2	0.1	0.2	0.1	0.1	0.2	0.2	0.1	0.1
Botswana	2.4	5.5	3.7	15.6	1.0	6.7	9.0	8.0	4.3	3.2
Burkina Faso	6.8	9.6	8.8	15.7	5.4	11.8	12.6	12.5	13.4	8.1
Côte d'Ivoire	1.4	2.2	1.8	4.6	0.9	2.8	3.3	3.2	2.4	1.7
Ethiopia	1.1	1.3	1.3	2.7	0.6	3.3	2.2	2.3	1.8	1.1
Ghana	1.1	1.8	1.4	3.1	0.8	2.6	3.0	2.9	1.6	1.3
Madagascar	6.8	10.4	9.6	18.8	5.3	9.9	11.8	11.6	13.8	8.6
Malawi	1.3	2.3	2.2	3.8	1.3	2.3	3.4	3.2	2.7	2.0
Mali	1.0	1.5	1.4	2.5	0.7	1.8	2.2	2.2	1.4	1.4
Mozambique	1.5	2.6	2.3	5.5	0.8	3.1	3.5	3.5	3.0	2.0
Niger	2.2	3.9	3.6	5.2	2.4	4.1	4.4	4.4	5.3	3.3
Nigeria	0.3	0.4	0.3	0.6	0.2	0.4	0.4	0.4	0.5	0.3
Rwanda	5.3	9.6	8.9	16.8	3.7	11.7	13.3	13.2	11.4	8.0
São Tomé and Príncipe	1.7	1.8	1.7	2.7	1.2	2.1	2.2	2.1	1.9	1.6
Senegal	2.1	3.7	2.9	6.5	1.9	3.7	5.0	4.6	2.6	3.0
Sierra Leone	3.8	5.9	5.1	8.7	3.1	5.6	7.1	6.8	5.1	5.1
South Africa[a]	1.0	1.6	1.2	2.8	0.3	2.1	2.0	2.1	1.3	1.1
Swaziland	1.7	2.0	1.9	4.2	1.0	3.1	2.6	2.7	1.9	1.9
Tanzania	1.2	2.2	1.9	3.7	1.0	3.4	3.6	3.6	2.3	1.7
Togo	4.1	9.0	6.9	16.4	3.5	6.6	11.1	10.0	9.3	6.3
Uganda	3.1	4.9	4.4	8.6	2.3	8.6	8.8	8.7	5.3	4.0
Zambia	2.1	5.2	4.1	8.6	1.4	4.1	6.2	5.9	4.9	3.8
Median	1.7	2.5	2.2	4.9	1.1	3.3	3.6	3.5	2.7	2.0

Source: World Bank staff calculations based on utility information and household survey data.
a These numbers are for Johannesburg. Depending on eligibility, poor households are provided with 50, 100, or 150 kWh of free electricity a month in Johannesburg.

Table 6 presents results that are more easily compared to those of Briceño-Garmendia and Shkaratan (2011), except that, thanks to significant progress in energy efficiency improvement, power consumption at the subsistence level has declined from 50 kWh a month to 30 kWh in the intervening years. The table shows the hypothetical expenditure shares for those with and without actual expenditures on electricity as well as for those with and without access to the grid (definition 1 on page 6). It also calculates the percentage of households for which the expenditure share lies below 5 percent. The expenditure shares for those who reported non-zero expenditures on electricity lie close to the expenditure shares of those with access to the grid due to a considerable overlap between these groups. As expected, with the exception of Angola and Nigeria, a greater percentage of those not connected to the grid found electricity unaffordable than grid-connected households.

Table 6: Expenditure share of monthly electricity consumption of 30 kWh by grid connection status and current spending

	Share of household expenditure					% of households for which share ≤ 5%				
	All	Expenditure on electricity		Grid connection		All	Expenditure on electricity		Grid connection	
Country		Yes	No	Yes	No		Yes	No	Yes	No
Angola	0.1	0.0	0.1	0.1	0.1	100	100	100	100	100
Botswana	3.7	1.3	4.9	1.7	5.4	86	98	80	96	77
Burkina Faso	8.8	4.2	9.5	4.5	9.5	32	72	26	71	26
Côte d'Ivoire	1.8	1.2	2.4	—	—	95	99	92	—	—
Ethiopia	1.3	0.9	1.4	1.1	1.3	98	99	98	99	98
Ghana	1.4	1.1	1.9	1.2	2.0	98	99	96	99	95
Madagascar	9.6	4.0	10.4	—	—	25	75	18	—	—
Malawi	2.2	0.7	2.3	0.8	2.3	96	100	95	100	95
Mali	1.4	1.1	1.5	0.8	1.6	99	99	99	100	99
Mozambique	2.3	0.6	2.5	0.0	0.0	93	100	92	—	—
Niger	3.6	1.7	3.8	1.6	3.8	82	98	80	98	81
Nigeria	0.3	0.3	0.4	0.3	0.4	100	100	100	100	100
Rwanda	8.9	2.2	9.7	2.4	9.7	31	92	25	90	24
São Tomé and Príncipe	1.7	1.3	1.9	—	—	97	99	96	—	—
Senegal	2.9	2.1	4.1	1.9	4.1	88	94	79	95	79
Sierra Leone	5.1	2.9	5.5	2.9	5.5	61	90	56	90	56
South Africa[a]	1.2	1.0	1.5	1.0	2.2	98	99	97	99	95
Swaziland	1.9	0.9	2.4	—	—	94	100	92	—	—
Tanzania	1.9	0.9	2.1	0.9	2.1	95	100	94	100	94
Togo	6.9	3.6	9.0	3.6	9.0	54	81	37	81	37
Uganda	4.4	1.7	4.7	2.0	4.7	71	97	69	96	68
Zambia	4.1	1.0	4.6	1.2	4.9	71	100	66	99	63
Median	2.2	1.1	2.4	1.2	3.0	93	99	92	99	81

Source: World Bank staff calculations based on utility information and household survey data.
Note: — = Grid connection status not available in the survey.
a. These numbers are for Johannesburg. Depending on eligibility, poor households are provided with 50, 100, or 150 kWh of free electricity a month in Johannesburg.

In Angola (effective unit charge of US$0.012/kWh), Ethiopia (US$0.022), Ghana (US$0.069), Mali (US$0.12), Nigeria (US$0.026), and South Africa (US$0.10 used in the calculation, although it could be zero in some municipalities), virtually the entire population should find electricity consumption at the subsistence level affordable. At the opposite end of the spectrum are Burkina Faso (US$0.28/kWh), Madagascar (US$0.12), and Rwanda (US$0.23), where only one-quarter or less of those not yet connected to the grid can afford electricity.

The definition of affordability in the multi-tier framework is based on the share of household income, arguably making cash expenditures more suitable as the basis for computing the expenditure share. Data on cash expenditures excluding home-grown food were available in 18 countries. The results are shown in Table 7.

Table 7: Expenditure share of monthly consumption of 30 kWh by location, quintile, poverty status, and gender of household head, based on total household cash expenditures

	All households					Poor households			Household head	
Country	Urban	Rural	Total	Q1	Q5	Urban	Rural	Total	Female	Male
Botswana	2.4	6.8	4.2	16.7	1.4	6.9	10.7	9.0	4.8	3.8
Burkina Faso	7.8	15.0	13.0	22.3	7.8	13.1	18.9	18.1	19.1	12.0
Côte d'Ivoire	1.6	3.2	2.4	6.5	1.1	3.2	5.1	4.5	3.1	2.2
Ethiopia	1.3	3.7	3.3	7.2	1.4	3.7	6.2	6.0	4.7	2.9
Ghana	1.2	2.4	1.8	4.4	0.9	2.9	4.3	4.0	1.9	1.7
Malawi	1.6	4.0	3.6	6.3	1.9	3.0	5.8	5.5	4.8	3.2
Mali	1.0	2.2	1.8	3.5	0.9	1.9	3.1	3.0	1.7	1.8
Niger	2.6	5.3	4.8	7.7	3.0	5.9	6.4	6.3	7.9	4.4
Nigeria	0.4	0.7	0.6	1.2	0.3	0.7	0.9	0.8	0.8	0.5
Rwanda	6.8	15.3	14.1	26.9	5.1	16.1	21.7	21.3	18.4	12.4
São Tomé and Príncipe	1.7	1.9	1.8	2.8	1.2	2.1	2.2	2.2	1.9	1.7
Senegal	2.2	4.4	3.3	7.8	2.0	3.8	6.1	5.4	2.8	3.5
Sierra Leone	3.9	7.6	6.2	10.6	3.7	5.8	8.8	8.2	6.2	6.2
Swaziland	1.8	2.8	2.4	5.3	1.1	3.4	3.6	3.5	2.5	2.3
Tanzania	1.6	5.8	4.5	10.0	1.5	5.3	10.1	9.7	6.0	3.9
Togo	4.3	12.3	8.8	22.2	3.9	7.0	15.4	13.4	11.0	8.2
Uganda	4.3	9.2	7.9	15.9	3.3	15.0	16.3	16.2	10.6	6.7
Zambia	2.4	11.1	8.0	17.4	1.9	4.9	13.3	12.0	10.4	7.3
Median	2.0	4.9	3.9	7.8	1.7	4.4	6.3	6.2	4.8	3.6

Source: World Bank staff calculations based on utility information and household survey data.

Predictably, electricity becomes markedly less affordable. The 5-percent threshold is exceeded for the poor in two-thirds of the countries (against one-third previously), and for four-fifths of the bottom quintile (against half previously). These results are consistent with much greater reliance on home-grown food by the poor than the rich.

Table 8 reproduces Table 6 based on total household cash expenditures. In Burkina Faso and Rwanda, only about one out of every eight households not connected to the grid would find 30 kWh of electricity a month affordable, compared to one out of every four in Table 6. Out of the 15 countries for which full information was available, more than half of non-connected households would not find electricity affordable in six countries.

Table 8: Expenditure share of monthly electricity consumption of 30 kWh by grid connection status and current spending, based on total household cash expenditures

	Share of household expenditure					of households for which share ≤ 5				
	All	Expenditure on electricity		Grid connection		All	Expenditure on electricity		Grid connection	
Country		Yes	No	Yes	No		Yes	No	Yes	No
Botswana	4.2	1.4	5.6	1.8	6.3	83	98	76	96	72
Burkina Faso	13.0	5.0	14.2	5.2	14.2	21	64	14	63	14
Côte d'Ivoire	2.4	1.3	3.4	—	—	92	98	85	—	—
Ethiopia	3.3	1.2	3.7	1.4	3.9	86	98	83	96	83
Ghana	1.8	1.2	2.5	1.4	2.7	95	99	91	98	90
Malawi	3.6	0.7	3.8	0.9	3.8	80	100	78	100	78
Mali	1.8	1.3	2.2	0.8	2.2	96	98	94	100	94

Country	Share of household expenditure					of households for which share ≤ 5				
	All	Expenditure on electricity		Grid connection		All	Expenditure on electricity		Grid connection	
		Yes	No	Yes	No		Yes	No	Yes	No
Niger	4.8	1.8	5.2	1.6	5.2	68	97	64	98	64
Nigeria	0.6	0.4	0.8	0.4	0.8	100	100	99	100	99
Rwanda	14.1	2.4	15.3	2.6	15.4	21	90	14	88	13
São Tomé and Príncipe	1.8	1.3	2.0	—	—	97	99	96	—	—
Senegal	3.3	2.1	5.0	2.0	4.9	85	94	72	95	73
Sierra Leone	6.2	2.9	6.7	2.9	6.7	50	90	43	90	43
Swaziland	2.4	0.9	3.1	—	—	89	100	84	—	—
Tanzania	4.5	1.1	5.2	1.1	5.3	78	100	73	100	73
Togo	8.8	3.7	12.0	3.8	12.0	46	79	25	79	26
Uganda	7.9	1.9	8.5	2.2	8.6	51	97	47	94	46
Zambia	8.0	1.0	9.1	1.3	9.9	52	99	44	99	39
Median	3.9	1.3	5.1	1.6	5.3	81	98	74	96	72

Source: World Bank staff calculations based on household survey data.
Note: — = Grid connection status not available in the survey.

Affordability at higher levels of consumption

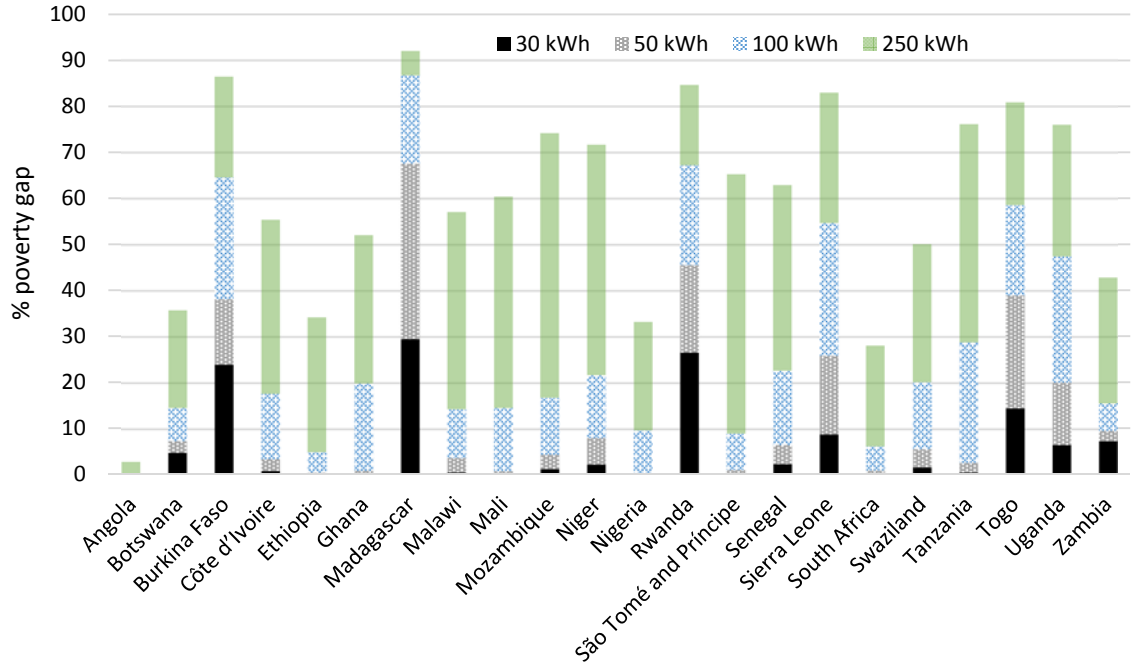
Corresponding results for 50, 100, and 250 kWh are shown in Table A.9–Table A.12, Table A.13–Table A.14, and Table A.15–Table A.16, respectively, in the annex. Although this paper uses monthly consumption of 30 kWh to define affordability, higher consumption levels were also tested to see how many households could "afford" (that is, pay no more than 5 percent of total household expenditures to purchase) more electricity. The number of countries in which electricity consumption becomes unaffordable (exceeding the 5-percent threshold) to the poor, based on total household expenditures (including imputed values), nearly doubles from 7 to 13 at 50 kWh. At 100 and 250 kWh a month, electricity is unaffordable to the poor in all but Angola and South Africa (where the poor are entitled to varying amounts of free electricity, depending on the municipality). The number of countries in which electricity becomes unaffordable to urban households doubles from three at 30 kWh to six at 50 kWh, and more than doubles to 14 at 100 kWh a month.

Table A.10 in the annex enables a limited degree of comparison with the findings of Briceño-Garmendia and Shkaratan (2011). That study covered 18 countries, 14 of which are also in this study. Briceño-Garmendia and Shkaratan found that monthly consumption of 50 kWh would be affordable to about one-third of unconnected households on average, whereas this study found that the median for 50 kWh being affordable would be two-thirds of unconnected households and the average would be three-fifths. These results suggest that electricity tariffs became more affordable in the intervening years.

Grid-electricity poverty measures

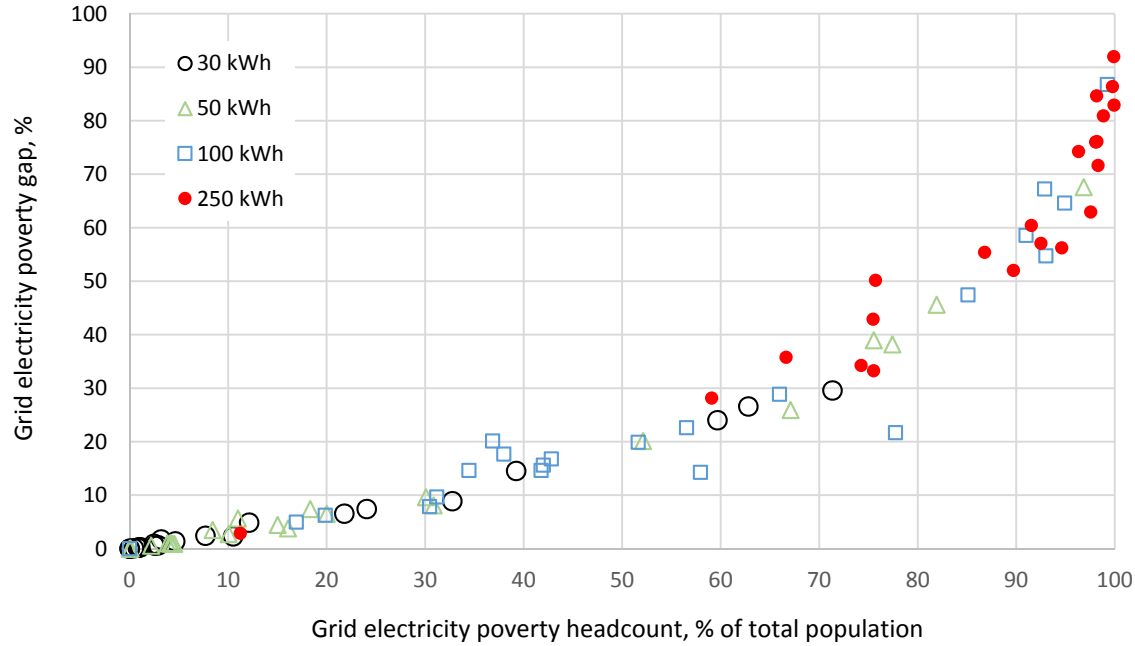
The electricity poverty gaps for different levels of consumption are shown in Figure 5. In the figure, each rectangle for different monthly consumption is incremental. For example, the poverty gaps in Rwanda for 50, 100, and 250 kWh are 46, 67, and 85 percent, respectively. Table A.17 in the annex provides the results by location (urban and rural). Figure 6 contrasts the poverty gap and headcount. The highest poverty gap for 30 kWh is less than 30 percent, but the corresponding poverty headcount is in excess of 70 percent.

Figure 5: Grid-electricity poverty gap for monthly consumption of 30, 50, 100, and 250 kWh



Source: World Bank staff calculations based on utility information and household survey data.
Note: Municipalities in South Africa have different eligibility criteria for households entitled to receive free electricity. For simplicity, the lowest tariffs in Johannesburg without entitlement to free electricity are used for these calculations.

Figure 6: Comparison of grid-electricity poverty gap and poverty headcount for monthly consumption of 30, 50, 100, and 250 kWh



Source: World Bank staff calculations based on utility information and household survey data.

One way of gauging the effects of tariff structures on grid electricity users is to look at the incremental impact of increasing consumption on the grid-electricity poverty gap. The cost increase from 30 to 50 kWh is

substantial relative to household expenditures, more than doubling the poverty gap in 17 out of 22 countries including, predictably, every country where the lifeline block is smaller than 50 kWh a month. Going from 50 kWh to 100 kWh and from 100 kWh to 250 kWh a month more than double the poverty gap in 16 countries each. A rapid rise in the poverty gap between 30 and 50 kWh raises concerns. At the opposite end of the spectrum, there is no compelling reason to make 250 kWh of monthly consumption so affordable in Angola—which unfortunately could not be covered in the analysis of quasi-fiscal deficits for lack of data.

Subsidy to make the subsistence level of electricity affordable to all

Given limited resources, and in line with the affordability criterion for the multi-tier access framework, enabling households to consume 30 kWh a month would arguably be an appropriate goal for the foreseeable future in Africa. Table 9 lists the grid-electricity poverty gap and headcount for 30 kWh, the access rate (according to definition 1, or definition 2 in the absence of data for grid connection), the percentage of the total household expenditures needed to pay for 30 kWh of grid electricity a month, and the subsidies needed to make up the difference between the amount in excess of 5 percent of household expenditures and the monthly electricity bill, expressed as percentage of the quasi-fiscal deficit, total revenue collected by the utility, and GDP. These subsidy calculations assume a perfect world where precise targeting of individual households based on income is possible. The countries are listed in order of decreasing grid-electricity poverty gap. The calculation procedures and detailed results for quasi-fiscal deficits are available in Trimble et al. (2016).

Table 9: Electricity poverty, access, and subsidy statistics for monthly consumption of 30 kWh

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

Source: World Bank staff calculations based on utility information and household survey data.
Note: For South Africa, see the note for Figure 5. Quasi-fiscal deficits are current deficits. HH = household; QFD = quasi-fiscal deficit; — = not available.

The results show that the subsidies needed to enable all households to consume 30 kWh a month are generally not large. In seven countries, the total (perfectly targeted) annual subsidy is less than US$1 million. As a percentage of the cash collected by utilities, the highest is 6 percent in Madagascar and Rwanda. However, it should be noted that such assistance is unlikely to make sense for rural households—there are many rural households for whom connection to the grid network would be too costly for the utility, and they would be better served by off-grid electricity. A lower bound would be the total subsidy required to make grid electricity affordable to every urban household. Table A.19 in the annex provides additional results for annual subsidies for monthly consumption of 30, 50, and 100 kWh, splitting subsidies into urban and rural areas. The highest annual subsidy to make grid electricity affordable to all urban households is US$14 million in Burkina Faso, followed by US$10 million in Madagascar. The annual subsidy for this purpose is less than US$1 million in 15 countries. Given the relatively small levels of subsidies required, cross-subsidies—by better-off residential customers as well as commercial and industrial customers—are likely to be a reasonable source of funding.

Further analysis of the top ten countries in Table 9 is informative. Among them, only Togo, Uganda, and Niger do not suffer from underpricing, which is a measure of how much lower tariffs are compared to the tariffs required to eliminate quasi-fiscal deficits if utilities improve operational efficiency by reducing network losses, bill collection losses, and overstaffing (Trimble et al. 2016)—in other words, they have the "fiscal space," as it were, to cross-subsidize needy households. All other countries will continue to have underpricing as a problem even after attaining benchmark performance in operational efficiency. Aside from Sierra Leone, where underpricing is less than 0.1 percent of GDP, other countries have underpricing of at least 0.4 percent, and Zambia, Botswana, and Senegal have underpricing in excess of 1 percent of GDP, with 3.3 percent in Botswana even at benchmark performance being the highest. The current quasi-fiscal deficits are not small in the top three countries: 2.2 percent of GDP in Madagascar, 1.0 percent in Rwanda, and 1.1 percent in Burkina Faso. The presence of underpricing does not mean there is no scope for making the subsistence level of electricity consumption more affordable. Two examples of mitigation steps are to introduce a lifeline rate (Rwanda, Botswana) and consider volume-differentiated in the place of increasing block tariffs (Madagascar, Sierra Leone, Zambia, Senegal). But these observations point to the challenges facing the countries with high electricity poverty gaps and low access rates.

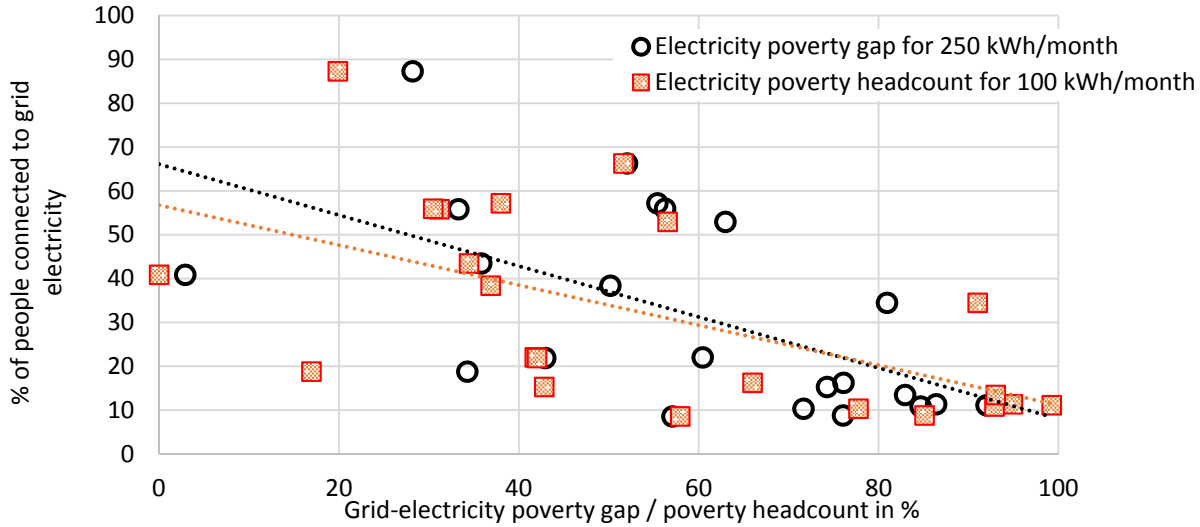
Relationships between access, poverty, and quasi-fiscal deficits

Which is the best predictor of access, grid-electricity poverty at 30 kWh? Do quasi-fiscal deficits tend to rise with increasing affordability of electricity? Or are deficits high precisely in countries where people are too poor to pay for electricity? To answer these questions, relationships between access, poverty gap, poverty headcount, and quasi-fiscal deficits at current performance as well as benchmark performance (eliminating operational inefficiencies) were examined. Poverty measures at 30, 100, and 250 kWh, and nine measures of quasi-fiscal deficits—deficit at current utility performance, that at benchmark performance (which is identical to underpricing, the degree to which tariffs fall short of cost recovery at efficient operation), and deficit due to operational inefficiencies, each as a percentage of GDP, bills sent out by the utilities, and cash collected by the utilities—were examined for this purpose.

Correlation coefficients between access (using definition 1 where the information is available, and definition 2 otherwise) and the two measures of grid-electricity poverty at different electricity consumption levels are all negative and statistically significant using a 5-percent significance test, with the exception of the poverty headcount at 250 kWh. The poverty gap at 250 kWh and the poverty headcount at 100 kWh have the highest correlation coefficients and remain statistically significant at 1 percent. Correspondingly, when access is

regressed on different measures of grid-electricity poverty, the poverty gap at 250 kWh and headcount at 100 kWh, shown in Figure 7, are the two best predictors of access. However, although countries do not overlap, the correlation coefficients are not as high as between access and the economic poverty gap at $3.10 or $1.90. The share of total household expenditures required to consume different amounts of electricity is another predictor of access, but is not as good as the two measures of grid-electricity poverty.

Figure 7: Comparison of access with grid-electricity poverty gap and poverty headcount



Source: World Bank staff calculations based on utility information and household survey data.

As mentioned above, because extending grid electricity to rural households is costly and off-grid electricity will be cheaper for low-density, low-consumption areas, and because the grid network is nonexistent in many parts of rural areas, these grid-electricity poverty statistics are arguably more relevant for urban households. Repeating the above exercise for urban households only delivers similar results, with the urban poverty gap at 250 kWh and urban poverty headcount at 100 kWh having the highest correlation coefficients with urban access rates. The highest correlation coefficients between urban access and the measures of grid-electricity poverty are obtained when the latter are calculated nationally, and different measures of national grid-electricity poverty are better correlated with urban access than with national access. There is no obvious explanation for these results.

The poverty gap and headcount at 30 kWh have the smallest correlation coefficients and have the weakest predictive power for access for both national and urban statistics. This may seem counterintuitive at first glance—should the affordability to the poor not determine the rate of access? Several reasons may be offered for this finding. First, the total household expenditures used include freely acquired food and other items, making cash available much smaller for some households, especially in rural areas. Yet excluding freely acquired goods and services is not necessarily a more compelling approach, because two households with the same cash income but one of which does not have to pay for food are clearly not in the same financial situation. Second, a household that can barely pay for 30 kWh a month of electricity may have other pressing demands on its budget. Third, connection costs are high in many countries (see the next paragraph), and a household that can just afford 30 kWh a month may have no financial resources to pay for the initial connection. Lastly, depending on how many higher-consumption, better-off consumers are in the same area, it may not be financially viable for the utility to extend the grid to poor households for whom even 30 kWh a month poses an affordability challenge.

By contrast, correlation coefficients between access with different measures of quasi-fiscal deficits are not statistically significant at 5 percent as long as South Africa (which has the highest rate of access and high quasi-fiscal deficits) is omitted. This finding would suggest that access expansion is not an important driver of quasi-fiscal deficits. The poverty gap and headcount at 30 kWh are not correlated with any of the nine measures of quasi-fiscal deficits using a 5-percent significance test, and quasi-fiscal deficits due to operational inefficiencies are not correlated with any measure of poverty at any monthly consumption level. The highest correlation coefficients are for the poverty headcount at 250 kWh for quasi-fiscal deficits at benchmark performance. Using a 1-percent significance test, the correlations that remain are those between the three measures of quasi-fiscal deficits at benchmark with the poverty headcount at 250 kWh and the poverty gap at 250 kWh. All coefficients are negative. This finding seems reasonable: the larger the underpricing—that is, the more subsidized the tariffs compared to cost-recovery levels at efficient operation, the lower the grid-electricity poverty.

Affordability of connection costs

For the poor, compounding the challenge of paying for minimal monthly consumption of electricity is the upfront cost of getting connected to the grid. Mozambique and South Africa offer free connection to those who consume little electricity, and Senegal offers free connection to those living within 40 meters of the grid. Nigeria has prohibited connection fees, although customers pay for the materials needed for the connection. Table 10 summarizes the lowest costs charged for connecting to the grid as multiples of monthly household expenditures. The costs shown typically do not apply to cases where the distribution line needs to be extended, requiring the household to be located close to the distribution network. Table 11 recalculates the same costs as multiples of monthly household cash expenditures.

Table 10: Initial connection payment as multiples of monthly household expenditures

	All households					Poor	Household head	
Country	Urban	Rural	Total	Q1	Q5	households	Female	Male
Angola	0.1	0.2	0.1	0.3	0.1	0.2	0.2	0.1
Botswana[a]	1.1	2.5	1.7	7.1	0.4	3.6	2.0	1.4
Burkina Faso	1.0	0.6	0.7	1.1	0.5	0.9	1.0	0.6
Côte d'Ivoire	0.9	1.3	1.1	2.8	0.6	2.0	1.5	1.0
Ethiopia	1.1	1.3	1.3	2.8	0.7	2.4	1.9	1.1
Ghana	0.5	0.8	0.6	1.3	0.3	1.2	0.7	0.6
Madagascar	2.8	4.2	3.9	7.7	2.2	4.7	5.6	3.5
Malawi	0.6	1.0	1.0	1.7	0.6	1.4	1.2	0.9
Mali	0.5	0.8	0.7	1.3	0.4	1.2	0.7	0.7
Mozambique	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Niger	0.1	0.1	0.1	0.2	0.1	0.1	0.2	0.1
Nigeria[b]	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Rwanda	0.5	0.9	0.9	1.6	0.4	1.3	1.1	0.8
São Tomé and Príncipe	0.3	0.3	0.3	0.5	0.2	0.4	0.3	0.3
Senegal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sierra Leone[c]	0.8	1.3	1.1	1.8	0.6	1.4	1.1	1.1
South Africa	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Swaziland	0.1	0.1	0.1	0.2	0.0	0.1	0.1	0.1
Tanzania	1.2	1.2	1.2	2.2	0.8	2.1	1.5	1.1
Togo	1.2	2.7	2.0	4.9	1.0	3.0	2.7	1.8
Uganda	0.5	0.9	0.8	1.5	0.4	1.5	0.9	0.7
Zambia	0.6	1.5	1.2	2.5	0.4	1.7	1.4	1.1

Country	All households					Poor households	Household head	
	Urban	Rural	Total	Q1	Q5		Female	Male
Median	0.5	0.9	0.8	1.5	0.4	1.3	1.0	0.7

Source: World Bank staff calculations based on household survey data.
Note: n.a. = information on connection costs not available.
a. The connection payment is the first payment in an installment plan (same first payment irrespective of the number of months over which payments are spread). A one-off payment is 4.8 times higher.
b There is no connection fee but customers buy the materials needed and present them to the utility. There is supposed to be no exchange of money between the customer and the utility.
c. The connection payment is the first payment in an 18-month installment plan. A one-off payment is twice as high.

Table 11: Initial connection payment as multiples of monthly cash household expenditures

Country	All households					Poor households	Household head	
	Urban	Rural	Total	Q1	Q5		Female	Male
Botswana[a]	1.1	3.1	1.9	7.5	0.6	4.1	2.2	1.7
Burkina Faso	1.1	0.9	1.0	1.5	0.7	1.3	1.4	0.9
Côte d'Ivoire	1.0	2.0	1.5	4.1	0.7	2.8	1.9	1.4
Ethiopia	1.4	3.8	3.4	7.4	1.4	6.2	4.8	2.9
Ghana	0.5	1.0	0.8	1.9	0.4	1.7	0.8	0.7
Malawi	0.7	1.8	1.6	2.8	0.8	2.4	2.1	1.4
Mali	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Mozambique	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Niger	0.1	0.2	0.1	0.2	0.1	0.2	0.2	0.1
Nigeria[b]	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Rwanda	0.7	1.5	1.4	2.6	0.5	2.1	1.8	1.2
São Tomé and Príncipe	0.3	0.3	0.3	0.5	0.2	0.4	0.3	0.3
Senegal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sierra Leone[c]	0.8	1.6	1.3	2.2	0.8	1.7	1.3	1.3
South Africa	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Swaziland	0.1	0.1	0.1	0.3	0.1	0.2	0.1	0.1
Tanzania	1.6	3.2	2.7	5.8	1.1	5.6	3.7	2.4
Togo	1.3	3.6	2.6	6.6	1.1	4.0	3.3	2.4
Uganda	0.8	1.6	1.4	2.8	0.6	2.8	1.9	1.2
Zambia	0.7	3.2	2.3	5.0	0.5	3.4	3.0	2.1
Median	0.7	1.6	1.3	2.4	0.6	1.9	1.6	1.2

Source: World Bank staff calculations based on household survey data.
Note: For footnotes a–c, see the previous table. n.a. = information on connection costs not available.

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 share of monthly electricity consumption and multiples of monthly household expenditures for the lowest connection costs is 0.58, statistically significant at 5 percent. Botswana and Sierra Leone offer installment plans to make it easier to pay for the upfront cost of connection. However, the costs remain relatively high, and the subsequent monthly payments make electricity even at the subsistence level too expensive for the poor. In Botswana, the total payment even when payments are spread over 180 months make the monthly bill for 30 kWh 28 percent of monthly cash expenditures and the corresponding percentage is 19 in Sierra Leone. These would be unaffordable by any measure.

It is informative to compare the share of total expenditures required for the initial connection between those with and without positive expenditures on electricity or grid connection. The results are tabulated in Table

12. It is clear that those not connected to the grid are much more income-constrained than those connected to the grid.

Table 12: Initial connection payment as multiples of monthly expenditures by electricity spending and grid connection status

	Total household expenditures				Total household cash expenditures			
	Electricity spending		Grid connection		Electricity spending		Grid connection	
Country	Yes	No	Yes	No	Yes	No	Yes	No
Angola	0.1	0.2	0.1	0.2	n.a.	n.a.	n.a.	n.a.
Botswana[a]	0.6	2.2	0.8	2.4	0.6	2.5	0.8	2.8
Burkina Faso	0.6	0.7	0.6	0.7	0.7	1.0	0.7	1.0
Côte d'Ivoire	0.7	1.5	n.a.	n.a.	0.8	2.1	n.a.	n.a.
Ethiopia	0.9	1.4	1.1	1.4	1.3	3.8	1.5	4.0
Ghana	0.5	0.8	0.5	0.8	0.5	1.1	0.6	1.2
Madagascar	1.6	4.2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Malawi	0.3	1.0	0.3	1.0	0.3	1.7	0.4	1.7
Mali	0.6	0.8	0.4	0.8	0.7	1.2	0.4	1.2
Mozambique	0.0	0.0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Niger	0.1	0.1	0.0	0.1	0.1	0.2	0.0	0.2
Nigeria[b]	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Rwanda	0.2	0.9	0.2	0.9	0.2	1.5	0.3	1.5
São Tomé and Príncipe	0.2	0.3	n.a.	n.a.	0.2	0.3	n.a.	n.a.
Senegal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sierra Leone[c]	0.6	1.2	0.6	1.2	0.6	1.4	0.6	1.4
South Africa	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Swaziland	0.0	0.1	n.a.	n.a.	0.0	0.2	n.a.	n.a.
Tanzania	0.8	1.3	0.9	1.3	1.0	3.1	1.0	3.2
Togo	1.1	2.7	1.1	2.6	1.1	3.5	1.1	3.5
Uganda	0.3	0.8	0.3	0.8	0.3	1.5	0.4	1.5
Zambia	0.3	1.3	0.3	1.4	0.3	2.6	0.4	2.8
Median	0.3	0.8	0.4	0.9	0.3	1.4	0.4	1.5

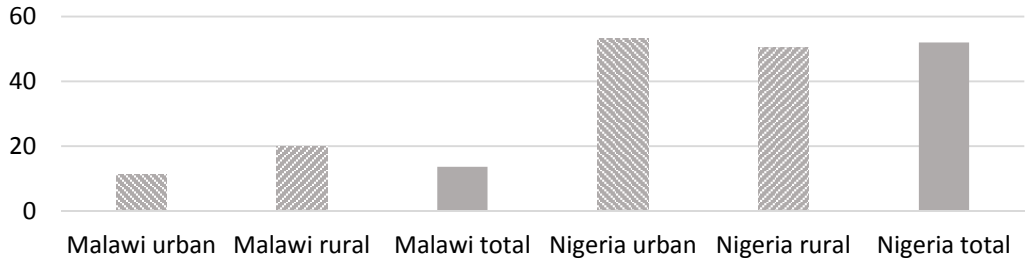
Source: World Bank staff calculations based on household survey data.
Note: For footnotes a–c, see the previous table. n.a. = not available.

Corruption in the form of bribes extracted add to the cost of using electricity. Surveys in 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 (free since August 2012 in Nigeria), while the survey in Senegal asked about the general perception of corruption in the government and specifically about the power sector.

The results for Malawi and Nigeria are shown in Figure 8. Bribery was more prevalent in Nigeria. In Malawi, there were too few households in the bottom quintiles for meaningful statistics, but in Nigeria every quintile had enough households sampled. The percentage of households reporting informal payments was lowest in the bottom quintile and highest for the top quintile—that is, those who are most able to pay bribes are also most likely to be asked and pay—although there was no consistent pattern with increasing quintile. Recognizing the pervasive nature of this problem, the Nigerian Electricity Regulatory Commission in August 2012 prohibited connection fees and required that new customers be given a list of materials to purchase and provide the utilities with the materials, so as to avoid a "direct exchange" of money between the customer and the utility. The only variable is the length of the connection wire. After the materials are presented and checked by the utility, the utility has 48 hours in which to connect the new customer (NERC

2012). The regulator announced that this new regulation was intended to "rid the power sector of corruption and protect electricity consumers from fraud and extortion often committed against them by electricity companies." As one potential indication of progress in this area, the percentage of households reporting informal payments declined from those in the 2010 survey by 3.8 percentage points nationally, 2.0 percentage points in urban areas, and 5.8 percentage points in rural areas. The decline was primarily among lower-decile households, while the top decile statistics remained largely the same.

Figure 8: Percentage of households who paid a bribe to get grid connection



Source: World Bank staff calculations using household survey data.

In Senegal, 86 percent of households said that corruption had increased over time. However, only 1 percent of those connected to the grid said that they had been asked by utility officials to pay bribes. The question asked in Senegal is not comparable to that in Malawi and Nigeria. It is possible that this more positive outcome in Senegal was due in part to the fact that the question concerned only the past 12 months, and if bribes are associated primarily with the initial connection, those households that had obtained grid connection more than 12 months earlier would not have reported bribe payments.

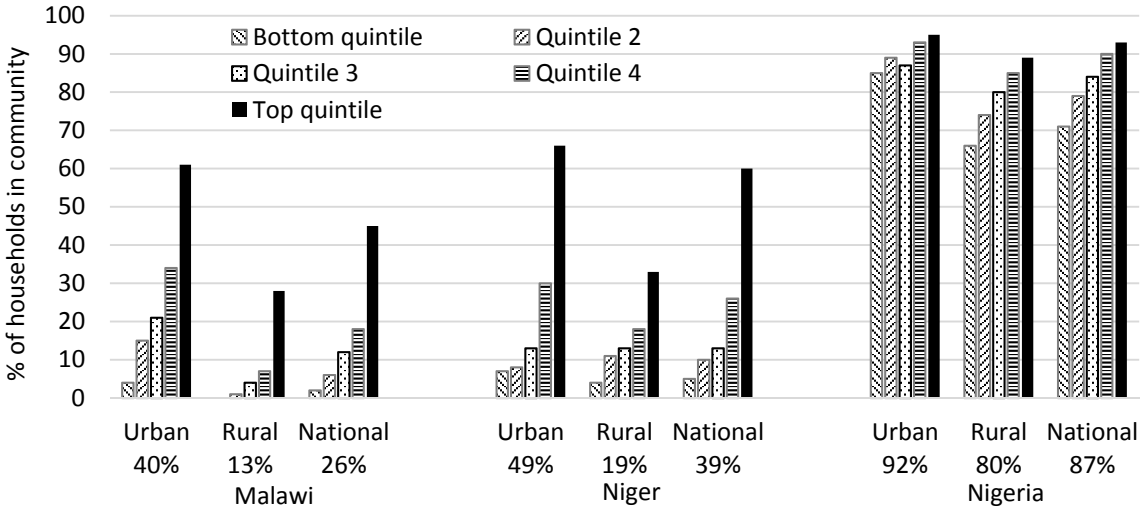
Community versus Household Access

In Malawi, Niger, and Nigeria, the survey asked whether their communities had electricity.[11] The data can be used to examine electrified communities and compute the percentage of households that have chosen to connect to the grid. In urban Nigeria, 92 percent of all households living in electrified communities had connected to the grid, whereas less than half of such urban households in Niger and Malawi had grid electricity. In rural areas, the percentages were much lower in the latter two countries, as shown in Figure 9. Predictably, the percentage increased with quintile, but remained one-third or lower in rural Malawi and Niger.

Figure 10 examines households without grid connection. Most urban households without grid connection in Malawi and Niger lived in electrified neighborhoods, whereas a lower percentage in urban Nigeria lived in neighborhoods connected to the grid, pointing to lack of community electrification as an important barrier. Most rural households without grid connection lived in communities without grid electricity.

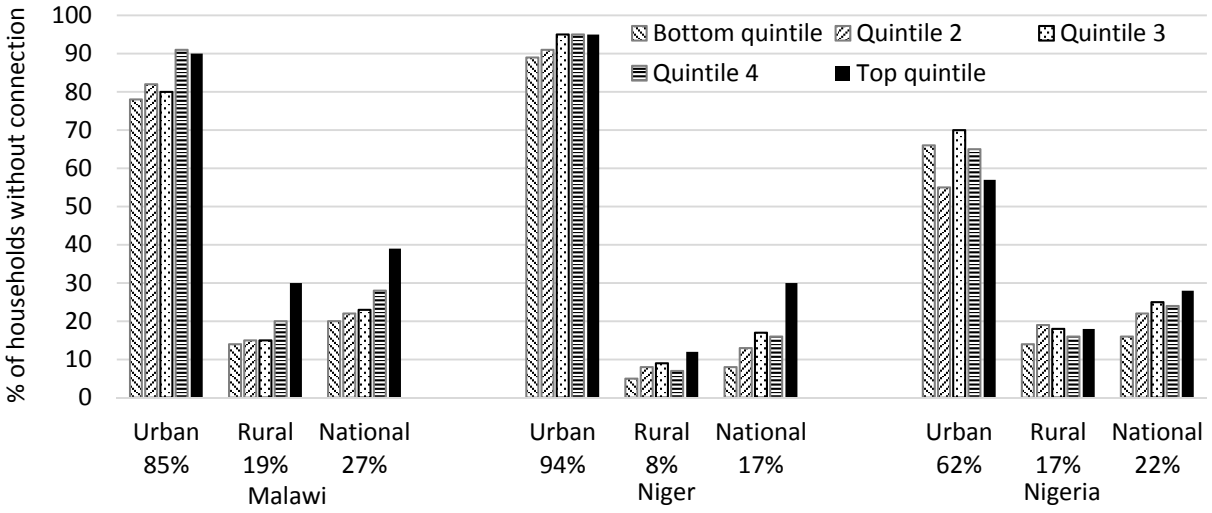
[11] In Malawi and Nigeria, the survey asked each household, whereas in Niger the survey asked this question in the community questionnaire. In Ghana the survey also asked in the community questionnaire, but the data were not available to the World Bank. In Senegal the survey asked if the community had been newly electrified over the previous five years, but that would not identify all households living in communities with electricity.

Figure 9: Households living in electrified neighborhoods that have household connection



Source: World Bank staff calculations using household survey data.

Figure 10: Households without grid connection living in electrified neighborhoods



Source: World Bank staff calculations using household survey data.

For households living in communities connected to the grid, in Malawi and Nigeria the survey asked households without grid electricity why they had not connected (Table 13). The reasons were specified in the questionnaire and households selected from a range of options. Not surprisingly, unaffordability of the connection charge was the most common reason. In Malawi, the payment for the initial connection to the grid is large, costing about US$160 even when no grid extension is required and about US$450 if one-pole extension is required. The second most common reason in urban Nigeria was poor reliability of grid electricity; all but one of those respondents who cited poor reliability had a private generator.

Table 13: Percentage of households citing reasons for not connecting to the grid

Location	Too costly	No need	Dwelling unsuited	Pending	Discon-nected	Unreliable service	Other	No reply
Malawi urban	37	2	4	6	0.0	—	0.1	51
Malawi rural	56	3	8	2	0.1	—	4	27
Malawi total	49	2	7	4	0.1	—	2	36
Nigeria urban	59	6	2	1	—	15	16	—
Nigeria rural	63	8	8	5	—	8	9	—
Nigeria total	62	7	6	4	—	10	11	—

Source: World Bank staff calculations using household survey data.
Note: No need = no need for electricity; dwelling unsuited = dwelling unsuited for connection to the grid; pending = application for connection pending; disconnected = disconnected for non-payment; — = reason not among the options cited in the questionnaire.

No spending on grid electricity

Survey questionnaires are generally not sufficiently detailed to quantify how many households do not pay for electricity. The data collected should ideally be able to separate the absence of reported household spending on electricity for legitimate reasons—such as inclusion of electricity in the rent, or in the compensation package for employment—from evasion of payment, such as theft of electricity or non-payment without disconnection. No household survey enabled probing of this question at that level of detail.

- In Mali, Niger, and Zambia, the survey asked if the rent included electricity. In South Africa, the survey asked if rent or free rental included "electricity, water, etc." without isolating electricity. In South Africa, the survey also asked how much the household had spent on utilities if water and electricity bills were bundled.
- In Mali and Niger, the survey asked if the household received free "water-electricity" as part of employment compensation, without isolating electricity.
- In South Africa, the survey asked if the household received free electricity and its value. Low-consumption or poor households (depending on the municipality) can obtain certain amounts free of charge and pay for the rest. Therefore, answering yes to the question does not mean no payment to the utility was required. It is also possible that some households would report stolen electricity as free electricity. In Uganda and Zambia, the survey did not ask about free electricity, but the household was asked to value electricity received without making payment. Neither survey asked why free electricity was available.
- In Sierra Leone, the survey asked if the household had paid electricity bills (either bills addressed to the household or shared with others) over the past 12 months.

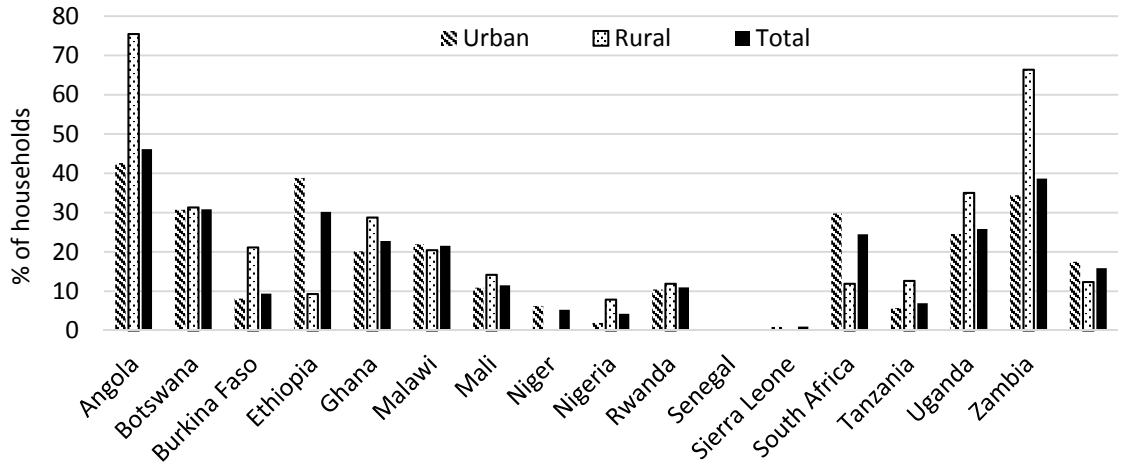
Asking if the household had made payment at any point over a long time period, such as 12 months in Sierra Leone, is far more likely to catch payments than asking about the past 30 days, when the household may have missed a payment, pre-paid enough in advance, or pay less frequently than once a month. Households with missing values (missing answers) may not have answered the question despite having paid (for example, the respondent may have had trouble recalling the amount paid), but all missing values were assigned zero for the purpose of this study.

It is important to note that national household expenditure survey data cannot be used to estimate bill collection losses (percent of the total billed amount not collected by the utility) from residential consumers because no survey asks what should have been paid. It is not possible to tell from non-zero expenditure

whether the payment was made in full, or in part, or whether it was to pay for arrears. Nevertheless, a large percentage of grid-connected households reporting zero expenditures could signal many households not paying fully, if at all, for electricity.

The results, summarized in Figure 11, show that Angola, Botswana, Ethiopia, Malawi, South Africa, Uganda, and Zambia had one-fifth or more of households connected to the grid reporting zero expenditures on electricity, with Angola (46 percent), Zambia (38 percent), and Botswana (31 percent) leading. By contrast, Nigeria—where bill collection losses have been documented to be very high—significantly under-reported non-payment, showing a non-payment rate of only 4 percent. The survey in Senegal, which asked for expenditures over the last 12 months, found no households connected to the grid not having made payments. The results by quintile are shown in Table A.20 in the annex. Generally, the share of grid-connected households reporting zero expenditures declined with quintile, but Ethiopia and Uganda showed the opposite trend, with the top quintile having the highest proportion of grid-connected households reporting zero expenditures. There are several potential explanations. The rich may be more likely to get jobs with generous benefits, including free electricity. They may be more likely to rent houses with electricity included in the rent. Or they are able to manipulate meters or bribe utility employees to avoid bill payment, in which case they should be targeted for reducing commercial and bill collection losses.

Figure 11: Share of households connected to the grid with zero expenditures on electricity



Source: World Bank staff calculations using household survey data.

Among the countries with one-fifth or more of grid-connected households reporting zero expenditures, only South Africa and Zambia enable further analysis. Of the two, only Zambia isolates electricity for inclusion in rent, whereas South Africa includes water in addition to electricity, making disaggregation of electricity from other items not possible. If every appearance of combined electricity and water bills paid is assumed always to include electricity, and if everyone receiving free electricity is considered to rely only on free electricity, which is unlikely—the percentage of households receiving free electricity increases from 2 percent in the bottom two quintiles to 3 percent in the top three quintiles—the share of households not paying for grid electricity without justification declines from 29, 11, and 24 percent for urban, rural, and national to 2 percent each in South Africa. The reduction is primarily from inclusion of electricity in rent or electricity and water bills being bundled.

In Zambia, the number of grid-connected households who had zero expenditures on electricity but whose rent included electricity was significant in urban areas. The share of non-paying households decreases from

33, 65, and 38 percent for urban, rural, and national to 17, 59, and 23 percent, respectively, once inclusion of electricity in rent is taken into account.

Multiple Connections

Progressive tariffs to protect the poor would be effective only if each household is individually metered. Unfortunately, shared metering is all too common in Africa. Multiply connected households cannot take full advantage of lifeline rates, and end up paying higher effective unit prices charged to the bulk of the consumption (see Table 4 for more detail). Four surveys asked questions from which the prevalence of multiple connections can be estimated:

- In Côte d'Ivoire, the survey asked if the household had its own meter, or shared a meter with others, or had no meter.
- In Ethiopia, the survey asked if the household had its own meter or shared a meter.
- In Sierra Leone, the survey asked if the household shared an electricity bill with others.
- In Senegal, the survey asked the household to report the amount paid to the neighbor over the last 12 months if the household did not have a contract with the utility and was using its neighbor's electricity.

The results show that multiple connections are widespread in the first three countries. The share of households connected to the grid that had their own meters in Côte d'Ivoire and Ethiopia or did not share a utility bill with others in Sierra Leone was less than half, 42 percent, 40 percent, and 44 percent, respectively. In Côte d'Ivoire, this percentage did not vary much by quintile, but in Sierra Leone the share increased from the bottom quintile (26 percent) to the top quintile (46 percent), signaling that shared metering was dominant among low-income households. By contrast, in Ethiopia, the share fell markedly in the top quintile, meaning shared meters were, unexpectedly, most common among the top quintile. To the extent that progressive tariffs are intended to help the poor, shared meters among the richest 20 percent do not defeat the purpose of progressive tariff design.

Perhaps not surprisingly, in Senegal—which does not charge the connection fee if a household is within 40 meters of the nearest power line—a much lower percentage reported not having a contract with the utility and paying their neighbors instead. The actual percentage of households with shared meters depends on the assumption about how many households are connected to a single meter on average, with the highest percentage of shared meters corresponding to only two households per meter. If only two households are assumed to be connected to the same meter on average, then 84 percent of households would have had their own meters. This percentage was lowest in the bottom quintile, 53 percent, and highest in the top two quintiles, 90–91 percent. If three households are connected to a meter on average, the percentage increases to 88 percent of all households having their own individual meters.

If there is only one distribution company and the number of residential consumers is separately reported by that company, comparison of the number of households connected to the grid found in the survey and the number of residential customers reported by the utility gives another indication of the prevalence of multiple connections. Such comparison is possible only in Malawi, where the utility data are available for the survey year. If every shared meter is assumed to be connected to two households, the percentage of grid-connected households with their own unshared meters is 57 percent. If more than two households are connected, this percentage increases, for example to 68 percent if three households on average are connected to a single shared meter.

In Mali, the monopoly distribution company reports the total number of low-voltage (but not residential) customers in the survey year. The number of households reporting connection to the grid exceeds the number of low-voltage customers by 30 percent. If all voltage customers are assumed to be residential—which they are not—and an average of two households are assumed to be connected to a shared meter, the percentage of households with their own unshared meter is calculated to be 54 percent. The percentage increases to 65 percent if the assumption is changed to three households for every shared meter on average.

Lastly, in Ethiopia, the monopoly distribution company reports the total number of residential customers in the year before the survey year. The number is 1.65 million customers in 2012, against 1.63 million households that reported having their own private meters out of a total of 4.2 million households reporting connection to the grid in 2013. These numbers strongly suggest that many households that replied that they had private meters were actually sharing their meters with their neighbors, with the distinction understood by survey respondents to be between having meters installed on their premises (private meters) versus connected to neighbors' meters (shared meters). This in turn would mean that the percentage of households sharing meters was much greater in Ethiopia than the survey finding of 60 percent.

Outages

Seven surveys—Ethiopia, Madagascar, Malawi, Mali, Niger, Nigeria, and Senegal—asked questions about power outages. Because questions asked varied from country to country, it is not possible to compare them on a common basis. The results are summarized in Table 14 for households connected to the grid who replied to the questions on the frequency, duration, or both of blackouts. Power outages were common in all the countries, and serious in Malawi (six out of every seven households reporting daily blackouts over the last 12 months), Niger, Nigeria, and Senegal.

Table 14: Summary of power blackout information

Country	Findings	Quintile dependence	Urban vs. rural
Ethiopia	27% of households replying reported no blackouts during the last 7 days, but 24% reported more than 3 blackouts. The number of hours without electricity over the last 7 days translated to 1.8 hours a day.	Both measures (no blackouts, more than 3 blackouts) decreased with increasing quintile. The numbers of hours without electricity did not vary much with quintile.	20% of urban and 38% of rural households reported no blackouts, while 22% of urban and 28% of rural households reported more than 3 blackouts. The number of hours per day without electricity translated to 1.6 hours in urban and 2.3 hours in rural areas.
Madagascar	The number of hours per day electricity was available averaged 19. 68% of households replying reported 24-hour availability.	Excluding the bottom two quintiles, which had too few samples, the number of hours electricity was available per day increased with quintile nationally.	The number of hours electricity was available per day averaged 20 in urban and 18 in rural areas. 70% of urban and 64% of rural households reported 24-hour availability of electricity.
Malawi	86% of households said they had experienced blackouts every day over the last 12 months.	The bottom 2 quintiles in urban and the bottom 4 quintiles in rural areas had too few sampled households for meaningful statistics. There was no consistent	89% of urban and 80% of rural households reported daily blackouts.

Country	Findings	Quintile dependence	Urban vs. rural
		pattern as a function of quintile.	
Mali	49% of households reported at least one blackout over the last 7 days. The number of days with blackouts averaged 2.1 days, the number of times per day averaged 1.5, 33% reported that blackouts lasted 15 to 30 minutes at a time, 21% reported 30 to 60 minutes, and 20% reported less than 15 minutes, while 11% reported longer than 3 hours.	The bottom 2 quintiles had too few sampled households for meaningful statistics. There was no consistent pattern by quintile.	Rural households reported more frequent blackouts. The largest difference was in answer to the question on whether the household had experienced at least one blackout over the last 7 days: 46% of urban and 60% of rural households replied "yes."
Niger	Questions were identical to those in Mali. 91% of households reported at least one blackout over the last 7 days. The average number of days with blackouts was 4.4, the number of blackouts per day was 2.2, 34% reported that blackouts lasted 30 to 60 minutes, followed by 25% reporting 15 to 30 minutes, 17% reporting 1 to 3 hours, 14% reporting less than 15 minutes, and 11% reporting more than 3 hours.	The bottom 2 in urban and the bottom 4 quintiles in rural areas had too few sampled households for meaningful statistics. The frequency of blackouts increased with quintile in urban areas.	Meaningful comparison was not possible because even the top quintile in rural areas had a total of only 31 samples.
Nigeria	57% of households reported daily blackouts in their areas, and 31% reported several blackouts over the last 7 days.	The percentage of households reporting daily blackout declined from 62 in the second to 54 in the top quintile.	55% of urban and 59% of rural households reported daily blackouts.
Senegal	Over the last 4 weeks, households connected to the grid reported blackouts 15 days on average, or 53% of the time.	The number of days with outages decreased slightly from the second to the top quintile.	The average number of days with blackouts over the last 4 weeks was 14 in urban and 18 in rural areas.

Source: World Bank staff analysis of household surveys
Note: All percentages are percentages of households connected to the grid who replied to the questions on blackouts.

Gender of Head of Household

Is there evidence that female-headed households tend to be poorer? If they are, examining the relationship between the gender of the head of household and access could be misleading, confusing poverty with gender. Are female-headed households less likely to have access to electricity, or buy less electricity, than their male-counterparts, after accounting for per capita and household expenditures?

Female-headed households are over-represented in lower quintiles in Botswana, Malawi, Rwanda, South Africa, and Swaziland. The worst is South Africa, where only 10 percent of all people living in female-headed households is in the top quintile. Conversely, female-headed households are over-represented in upper quintiles in Burkina Faso, Ethiopia, Mali, Niger, and Senegal. In Mali, only 3 percent of all people living in female-headed households was in the bottom quintile and 40 percent in the top quintile. Generally, per capita expenditures in each quintile were comparable between female- and male-headed households. However, with the exception of South Africa and Swaziland, female-headed households were considerably smaller, making their household expenditures smaller than their male counterparts.

In the regression analysis, the logarithms of per capita expenditure and household size as independent variables consistently gave a better fit than the logarithm of total household expenditure. Probit regression of the urban/rural dummy on the female/male dummy and the above two logarithms found that the gender of the head of household was insignificant only in Angola, and was negative only in Malawi and Swaziland. Being female-headed increased the probability of residing in urban areas by as much as 23 percent in Senegal (see Table A.21 in the annex); the median increase was 7 percent. This may be in part because rural areas tend to be more traditional, making it more difficult for women to head households.

Probit regression of the female/male dummy on three dependent variables—urban/rural dummy, logarithm of per capita household expenditure, and logarithm of household size—showed that the coefficients for both per capita expenditure and household size were significant and negative, except in Senegal where female-headed households had a positive significant coefficient for per capita expenditure and Botswana where the coefficient for household size was positive. (The coefficient for expenditure was insignificant in Mali and Sierra Leonne and that for household size was insignificant in South Africa and Swaziland.) The coefficient for the urban/rural dummy was usually statistically significant and positive. While the equation specification tested was overly simplified, these results suggest that, after accounting for the location (urban/rural), female-headed households may have tended to be poorer on average in most countries.

Statistically significant results found in the regression analysis relating the gender of the head of household to electricity use are shown in Table 15. For probit equations, the results show the difference in the probability between female- and male-headed households that the dependent variable (for example, electrification) would be 1 at mean values of per capita expenditure and household size. For ordinary least squares, the table shows the percentage by which spending on electricity increases, again at mean values of per capita expenditure and household size. In total, the gender dummy was statistically significant in at least one equation in 15 countries. The coefficients for probit equations were negative in Ghana (all urban), Sierra Leone (rural expenditure and rural grid dummies), Togo (all urban), and Zambia (rural grid), and positive elsewhere. While the gender dummy was negative for rural households in Sierra Leone, these were the only equations in which the logarithm of per capita expenditure was not statistically significant, casting doubt on the results. Among those who reported positive expenditures on electricity, the gender of the head of household affected the amount spent only in four countries, with negative coefficients in Ghana and positive elsewhere. On balance, female-headed households did not differ from male-headed households once per capita expenditure and household size were taken into account, and if anything evidence pointed to female-headed households being more likely to use electricity, with urban Ghana and urban Togo being notable exceptions. However, when the logarithm of expenditure on electricity is examined among grid-connected households only, female-headed households had spent considerably less in rural São Tomé and Príncipe and Sierra Leone, as shown in Table A.22 in the annex, although the opposite was observed in rural Angola.

Table 15: Impact of gender of household head on electricity-related variables

	Expenditure dummy[a]		Electricity dummy[b]		Grid dummy[c]		Log expenditure[d]	
	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
Angola	—	—	—	—	—	—	—	24
Botswana	—	0.07	—	0.09	—	0.08	—	—
Ethiopia	0.10	—	—	—	—	—	—	—
Ghana	-0.04	0.11	-0.02	0.11	-0.02	0.11	-10	-10
Madagascar	0.06	—	0.09	—	0.08	—	—	—
Mali	—	—	—	—	0.09	0.10	—	—
Niger	—	—	—	—	0.12	—	—	—
Nigeria	—	0.14	—	0.10	—	0.17	—	—
Rwanda	—	—	—	—	—	—	14	—
São Tomé and Príncipe	0.08	—	—	—	n.d.	n.d.	—	—
Senegal	—	0.24	—	0.23	—	0.23	—	35
Sierra Leone	—	-0.003	—	—	—	-0.003	—	—
South Africa	0.10	—	n.a.	n.a.	0.02	—	—	—
Togo	-0.06	—	-0.07	—	-0.06	—	—	—
Zambia	0.04	—	—	—	—	-0.01	—	—
Median	0.06	0.09	-0.02	0.11	0.05	0.10	NA	24

Source: World Bank staff calculations.

a. 1 if spending on electricity is positive, zero otherwise.

b. 1 for electricity (grid as well as off-grid, such as solar and diesel generators) as the primary source of energy for lighting or cooking, 0 otherwise.

c. 1 for households connected to the grid or electricity (excluding off-grid, such as solar and diesel generators) as the primary source of energy for lighting or cooking, 0 otherwise; see footnotes d and e and associated results in Table A.21 for more detail.

d. Logarithm of spending on electricity retaining all households with positive expenditure.

The results for the dummy represent the increase in the probability of the dependent variable being 1 as result of changing the gender dummy from 0 (male) to 1 (female). The results for log expenditure on electricity represent the percent increase in expenditure on electricity (not logarithm) as a result of changing the gender dummy from 0 to 1. — = statistically insignificant at 5; n.d. = no distinction made for different sources of electricity; n.a. = not available (data not collected); NA = not applicable.

The surveys in Malawi, Niger, and Nigeria enabled isolation of households who lived in communities connected to the grid. The probit regression for grid connection for households that could have connected was performed by taking these households as a single group as well as by separating urban from rural households. Statistically significant results were obtained when urban and rural households were combined only in Niger—female-headed households were more likely to connect—and separating urban and rural households similarly returned statistically significant results only in urban Niger—again female-headed households were more likely to connect.

Given the data limitations, these findings should be viewed only as preliminary, calling for more detailed investigation. A recent detailed analysis of the gender of the head of household in Africa since the 1990s suggests that the share of female-headed households has been rising, while that poverty has been declining faster among female-headed households than among their male counterparts (Milazzo and van de Walle 2015). These changing dynamics can inform future research and affect policy direction.

Conclusions

It is worth highlighting the limitations of this study—in scope and data availability—before summarizing the key findings and possible policy implications:

- With respect to household access, there is much less information on the supply side compared to the demand side. Connection charges tend to increase rapidly with increasing distance from the power line, and yet information on the distance between each household and the nearest distribution line is not available. Grid connection may not be a practical option even for many living in electrified communities.
- Information on income, let alone disposable cash income, is not available and is substituted by household expenditures used to calculate official poverty statistics. Those using kerosene for lighting have some cash-based expenditures to redirect to electricity purchase, but no survey separates spending on kerosene for lighting from that for cooking. Trying to pinpoint determinants of access beyond affordability based on national household expenditure surveys requires more data collection and analysis in individual countries.
- It would not be appropriate to extrapolate the conclusions and recommendations in this paper to off-grid electricity where different factors will be at play. There are many areas in Africa—areas with low population density and low household expenditures, and far from cities and towns—where it would be too costly to supply grid electricity. Where the unit cost of grid electricity supply markedly exceeds what would be considered reasonable to pay for grid electricity, off-grid solutions are likely to offer more practical solutions.

This paper confirms many widely accepted observations, such as that the percentage of population using electricity remains low in Africa, that electricity use is far more prevalent in urban than in rural areas, and that adoption of electricity and quantities consumed rise sharply with income. There are also relatively new findings. The rate of household access to grid electricity is only weakly correlated with affordability of tariffs applicable to the subsistence level of electricity consumption. There is little evidence of a trade-off between utilities' deficits and household access, but there is evidence of trade-offs between affordability at relatively high residential consumption levels and underpricing. There is no marked difference between female- and male-headed households with respect to access to electricity and spending on electricity, once income (per capita as well as household, captured through the combination of per capita expenditures and household size) and the place of residence are accounted for. The remainder of this section is largely about grid electricity.

The findings of this study suggest several measures that can enable use of electricity by more households:

- Avoid multiple connections. They substantially reduce, if not eliminate altogether, the intended benefits of the subsidies provided by progressive tariffs. Shared connections also degrade the quality of service to those so connected because the combined demand of the households can easily exceed the installed capacity.
- Making connection charges affordable is one of the top priorities in a number of countries. The difference in the share of household expenditures needed to pay for the initial connection between those with and without grid connection is stark, with medians differing by a factor of two when total household expenditures are considered and a factor of three when only cash expenditures are considered. In some countries, connection charges are beyond the reach of low-income households, arguably an important reason for multiple connections. Easing payment terms for new connection

and building connection charges in general tariffs of all—and especially high-consumption consumers in all sectors—would help. In easing payment terms, attention should be paid to balancing tariffs and monthly installments for connection charges, because the combined effect could make monthly payments unaffordable.

- Utilities can do more to stamp out corruption and eliminate bribe payments demanded by their employees. In the two surveys where grid-connected households were asked if they had paid a bribe to get connection, many replied "yes." Bribes for connection further encourage multiple connections.
- Lifeline rates for blocks in the vicinity of 30–50 kWh a month may help strike a balance between affordability on the one hand and utility financial viability on the other. The first block of 25 kWh or less per month in some countries seems too small. If the country has a single schedule of a single block, progressive tariffs may be considered. For full benefits to be reaped, however, households need to be individually and accurately metered.
- Prepaid meters help low-income households. The ability to pay in small increments when cash is earned, and not having to face the prospect of disconnection and a high reconnection charge, help especially the poor. However, electricity services are unreliable—in every one of the seven countries in which households were asked about service quality, blackouts were common—and this could mean that prepaid customers pay in advance for electricity they cannot get when needed. For this reason, it may be unfair to mandate prepaid metering on all customers.
- Consideration may be given to basing lifeline rates on a moving average of consumption over several months. Volume-differentiated tariffs with a large increase in unit price from the first to the second block in particular may pose financial hardships for the poor if they are applied strictly on monthly consumption. To address this concern, in Cape Town, South Africa, free electricity is based on monthly consumption averaged over the past 12 months. Using moving averages and issuing warning messages in advance to customers as they approach the limit are two ways of alleviating such hardships.
- High appliance efficiency further helps reduce monthly bills. Recent advances in energy efficiency improvement are enabling households to meet basic electricity needs for as little as 15 kWh a month. For example, using four light-emitting diode light bulbs of 800 lumens each for four hours a day, charging a cell phone, running a large fan for five hours a day, and watching one small efficient television for three hours a day consume about 15 kWh over a month. That said, light-emitting diode light bulbs and other efficient appliances are relatively expensive, making it difficult for the poor to pay the upfront costs—one of the main reasons energy is more expensive for the poor than for the rich, exacerbating energy poverty. Financial assistance may be needed.
- For gender equality, helping the poor is likely to go a long way in helping female-headed households. Once both per capita and total household expenditures are accounted for, there is little evidence that female-headed households are disadvantaged with respect to electricity use, except in urban Ghana and Togo. That said, these are preliminary findings, and the gender dimension should be investigated further to see how robust this finding is.

Utilities can take steps to provide more targeted assistance to low-income households without increasing their deficits markedly:

- Rolling out prepaid meters helps utilities. Utilities are assured of prompt payment for every kWh consumed.

- Tariffs do not have to be exceptionally low. Where consumption at the subsistence level is a very small share of monthly household cash expenditures, consideration may be given to raising tariffs. In the sampled countries, Angola and Nigeria have exceptionally low unit tariffs in absolute terms and relative even to the income of the poor.
- Volume-differentiated tariffs at the high end may be considered. Several countries have volume-differentiated tariffs between the first and the second block, followed by increasing block tariffs thereafter. But if households are individually metered so that high monthly consumption signals a household with many appliances, their ability to pay can be exploited more to cross-subsidize the low end of monthly consumption by switching the order: increasing block tariffs between the first and the second block, followed by volume-differentiated tariffs.
- Reallocation of cross-subsidies can help make electricity affordable in most countries. Targeted subsidies needed to make 30 kWh a month of grid electricity affordable to all urban residents, are not large in most countries. While recognizing that perfect targeting is not possible, the subsidies calculated in this study point to the potential for achieving universal access in urban and peri-urban areas.
- Eliminating operational inefficiencies may not eliminate underpricing, but can make subsidies to the poor more financially viable to utilities.
- Many Latin American countries treat assets associated with new connection no differently from all other assets—high- and medium-voltage transmission lines, for example—and capture them in the regulatory assets for tariff setting. Such an approach spreads the costs of new connection and helps reduce multiple connections by making the initial connection much more affordable in countries where connection fees are currently high.

Lastly, this paper found areas where questions in household surveys delivered ambiguous or questionable answers. A standardized approach to data analysis would also be helpful. Some examples follow.

- Quantitative information on kWh consumed seems difficult to obtain. Enumerators should be better trained to spot implausible answers if this question is asked. Without information on kWh consumed, it is not possible carry out the distributional analysis of subsidies outlined by Komives et al. (2005). In this paper, multiple schedules in many countries and the widespread practice of sharing meters meant that kWh consumed could not be back-calculated (except in Rwanda), because there is no way of telling which tariff schedule was applicable to each household.
- Given the policy implications of pervasive use of shared meters, the wording of questions concerning shared meters can be tightened, for example by distinguishing between “private” meters on one’s premises to which other households connect and unshared meters on one’s premises.
- It would be useful to distinguish between solar lanterns and solar panels, and avoid using the term “solar energy.”
- In countries where generator ownership is prevalent, it would be useful to separate spending on automotive fuels from spending on fuels for generators.
- In countries with large commercial and bill collection losses, it might be worth asking questions about nonpayment in a way that would enable more robust conclusions. Separating electricity from water where the questionnaire currently reads “free electricity/water” as employment benefits and inclusion in the rent are two examples.

- National household expenditure surveys are useful because they enable identification of the poor. They are less useful for calculating access to electricity. Agreeing how to standardize analysis across divergent household surveys among energy practitioners would help compare computation of access rates across studies.
- More systematic collection of freely acquired basic goods and services to separate cash expenditures from own consumption would help estimate disposable cash income, which is needed to assess the ability to pay for electricity.
- A national household expenditure survey cannot substitute a dedicated energy survey. One problem with energy surveys is that information on total household expenditures is not collected because that requires a long list of questions. One option is to launch the energy survey in parallel with the national household expenditure survey, visiting the same households. Further, examination of household survey data side by side with data on residential customers from utilities would enrich analysis considerably.

This paper has examined access largely from the point of view of demand. But supply constraints are equally important. Indeed, where data on community access and household connection to the grid were available, most unconnected households did not live in electrified communities, a result dominated by lack of community access in rural areas. This points to the importance of developing a financially viable strategy for rural electrification, while making grid electricity affordable in urban areas.

Annex

The surveys used in this study are listed in Table A.1. Total expenditures used to measure poverty are in real terms (accounting for regional and sometimes temporal differences in prices), except in Botswana, where the government's decision to use nominal values was followed. Poverty is based on per capita or per adult-equivalent expenditures, as indicated in the last column.

Table A.1: Household survey description

Country	Name	Survey period	Sample size	Poverty
Angola	Inquérito Integrado sobre o Bem Estar da População (IBEP)	May 2008–Jul 2009	9,002	Adult
Botswana	Botswana Core Welfare Indicator Survey	Apr 2009–Mar 2010	7,644	Adult[a]
Burkina Faso	Enquête Intégrale sur les Conditions de Vie des Ménages Burkinabè (EICVM) 2009–2010	Jul–Sep 2009	4,801	Adult
Côte d'Ivoire	Enquête Niveau de Vie des Ménages (ENM)	Jun-Oct 2008	12,600	p.c.
Ethiopia	Ethiopia Socioeconomic Survey	May–Dec 2013	5,257	n.d.[b]
Ghana	Ghana Living Standards Survey 6	Oct 2012–Sep 2013	16,702	Adult
Madagascar	Enquête Périodique Auprès des Ménages (EPM) 2010	Jun–Oct 2010	12,460	p.c.
Malawi	Integrated Panel Household Survey 2013	Apr–Dec 2013	4,000	p.c.
Mali	Living Standards Measurement Study - Integrated Surveys on Agriculture (LSMS-ISA)	2014		p.c.
Mozambique	Inquérito sobre Orçamento Familiar (IOF) 2008/9	Sep 2008–Aug 2009	10,832	p.c.[c]
Niger	Enquête Nationale sur les Conditions de Vie des Ménages (ECVM) 2011	Jul 2011–Jan 2012	3,859	p.c.
Nigeria	General Household Survey Panel Wave 2 (2012/13) Post-Harvest Visit	Feb–Nov 2013	4,568	p.c.
Rwanda	Enquête Intégrale sur les Conditions de Vie des Ménages (EICV3)	Mar 2010–Mar 2011	14,308	Adult
São Tomé and Príncipe	Inquérito aos Orçamento Familiar (IOF) 2009/2010	2010	3,128	p.c.
Senegal	Enquête de Suivi de la Pauvreté au Sénégal (ESPS-II)	Aug 2011–Feb 2012	5,944	Adult
Sierra Leone	Sierra Leone Integrated Household Survey (SLIHS)	Jan–Dec 2011	6,727	Adult
South Africa	Income and Expenditure Survey 2010/11	Jul 2010–Sep 2011	25,251	p.c.
Swaziland	2009/10 Swaziland Household Income and Expenditure Survey	Apr 2009–Mar 2010	3,177	Adult
Tanzania	National Panel Survey (NPS) 2012/2013	Oct 2012–Nov 2013	4,883	Adult
Togo	Questionnaire des Indicateurs de Base du Bien-être (QUIBB) 2011	Jul–Aug 2011	5,491	Adult
Uganda	Uganda National Household Survey (UNHS) 2012/13	Jun 2012–Jun 2013	6,888	Adult
Zambia	Living Conditions Monitoring Survey (LCMS) VI – 2010	Jan–Apr 2010	19,368	Adult

Sources: Household surveys named in the table.

a. Households' poverty status as determined by official poverty measurements is used in this work, but the official measurements included rare large expenditures in consumption aggregates. For the purpose of defining total household

expenditures to define quintiles and expenditure share on electricity, expenditures were reconstructed by omitting large purchases in the official consumption aggregates and adding back imputed values of non-purchased food and fuels (dung and wood) that had been excluded in the consumption aggregates constructed by the government.
b. This survey is not used to measure poverty. Based on the poverty rate of 30 in 2011, this paper assigned the poverty status to the bottom 30.
c. Poverty is based on regional poverty lines.
p.c. = per capita; n.d. = not defined.

Some descriptive statistics are given in Table A.2. Aggregated across the sample countries, 67 percent of all people and 63 percent of all households were in rural areas. The officially poor consisted of 51 percent of rural residents and 31 of urban residents, or 42 percent of all people. Where poverty is based on per capita expenditures, the bottom two quintiles were poor in all countries except Ethiopia where the bottom 30 percent were defined to be poor in the absence of poverty measurement using the 2013 Ethiopia Socioeconomic Survey. There tended to be a higher percentage of female-headed households in urban areas than in rural areas. The table also shows per capita real expenditures (except in Botswana, where real expenditures are not available and nominal expenditures are used) expressed in 2014 U.S. dollars.

Table A.2: Descriptive statistics

	Rural		of people officially classified poor			of people living in female-headed households			Total real monthly expenditure per capita in 2014 US$		
Country	People	Households	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Total
Angola	45	48	19	58	37	19	17	18	152	73	117
Botswana	43	42	16	24	19	49	51	50	199	115	163
Burkina Faso	78	72	25	53	47	13	7	8	53	29	34
Côte d'Ivoire	54	50	29	54	43	20	10	15	91	56	72
Ethiopia	87	82	11	33	30[a]	35	15	17	35	21	23
Ghana	50	45	11	38	24	30	20	25	92	50	71
Madagascar	80	78	51	81	75	18	14	15	23	13	15
Malawi	84	83	25	40	38	16	22	21	54	31	35
Mali	78	69	9	44	36	9	2	4	68	48	52
Mozambique	70	71	29	62	52	28	23	24	54	23	32
Niger	83	82	18	55	48	14	6	7	65	33	39
Nigeria	64	60	28	64	51	14	8	10	79	45	58
Rwanda	86	85	22	49	45	22	23	22	72	24	31
São Tomé and Príncipe	49	50	64	59	62	39	34	37	73	77	75
Senegal	57	51	33	57	47	36	15	24	78	51	63
Sierra Leone	62	61	31	66	53	30	24	26	42	26	32
South Africa	39	33	31	69	45	36	54	43	269	83	197
Swaziland	76	63	31	73	63	38	53	50	124	51	69
Tanzania	74	69	6	26	21	24	21	22	62	29	38
Togo	62	56	35	73	58	20	15	17	73	36	50
Uganda	77	73	10	22	19	32	26	27	76	38	47
Zambia	65	64	28	77	60	20	19	20	69	22	39
Median	67	63	26	56	46	23	20	21	73	37	49

Sources: Household expenditure surveys and World Bank staff calculations.

Note: Per capita expenditures in 2014 U.S. dollars take real expenditures in the survey (except Botswana where only nominal expenditures are available) and inflate them to 2014 in local currency using the country's consumer price index, and convert them to U.S. dollars using the official exchange rate in 2014.

a. This survey is not used to measure poverty. Based on the poverty rate of 30 in 2011, this paper assigned the poverty status to the bottom 30.

Access to grid electricity expressed as the percentage of all people who live in households reporting connection to the grid is shown in Table A.3. The statistics in the table correspond to the lowest measure of access rate.

Table A.3: Percentage of all people who have grid connection

	All people					People classified poor		
Country	Urban	Rural	Total	Q1	Q5	Urban	Rural	Total
Angola	67	10	41	6	73	38	4	14
Botswana	60	21	43	15	74	41	10	24
Burkina Faso	46	2	11	1	35	13	1	2
Côte d'Ivoire	—	—	—	—	—	—	—	—
Ethiopia	94	8	19	5	38	83	4	8
Ghana	88	44	66	35	89	73	30	40
Madagascar	—	—	—	—	—	—	—	—
Malawi	38	3	9	0	30	8	0	1
Mali	75	7	22	2	54	36	1	3
Mozambique	—	—	—	—	—	—	—	—
Niger	48	2	10	1	37	9	1	1
Nigeria	89	37	56	26	82	84	29	40
Rwanda	46	5	11	1	43	5	0	1
São Tomé and Príncipe	—	—	—	—	—	—	—	—
Senegal	90	25	53	26	83	79	18	36
Sierra Leone	35	0	13	2	37	20	0	6
South Africa	93	78	87	76	99	86	75	80
Swaziland	—	—	—	—	—	—	—	—
Tanzania	50	4	16	1	53	7	0	1
Togo[a]	77	9	34	5	73	60	5	18
Uganda	33	2	9	1	31	3	1	1
Zambia	55	4	22	1	71	16	1	4
Median	60	7	22	2	54	36	1	6

Source: World Bank staff analysis of household surveys.

a. In Togo, households were not asked directly about connection to the grid, but were asked about expenditures during the last two months on grid electricity, and the response is used in this table.

— = Grid connection status not available in the survey; Q1 = expenditure quintile 1 (bottom 20); Q5 = expenditure quintile 5 (top 20).

Table A.4 and Table A.5 show electricity expenditure shares by quintile for total expenditures with and without imputed values, respectively.

Table A.4: Share of total household expenditures spent on electricity by quintile

	Urban					Rural					National				
Country	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Angola	4.7	5.3	3.3	7.2	2.3	—	4.0	3.1	2.7	2.2	4.7	5.2	3.3	7.0	2.3
Botswana	10.2	9.3	7.7	7.5	4.9	11.4	11.5	9.2	9.0	4.8	10.5	10.1	8.1	7.8	4.9
Burkina Faso	5.2	6.4	4.7	4.8	4.5	0.7	5.0	3.5	5.0	4.0	1.4	6.0	4.4	4.9	4.4
Cote d'Ivoire	3.5	3.0	2.7	2.5	2.2	3.7	2.5	2.5	1.9	2.0	3.6	2.8	2.7	2.4	2.2
Ethiopia	4.8	4.0	3.7	2.7	2.2	3.4	1.4	1.1	1.2	1.0	4.2	2.8	2.8	2.1	1.8
Ghana	3.2	2.9	2.8	2.7	2.3	2.5	1.9	1.9	2.0	1.7	2.8	2.4	2.5	2.6	2.2
Madagascar	7.2	4.9	3.7	4.2	4.5	9.5	2.6	3.3	4.0	4.1	8.8	4.2	3.4	4.1	4.4
Malawi	0.5	0.4	0.3	0.2	0.3	—	0.4	0.3	0.3	0.3	0.5	0.4	0.3	0.3	0.3
Mali	2.1	2.9	2.6	2.8	3.0	1.1	1.1	0.9	1.0	2.2	1.3	1.5	1.8	2.2	2.8
Mozambique	9.2	7.0	5.1	3.5	3.6	9.4	4.3	5.1	3.7	2.8	9.4	6.7	5.1	3.5	3.5
Niger	3.6	3.3	2.6	2.6	3.5	1.4	2.2	1.6	1.7	3.1	2.6	2.5	2.1	2.3	3.5
Nigeria	4.3	2.8	2.5	2.1	2.7	3.5	2.5	2.1	2.1	2.0	3.8	2.6	2.3	2.1	2.5
Rwanda	1.8	3.1	2.2	2.1	1.3	4.7	3.2	2.2	2.4	1.2	3.6	3.1	2.2	2.2	1.3
São Tomé and Príncipe	2.8	2.2	2.2	1.9	1.8	2.9	3.1	1.7	1.9	1.7	2.8	2.3	2.0	1.9	1.8
Senegal	4.6	3.4	3.0	3.5	4.0	4.2	3.3	2.6	3.7	3.9	4.5	3.4	2.9	3.6	4.0
Sierra Leone	7.5	5.1	4.3	4.8	4.3	11.6	14.3	11.4	5.0	5.0	8.0	5.3	4.5	4.8	4.3
South Africa	8.8	6.9	6.1	5.2	3.9	6.8	5.4	4.8	4.3	3.6	7.6	6.1	5.6	5.0	3.8
Swaziland	8.7	9.2	17.2	11.3	8.3	19.6	11.7	10.2	8.9	8.0	17.2	11.3	12.3	9.8	8.2
Tanzania	1.9	3.0	3.7	3.3	2.9	5.9	5.0	5.1	3.8	2.8	3.1	3.5	4.2	3.4	2.9
Togo	4.1	4.1	3.3	3.1	3.0	3.2	4.3	2.6	3.3	2.9	3.8	4.1	3.2	3.1	3.0
Uganda	1.8	2.6	2.7	2.1	2.5	5.3	0.3	1.3	1.8	1.9	3.7	2.1	2.5	2.0	2.4
Zambia	4.4	8.0	7.9	7.4	4.9	1.1	5.9	7.6	10.2	5.1	1.7	7.5	7.8	7.6	4.9
Median	4.4	3.7	3.3	3.2	3.0	4.0	3.2	2.6	3.0	2.8	3.7	3.5	3.0	3.3	2.9

Source: World Bank staff calculations using household survey data.
Note: — = No households with non-zero expenditures on electricity

Table A.5: Share of total household cash expenditures spent on electricity by quintile

	Urban					Rural					National				
Country	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Botswana	10.9	9.4	7.7	7.6	4.9	11.4	12.2	9.7	9.4	5.0	11.0	10.4	8.3	7.9	4.9
Burkina Faso	5.4	7.1	5.2	5.6	5.3	1.4	7.5	4.9	6.1	4.5	2.0	7.2	5.2	5.6	5.2
Cote d'Ivoire	3.7	3.1	2.8	2.6	2.3	4.8	3.1	3.1	2.3	2.3	4.2	3.1	2.9	2.5	2.3
Ethiopia	5.0	4.4	4.4	2.9	2.2	4.4	2.2	1.7	2.4	1.7	4.7	3.4	3.4	2.7	2.1
Ghana	3.4	3.0	2.9	2.8	2.3	3.1	2.2	2.1	2.3	1.9	3.2	2.7	2.6	2.7	2.3
Malawi	0.5	0.4	0.4	0.3	0.3	—	0.4	0.3	0.4	0.3	0.5	0.4	0.3	0.3	0.3
Mali	2.2	3.0	2.6	2.8	3.0	1.5	1.6	1.2	1.3	2.5	1.6	1.9	1.9	2.3	2.9
Niger	4.0	3.6	2.8	2.7	3.6	2.0	2.5	2.1	1.9	3.5	3.1	2.8	2.4	2.4	3.6
Nigeria	6.2	4.3	3.8	3.2	3.7	6.0	4.5	3.4	3.5	3.2	6.1	4.4	3.6	3.3	3.6
Rwanda	1.8	3.4	2.3	2.2	1.3	5.3	4.9	2.7	2.8	1.3	4.0	4.3	2.5	2.5	1.3
São Tomé and Príncipe	2.8	2.2	2.2	1.9	1.8	3.1	3.2	1.7	1.9	1.7	2.9	2.4	2.0	1.9	1.8
Senegal	4.6	3.4	3.0	3.6	4.0	4.8	3.5	2.7	3.8	4.0	4.7	3.5	3.0	3.6	4.0
Sierra Leone	7.5	5.1	4.3	4.8	4.3	13.5	14.3	14.9	5.0	6.8	8.2	5.4	4.6	4.8	4.3
Swaziland	8.8	10.0	17.5	11.8	8.5	20.8	13.2	11.4	9.8	8.6	18.2	12.6	13.2	10.6	8.5
Tanzania	2.0	3.6	4.2	3.7	3.2	7.4	6.9	7.0	4.9	3.6	3.7	4.5	5.2	3.9	3.3
Togo	4.4	4.2	3.3	3.2	3.0	3.9	5.4	2.9	3.5	3.0	4.2	4.6	3.3	3.2	3.0
Uganda	1.8	2.7	3.1	2.2	2.6	6.8	1.0	1.5	2.3	2.1	4.5	2.3	2.9	2.2	2.6
Zambia	4.5	8.5	8.5	7.7	5.1	4.0	10.6	8.8	11.2	5.4	4.1	9.0	8.5	8.1	5.1
Median	4.2	3.6	3.2	3.0	3.1	4.8	4.0	2.8	3.2	3.1	4.1	3.9	3.1	3.0	3.2

Source: World Bank staff calculations using household survey data.
Note: — = No households with non-zero expenditures on electricity

Residential tariff structures in 39 countries in Africa are provided in Table A.6. A schedule has its own unique energy and fixed charges, and therefore two schedules with identical energy charges but different fixed charges are considered distinct and counted as two. The table shows the number of schedules for single-phase and three-phase electricity connections. Some countries do not make this distinction, but where the schedule depends on installed capacity (kilowatts or kilovolt-amperes), the inferred number of phases is used to construct the entries in Table A.6. If no distinction is made and the schedule is independent of installed capacity, the number of schedules appears under single phase only in the table below, with no entries under three phases.

Table A.6: Residential tariff structure characteristics

Country	# of single phase schedules	# of blocks	Type of tariff schedule	# of 3-phase schedules	# of blocks	Type of schedule	Prepaid schedule
Angola	2	2/1	increasing block tariff/—	2	1	—	N
Benin	1	3	volume differentiated for block 2, increasing thereafter	—	—	—	N
Botswana	1	2	n.a.	—	—	—	N
Burkina Faso	7	3	increasing	5	3	increasing	N
Burundi	1	3	Increasing	—	—	—	N
Cabo Verde	2	2	Volume differentiated	2	2	volume differentiated	N
Cameroon	1	5	volume differentiated, but first block is exempt from tax for all consumption levels	—	—	—	N
Chad	1	2	n.a.	—	—	—	N
Comoros	2	1	—	—	—	—	Y
Côte d'Ivoire	3	2/1/2	increasing/—/decreasing	—	—	—	N
Ethiopia	1	9	increasing	1	7	increasing	N
Gabon	9	1	—	7	1	—	Y
Gambia, The	2	4/1	increasing /—	—	—	—	Y
Ghana	1	4	volume differentiated for block 2, increasing thereafter	—	—	—	N
Guinea	1	3	increasing	1	3	increasing	N
Kenya	1	3	increasing	—	—	—	N
Lesotho	1	1	—	—	—	—	N
Liberia	1	1	—	—	—	—	N
Madagascar	2	2	increasing block tariff; each of the four regions has two different schedules	—	—	—	N
Malawi	2	1	—	2	1	—	Y

Country	# of single phase schedules	# of blocks	Type of tariff schedule	# of 3-phase schedules	# of blocks	Type of schedule	Prepaid schedule
Mali	17	4 for prepaid social, 2 otherwise	increasing	10	2	increasing	Y
Mauritania	8	1	—	—	—	—	N
Mauritius	1	8	increasing	1	8	increasing	N
Mozambique	3	1/3/1	—/increasing/—	—	—	—	Y
Namibia	4	1	—	1	1	—	Y
Niger	1	2	increasing	—	—	—	N
Nigeria	2	1	volume differentiated in that exceeding 50 kWh moves the consumer to another schedule	3	1	—	N
Rwanda	1	1	—	—	—	—	N
São Tomé and Príncipe	2	3	volume differentiated	2	3	volume differentiated	N
Senegal	2	3/1	increasing/—	3	3/1/2	increasing/—/TOU	Y
Seychelles	2	5	increasing	1	5	increasing	N
Sierra Leone	1	3	increasing	—	—	—	N
South Africa (Johannesburg)	7	5 or TOU seasonal	increasing	6	5/TOU seasonal	increasing	Y
Swaziland	2	1	—	—	—	—	N
Tanzania	2	2/1	increasing/–	1	1	—	N
Togo	1	4	volume differentiated for block 2, increasing thereafter	2	3	increasing	N
Uganda	1	2	increasing	—	—	—	N
Zambia	2	3/1	increasing /—	—	—	—	Y
Zimbabwe	3	3/1/3	increasing/—/increasing	—	—	—	Y

Sources: Utility and regulatory agency websites.

Note: "Volume differentiated for block 2, increasing thereafter" means the tariff schedule is volume-differentiated between block 1 and block 2, but assumes a increasing block tariff structure from block 2 to block 3 and higher blocks.

# of single-phase schedules = number of schedules for single-phase connection or all connections in countries with no distinction between single and three phases; # of blocks = number of blocks in the schedules preceding the column; # of 3-phase schedules = number of schedules explicitly associated with three-phase connection, or with power capacity that is associated with three phases; prepaid schedule = Y (yes) if a schedule for pre-paid is separately listed, N (no) otherwise; n.a. = not available (information could not be obtained); TOU = time of use.

Table A.7 shows examples of effective unit tariffs for monthly consumption of 30, 50, 100, and 250 kWh, as well as examples of upfront payments needed to connect to grid electricity. For effective tariffs, the lowest-cost option is presented in the table. Unless indicated otherwise, connection charges also represent lowest-cost options (such as single phase and not requiring a grid line extension). All the charges were in effect in July 2014 and converted to U.S. dollars using the official exchange rate in July 2014.

Table A.7: Examples of effective unit tariffs and upfront cost of grid connectionfor households in July 2014

	Effective tariff charge in US$/kWh for monthly consumption in kWh below				Upfront connection cost in US$			
Country	30	50	100	250	Rate 1	Description	Rate 2	Description
Angola	0.012	0.012	0.023	0.038	52[a]	—	—	—
Benin	0.32	0.30	0.29	0.28	278	—	—	—
Botswana	0.16	0.13	0.10	0.090	679	One-off payment	141	1st of 180 payments over 180 months; $5 thereafter[b]
Burkina Faso	0.28	0.25	0.25	0.28	270	Ouagadougou and Bobo-Dioulasso	70	Provinces
Burundi	0.044	0.044	0.066	0.128	155	Beginning Sep 2014, households also purchase materials	—	—
Cabo Verde	0.46	0.45	0.54	0.54	2[c]	—	—	—
Cameroon	0.10	0.10	0.10	0.16	50	—	—	—
Chad	0.18	0.18	0.18	0.21	n.a.	—	—	—
Comoros	0.36	0.36	0.36	0.36	181	—	—	—
Côte d'Ivoire	0.10[d]	0.11[d]	0.14[d]	0.17[d]	212	Lowest of four social connection costs, the other three being $308, $370, and $411	—	—
Ethiopia	0.022	0.019	0.022	0.027	76	—	—	—
Gabon	0.11	0.11	0.11	0.25	114	—	—	—
Gambia, The	0.23	0.23	0.23	0.23	169	Greater Banjul Area	81	Provinces
Ghana	0.069	0.064	0.12	0.12	87[e]	No extension	436[e]	Extension with 1 pole
Guinea	0.040	0.029	0.029	0.031	n.a.			
Kenya	0.20	0.18	0.23	0.27	171	If next to a clinic and other facilities with electricity	370	If not next to facilities
Lesotho	0.11	0.11	0.11	0.11	187	—	—	—
Liberia	0.51	0.51	0.51	0.51	54	—	—	—
Madagascar	0.12	0.20	0.17	0.17	165	No extension	453	Extension with 1 pole
Malawi	0.076	0.076	0.076	0.076	101	—	—	—
Mali	0.12	0.12	0.16	0.24	196	—	—	—
Mauritania	0.20	0.16	0.13	0.12	128	For 2 kilo-volt amperes	168	6 kilo-volt amperes
Mauritius	0.12	0.13	0.15	0.19	31	—	—	—
Mozambique	0.034	0.034	0.034	0.091	0	Social tariff customers	4	Others, single phase
Namibia	0.22	0.18	0.16	0.14	113	Urban[f]	—	—
Niger	0.18	0.16	0.17	0.18	19	—	—	—

Country	Effective tariff charge in US$/kWh for monthly consumption in kWh below 30	50	100	250	Upfront connection cost in US$ Rate 1	Description	Rate 2	Description
Nigeria	0.026	0.026	0.14	0.11	n.a.	There is no connection fee but customers are charged for costs of materials	—	—
Rwanda	0.23	0.23	0.23	0.23	82	Within 35 meters of a pole		
São Tomé and Príncipe	0.105	0.100	0.096	0.14	52	Single phase	108	Three phase
Senegal	0.25	0.24	0.24	0.27	0	Free if within 40 meters.	—	—
Seychelles	0.11	0.11	0.11	0.11	Based on actual investment cost			
Sierra Leone	0.19	0.19	0.19	0.21	233	One-off payment[g]	118	First of 18 payments over 18 months, $7/month thereafter[g]
South Africa	0.10[h]	0.10[h]	0.10[h]	0.10[h]	0	Homelight 20A (20 amperes)	—	—
Swaziland	0.088	0.088	0.088	0.088	13	—	—	—
Tanzania	0.073	0.073	0.12	0.20	197	Urban	110	Rural
Togo	0.22	0.28	0.24	0.24	244	—	—	—
Uganda	0.20	0.21	0.22	0.23	101	No extension	244	Extension with 1 pole
Zambia	0.15	0.10	0.064	0.062	125	Low-cost areas	277	Medium-cost areas[i]
Zimbabwe	0.021	0.021	0.069	0.095	95	Above ground, high-density areas[j]	185	Above ground, low density areas[j]
Median	0.12	0.12	0.14	0.17	103	—	141	—

Sources: Utility and regulatory agency websites.

Notes: Lowest costs (usually corresponding to the lowest installed capacity) are shown if a customer has more than one option. Effective tariff charges are inclusive of fixed charges and taxes. Upfront costs include deposits that are not refunded until the end of the contract with the utility. — = not applicable; n.a. = not available (information could not be obtained).

a. The reconnection charge after disconnection is more than double this charge.

b. New customers can spread the payment over 18, 60, or 180 months. The first payment is identical for all three options, but subsequent monthly payments are US$30 and US$11 over 18 and 60 months, respectively.

c. The reconnection charge after disconnection is much higher at US$15.

d. These are outside of Abidjan, where power tariffs are slightly lower than in Abidjan.

e. Assumes no VAT on connection (information on VAT not available).

f. Rural connection charges not available.

g. Costs of materials are charged to all customers and included in the figures, taking US$70 as a typical average cost. These are both for prepaid customers, who do not have to pay an initial deposit of US$31.

h. There are three categories of consumers entitled to free electricity for the first 50, 100, and 150 kWh a month. For those entitled to 150 kWh of free electricity, the effective unit tariff for monthly consumption of 250 kWh is US$0.04/kWh.

i. The connection cost in high-cost areas is US$466.

j. These are for single-phase connections. Single-phase underground cable service costs are US$155 and US$224 for high-density and low-density areas, respectively. Three-phase above-ground and underground costs in low-density areas are US$333 and US$362, respectively.

Table A.8 shows adjustments made to per capita expenditures to compute hypothetical grid electricity expenditures shares, and monthly spending on electricity for varying consumption levels and connection fees expressed in 2014 US$ for cross-country comparison. The tariff years are the closest years to the survey years when the tariffs used came into effect. The timing of when the connection fees came into effect was not necessarily the same, in which case different adjustment factors for total household expenditures were used.

Table A.8: 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 US$				Connection fee 2014 US$	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
Cote 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	165	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	196	1.00
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	3.15	4.99	9.60	34.26	52	1.30
Senegal	2011	2009	1.00	7.52	12.03	23.69	66.45	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[c]	2011	2014	1.23	3.02	5.03	10.07	25.17	0	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. US$141 is the first payment in an installment plan of 18, 60, and 180 months. For the 180-month plan, the monthly spending increases by US$4.98 in the remaining 179 months if the customer chooses to pay over 180 months. US$141 is used to examine the connection-charge share of expenditures.

b. US$118 is the first payment in an installment plan of 18 months. The monthly spending increases by US$6.72 in the remaining 17 months if the customer chooses this payment plan. US$118 is used to examine the connection-charge share of expenditures.

c These numbers are for Johannesburg. Depending on eligibility, poor households are provided with 50, 100, or 150 kWh of free electricity a month. Because free electricity cannot be generalized to the rest of the country, monthly spending without free allocation of electricity is shown.

Table A.9–Table A.12 reproduce Table 5–Table 8 for monthly consumption of 50 kWh. Table A.13 and Table A.14 present results for monthly consumption of 100 kWh, and Table A.15 and Table A.16 do the same for 250 kWh. Table A.17 shows poverty-gap calculations for grid electricity using the lowest-cost tariff schedule for each consumption amount. Table A.18 shows the corresponding poverty headcount, which is the percentage of people (rather than households) who have to spend more than 5 percent of their total household expenditures (inclusive of freely acquired food and other items) on grid electricity. For South Africa, where different municipalities with their own eligibility criteria provide varying amounts of free electricity, the tariff schedule in Johannesburg without free electricity was used for this purpose. Table A.19 summarizes the levels of subsidies needed to enable every household to consume 30, 50, and 150 kWh of electricity a month, expressed in millions of U.S. dollars as well as a proportion of the total revenue collected by the utilities.

Table A.9: Expenditure share of monthly consumption of 50 kWh by location, quintile, poverty status, and gender of household head

	All households					Poor households			Household head	
Country	Urban	Rural	Total	Q1	Q5	Urban	Rural	Total	Female	Male
Angola	0.1	0.3	0.2	0.4	0.1	0.2	0.3	0.3	0.2	0.2
Botswana	3.1	7.3	4.8	20.4	1.3	8.8	11.8	10.5	5.7	4.1
Burkina Faso	9.8	13.9	12.8	22.7	7.8	17.1	18.2	18.1	19.5	11.8
Côte d'Ivoire	2.5	3.8	3.2	8.1	1.7	5.0	5.9	5.6	4.2	3.0
Ethiopia	1.6	1.8	1.8	3.8	0.9	4.5	3.1	3.2	2.5	1.5
Ghana	1.8	2.8	2.2	4.8	1.3	4.1	4.6	4.5	2.6	2.1
Madagascar	18.2	27.9	25.8	50.4	14.3	26.5	31.7	31.0	36.9	23.2
Malawi	2.2	3.9	3.6	6.3	2.1	3.8	5.6	5.4	4.5	3.3
Mali	1.7	2.5	2.3	4.2	1.2	3.0	3.7	3.6	2.3	2.3
Mozambique	2.5	4.4	3.8	9.2	1.3	5.3	6.0	5.9	5.0	3.3
Niger	3.3	5.7	5.3	7.7	3.6	6.1	6.6	6.6	7.8	5.0
Nigeria	0.4	0.6	0.5	1.0	0.4	0.7	0.7	0.7	0.8	0.5
Rwanda	8.9	15.9	14.9	27.9	6.2	19.6	22.1	21.9	19.0	13.3
São Tomé and Príncipe	2.6	2.8	2.7	4.4	1.9	3.3	3.4	3.3	3.0	2.6
Senegal	3.4	5.9	4.7	10.3	3.0	5.9	7.9	7.3	4.2	4.9
Sierra Leone	6.3	9.9	8.5	14.5	5.1	9.3	11.8	11.2	8.5	8.4
South Africa[a]	1.6	2.7	2.0	4.7	0.5	3.5	3.4	3.5	2.1	1.9
Swaziland	2.8	3.4	3.2	7.0	1.6	5.2	4.4	4.6	3.2	3.2
Tanzania	2.0	3.6	3.1	6.1	1.7	5.6	6.0	6.0	3.9	2.9
Togo	8.9	19.3	14.8	35.1	7.5	14.0	23.8	21.4	19.8	13.4
Uganda	5.5	8.7	7.8	15.2	4.1	15.3	15.5	15.5	9.4	7.1
Zambia	2.4	6.0	4.7	9.9	1.6	4.7	7.2	6.8	5.7	4.4
Median	2.6	4.2	3.7	7.9	1.7	5.3	6.0	5.9	4.4	3.3

Source: World Bank staff calculations based on utility information and household survey data.

a. 50 kWh a month of free electricity may be provided to the poor in some municipalities, including Johannesburg.

Table A.10: Expenditure share of monthly electricity consumption of 50 kWh by grid connection status and current spending

	Share of household expenditure					of households for which share ≤ 5				
	All	Expenditure on electricity		Grid connection		All	Expenditure on electricity		Grid connection	
Country		Yes	No	Yes	No		Yes	No	Yes	No
Angola	0.2	0.1	0.2	0.1	0.2	100	100	100	100	100
Botswana	4.8	1.7	6.4	2.2	7.0	79	96	70	93	67
Burkina Faso	12.8	6.1	13.8	6.5	13.8	16	51	11	50	11
Côte d'Ivoire	3.2	2.1	4.2	—	—	86	94	78	—	—
Ethiopia	1.8	1.2	1.9	1.5	1.9	96	98	96	97	96
Ghana	2.2	1.7	2.9	1.9	3.1	93	97	88	95	87
Madagascar	25.8	10.7	27.8	—	—	3	15	1	—	—
Malawi	3.6	1.1	3.8	1.3	3.8	80	100	78	100	78
Mali	2.3	1.8	2.6	1.3	2.6	94	97	91	99	92
Mozambique	3.8	1.0	4.2	0.0	0.0	79	100	77	—	—
Niger	5.3	2.5	5.7	2.3	5.6	58	93	53	96	53
Nigeria	0.5	0.4	0.7	0.4	0.7	100	100	99	100	99
Rwanda	14.9	3.7	16.1	4.0	16.1	15	75	8	73	8
São Tomé and Príncipe	2.7	2.0	3.1	—	—	91	98	88	—	—
Senegal	4.7	3.3	6.6	3.1	6.6	72	85	55	87	54
Sierra Leone	8.5	4.8	9.1	4.8	9.1	28	66	21	66	21
South Africa[a]	2.0	1.7	2.4	1.7	3.6	93	95	89	95	81
Swaziland	3.2	1.5	4.0	—	—	83	98	76	—	—
Tanzania	3.1	1.5	3.5	1.6	3.5	85	98	82	98	82
Togo	14.8	7.7	19.2	7.7	19.1	19	39	7	40	7
Uganda	7.8	3.1	8.3	3.5	8.4	41	85	37	80	36
Zambia	4.7	1.1	5.3	1.4	5.6	65	99	59	99	55
Median	3.7	1.8	4.2	1.8	4.7	80	96	76	95	67

Source: World Bank staff calculations based on utility information and household survey data.
Note: — = Grid connection status not available in the survey.
a. 50 kWh a month of free electricity may be provided to the poor in some municipalities, including Johannesburg.

Table A.11: Expenditure share of monthly consumption of 50 kWh by location, quintile, poverty status, and gender of household head, based on total household cash expenditures

	All households					Poor households			Household head	
Country	Urban	Rural	Total	Q1	Q5	Urban	Rural	Total	Female	Male
Botswana	3.2	8.8	5.5	21.8	1.8	9.0	14.0	11.8	6.3	4.9
Burkina Faso	11.3	21.7	18.8	32.3	11.3	19.0	27.4	26.2	27.6	17.4
Côte d'Ivoire	2.8	5.7	4.2	11.6	1.9	5.7	9.1	7.9	5.5	3.9
Ethiopia	1.9	5.2	4.6	10.0	1.9	5.2	8.6	8.4	6.4	4.0
Ghana	1.9	3.8	2.8	6.9	1.4	4.6	6.8	6.3	3.0	2.7
Malawi	2.6	6.7	6.0	10.5	3.2	4.9	9.6	9.1	8.0	5.3
Mali	1.7	3.6	3.0	5.8	1.4	3.2	5.2	5.1	2.8	3.0
Niger	3.8	7.8	7.1	11.4	4.4	8.8	9.4	9.4	11.8	6.5
Nigeria	0.7	1.2	1.0	2.0	0.5	1.1	1.5	1.4	1.4	0.9
Rwanda	11.4	25.6	23.5	44.8	8.5	26.8	36.2	35.5	30.6	20.7
São Tomé and Príncipe	2.7	3.0	2.8	4.5	1.9	3.3	3.5	3.4	3.1	2.7
Senegal	3.5	7.1	5.3	12.5	3.2	6.1	9.8	8.6	4.4	5.6

Country	All households					Poor households			Household head	
	Urban	Rural	Total	Q1	Q5	Urban	Rural	Total	Female	Male
Sierra Leone	6.5	12.6	10.2	17.6	6.1	9.6	14.7	13.6	10.2	10.2
Swaziland	3.0	4.6	4.0	8.9	1.8	5.7	6.0	6.0	4.2	3.8
Tanzania	2.7	9.6	7.5	16.7	2.5	8.8	16.8	16.1	9.9	6.5
Togo	9.3	26.3	18.8	47.5	8.3	15.1	32.9	28.6	23.5	17.5
Uganda	7.7	16.4	14.0	28.1	5.8	26.5	29.0	28.7	18.8	11.9
Zambia	2.7	12.8	9.2	20.0	2.2	5.6	15.2	13.7	11.9	8.3
Median	2.9	7.5	5.8	12.0	2.3	5.9	9.7	9.2	7.2	5.5

Source: World Bank staff calculations based on utility information and household survey data.

Table A.12: Expenditure share of monthly electricity consumption of 50 kWh by grid connection status and current spending, based on total household cash expenditures

Country	Share of household expenditure					of households for which share ≤ 5				
	All	Expenditure on electricity		Grid connection		All	Expenditure on electricity		Grid connection	
		Yes	No	Yes	No		Yes	No	Yes	No
Botswana	5.5	1.8	7.4	2.4	8.2	75	95	65	93	61
Burkina Faso	18.8	7.3	20.6	7.6	20.6	10	39	5	39	5
Côte d'Ivoire	4.2	2.3	6.0	—	—	80	92	69	—	—
Ethiopia	4.6	1.7	5.2	2.0	5.4	76	96	72	94	71
Ghana	2.8	1.8	3.9	2.1	4.2	89	96	81	94	77
Malawi	6.0	1.2	6.3	1.5	6.4	55	99	52	98	51
Mali	3.0	2.2	3.6	1.4	3.6	84	93	77	99	78
Niger	7.1	2.7	7.7	2.4	7.6	42	91	35	95	36
Nigeria	1.0	0.7	1.4	0.7	1.4	99	100	97	100	97
Rwanda	23.5	4.1	25.5	4.3	25.7	11	73	5	72	5
São Tomé and Príncipe	2.8	2.0	3.2	—	—	90	98	87	—	—
Senegal	5.3	3.4	7.9	3.1	7.8	69	84	47	87	48
Sierra Leone	10.2	4.8	11.2	4.9	11.2	23	66	15	65	15
Swaziland	4.0	1.6	5.2	—	—	75	98	65	—	—
Tanzania	7.5	1.8	8.7	1.8	8.8	62	97	54	97	53
Togo	18.8	8.0	25.7	8.0	25.6	17	39	4	39	4
Uganda	14.0	3.3	15.1	4.0	15.3	28	84	22	78	21
Zambia	9.2	1.2	10.5	1.5	11.3	48	99	40	98	34
Median	5.8	2.1	7.5	2.4	8.2	65	94	53	94	48

Source: World Bank staff calculations based on utility information and household survey data.
Note: — = Grid connection status not available in the survey.

Table A.13: Expenditure share of monthly consumption of 100 kWh by location, quintile, poverty status, and gender of household head

	All households					Poor households			Household head	
Country	Urban	Rural	Total	Q1	Q5	Urban	Rural	Total	Female	Male
Angola	0.5	1.0	0.7	1.4	0.3	1.0	1.3	1.2	0.9	0.7
Botswana	5.0	11.8	7.8	33.0	2.1	14.2	19.0	16.9	9.2	6.7
Burkina Faso	20.4	28.9	26.5	47.2	16.2	35.5	37.9	37.5	40.4	24.4
Côte d'Ivoire	6.3	9.5	7.9	20.0	4.2	12.4	14.6	13.9	10.4	7.3
Ethiopia	3.7	4.3	4.2	9.0	2.1	10.8	7.4	7.6	6.0	3.7
Ghana	6.8	10.7	8.6	18.4	4.8	15.7	17.7	17.3	9.8	8.0
Madagascar	31.8	48.7	45.0	87.9	25.0	46.3	55.4	54.1	64.4	40.4
Malawi	4.4	7.8	7.2	12.6	4.2	7.7	11.2	10.8	9.1	6.6
Mali	4.4	6.5	5.9	10.8	3.0	7.9	9.5	9.4	5.9	5.9
Mozambique	4.9	8.7	7.6	18.2	2.6	10.5	11.9	11.6	9.9	6.6
Niger	6.8	11.7	10.9	15.8	7.4	12.6	13.6	13.5	16.1	10.2
Nigeria	4.9	6.5	5.8	10.9	3.8	8.0	7.9	7.9	8.7	5.3
Rwanda	17.8	31.8	29.8	55.9	12.5	39.1	44.2	43.8	37.9	26.7
São Tomé and Príncipe	5.0	5.5	5.3	8.4	3.6	6.3	6.6	6.4	5.7	5.0
Senegal	6.7	11.7	9.2	20.4	6.0	11.7	15.6	14.4	8.3	9.6
Sierra Leone	12.5	19.7	16.9	28.9	10.2	18.4	23.4	22.4	16.9	16.8
South Africa[a]	3.2	5.3	3.9	9.3	1.0	7.0	6.8	6.9	4.3	3.7
Swaziland	5.5	6.8	6.3	13.8	3.2	10.4	8.7	9.0	6.4	6.2
Tanzania	6.6	11.8	10.2	19.9	5.6	18.2	19.6	19.5	12.5	9.3
Togo	15.4	33.6	25.7	61.1	13.1	24.4	41.4	37.3	34.5	23.2
Uganda	11.5	18.2	16.4	31.7	8.6	31.9	32.5	32.4	19.7	14.9
Zambia	3.1	7.7	6.1	12.8	2.1	6.0	9.2	8.7	7.3	5.7
Median	5.9	10.1	7.8	18.3	4.2	12.0	14.1	13.7	9.5	7.0

Source: World Bank staff calculations based on utility information and household survey data.
a. 100 kWh a month of free electricity may be provided to the poor in some municipalities, such as Johannesburg.

Table A.14: Expenditure share of monthly electricity consumption of 100 kWh by grid connection status and current spending

	Share of household expenditure					of households for which share ≤ 5				
	All	Expenditure on electricity		Grid connection		All	Expenditure on electricity		Grid connection	
Country		Yes	No	Yes	No		Yes	No	Yes	No
Angola	0.7	0.3	0.8	0.3	0.9	100	100	100	100	100
Botswana	7.8	2.8	10.3	3.6	11.4	62	87	50	83	45
Burkina Faso	26.5	12.7	28.7	13.4	28.7	3	15	2	14	2
Côte d'Ivoire	7.9	5.2	10.5	—	—	50	62	37	—	—
Ethiopia	4.2	2.9	4.5	3.5	4.5	76	89	73	84	74
Ghana	8.6	6.5	11.2	7.2	11.9	39	50	26	46	22
Madagascar	45.0	18.6	48.6	—	—	1	4	0	—	—
Malawi	7.2	2.2	7.6	2.5	7.7	37	95	33	93	32
Mali	5.9	4.7	6.7	3.5	6.8	52	66	42	82	40
Mozambique	7.6	1.9	8.3	0.0	0.0	49	96	43	—	—
Niger	10.9	5.2	11.6	4.8	11.5	15	60	9	66	10
Nigeria	5.8	4.6	7.4	4.6	7.6	60	73	44	73	43
Rwanda	29.8	7.5	32.2	8.0	32.3	6	46	1	43	1
São Tomé and Príncipe	5.3	3.8	5.9	—	—	61	78	53	—	—

Country	Share of household expenditure					of households for which share ≤ 5				
	All	Expenditure on electricity		Grid connection		All	Expenditure on electricity		Grid connection	
		Yes	No	Yes	No		Yes	No	Yes	No
Senegal	9.2	6.5	13.0	6.1	12.9	36	53	12	56	13
Sierra Leone	16.9	9.6	18.1	9.6	18.1	5	17	3	17	3
South Africa[a]	3.9	3.4	4.9	3.4	7.2	75	79	68	79	47
Swaziland	6.3	3.0	8.0	—	—	54	84	39	—	—
Tanzania	10.2	5.0	11.4	5.1	11.4	27	61	19	59	19
Togo	25.7	13.4	33.4	13.4	33.3	6	14	1	14	1
Uganda	16.4	6.4	17.4	7.3	17.6	12	47	9	40	8
Zambia	6.1	1.4	6.8	1.8	7.3	53	99	46	97	41
Median	7.8	4.8	10.4	4.7	11.4	44	64	35	66	22

Source: World Bank staff calculations based on utility information and household survey data.
Note: — = Grid connection status not available in the survey.
a. 100 kWh a month of free electricity may be provided to the poor in some municipalities, such as Johannesburg.

Table A.15: Expenditure share of monthly consumption of 250 kWh by location, quintile, poverty status, and gender of household head

Country	All households					Poor households			Household head	
	Urban	Rural	Total	Q1	Q5	Urban	Rural	Total	Female	Male
Angola	1.9	4.1	3.0	5.9	1.3	3.9	5.3	5.0	3.8	2.7
Botswana	11.2	26.3	17.5	73.9	4.7	31.8	42.6	37.9	20.5	14.9
Burkina Faso	56.7	80.3	73.7	131.2	44.8	98.6	105.1	104.2	112.2	67.8
Côte d'Ivoire	19.2	29.0	24.1	61.2	12.7	38.0	44.8	42.5	31.7	22.5
Ethiopia	10.9	12.7	12.4	26.4	6.3	31.7	21.7	22.4	17.6	10.7
Ghana	16.2	25.6	20.4	43.7	11.5	37.4	42.2	41.1	23.2	19.1
Madagascar	77.9	119.3	110.3	215.2	61.3	113.3	135.6	132.5	157.6	99.0
Malawi	11.0	19.5	18.1	31.4	10.5	19.2	27.9	27.0	22.7	16.6
Mali	16.4	24.6	22.1	40.8	11.4	29.6	36.0	35.5	22.4	22.1
Mozambique	32.2	57.8	50.4	121.0	17.5	69.6	78.7	77.2	65.5	44.0
Niger	18.5	32.0	29.6	43.1	20.3	34.4	37.0	36.8	44.0	27.9
Nigeria	9.8	13.1	11.7	22.1	7.7	16.1	15.9	15.9	17.6	10.6
Rwanda	44.5	79.6	74.5	139.7	31.2	97.8	110.5	109.6	94.8	66.7
São Tomé and Príncipe	18.0	19.5	18.8	29.9	12.8	22.5	23.4	22.9	20.5	17.7
Senegal	18.9	32.7	25.9	57.1	16.7	32.8	43.9	40.3	23.2	26.9
Sierra Leone	35.3	55.5	47.6	81.6	28.7	52.1	66.2	63.2	47.8	47.5
South Africa[a]	8.1	13.3	9.8	23.4	2.6	17.5	17.1	17.3	10.7	9.2
Swaziland	13.8	17.1	15.8	34.6	8.0	26.0	21.9	22.7	16.1	15.6
Tanzania	28.1	49.9	43.1	84.1	23.5	77.0	83.1	82.6	53.1	39.5
Togo	37.4	81.5	62.3	148.2	31.8	59.1	100.4	90.4	83.6	56.3
Uganda	29.4	46.6	42.0	81.4	22.0	81.8	83.3	83.1	50.6	38.2
Zambia	7.3	18.4	14.4	30.4	4.9	14.3	21.9	20.7	17.4	13.5
Median	18.2	27.7	23.1	50.4	12.8	33.6	42.4	39.1	23.2	22.3

Source: World Bank staff calculations based on utility information and household survey data.
a. Where the poor are entitled to varying amounts of free electricity (as much as 150 kWh a month for some poor families in Johannesburg), the expenditure share would be lower.

Table A.16: Expenditure share of monthly electricity consumption of 250 kWh by grid connection status and current spending

	Share of household expenditure					of households for which share ≤ 5				
	All	Expenditure on electricity		Grid connection		All	Expenditure on electricity		Grid connection	
Country		Yes	No	Yes	No		Yes	No	Yes	No
Angola	3.0	1.2	3.4	1.4	3.8	84	100	80	99	75
Botswana	17.5	6.2	23.0	7.9	25.5	31	58	18	51	15
Burkina Faso	73.7	35.2	79.8	37.3	79.7	0	1	0	1	0
Côte d'Ivoire	24.1	16.0	32.1	—	—	8	12	4	—	—
Ethiopia	12.4	8.5	13.2	10.3	13.1	20	38	17	31	17
Ghana	20.4	15.4	26.6	17.1	28.3	7	11	3	9	2
Madagascar	110.3	45.5	118.9	—	—	0	0	0	—	—
Malawi	18.1	5.5	19.0	6.4	19.2	6	54	3	45	3
Mali	22.1	17.7	25.1	13.0	25.5	6	9	5	12	4
Mozambique	50.4	12.5	55.3	0.0	0.0	3	17	1	—	—
Niger	29.6	14.2	31.8	13.0	31.5	1	8	0	10	0
Nigeria	11.7	9.3	15.0	9.2	15.2	19	28	8	28	7
Rwanda	74.5	18.6	80.4	19.9	80.7	1	14	0	13	0
São Tomé and Príncipe	18.8	13.7	21.0	—	—	4	10	2	—	—
Senegal	25.9	18.3	36.6	17.0	36.3	2	3	0	3	0
Sierra Leone	47.6	27.1	51.2	27.2	51.2	0	0	0	0	0
South Africa[a]	9.8	8.6	12.2	8.6	18.1	39	42	33	44	8
Swaziland	15.8	7.4	20.0	—	—	19	43	7	—	—
Tanzania	43.1	21.1	48.1	21.7	48.3	1	5	0	5	0
Togo	62.3	32.4	81.0	32.5	80.7	1	2	0	2	0
Uganda	42.0	16.5	44.5	18.8	45.1	1	11	1	9	1
Zambia	14.4	3.4	16.2	4.2	17.3	22	81	12	70	8
Median	23.1	14.8	29.2	13.0	26.9	5	11	2	12	2

Source: World Bank staff calculations based on utility information and household survey data.
Note: — = Grid connection status not available in the survey.
a. Where the poor are entitled to varying amounts of free electricity (as much as 150 kWh a month for some poor families in Johannesburg), the expenditure share would be lower.

Table A.17: Grid-electricity poverty gap, percent

	Urban				Rural				National			
kWh/month	30	50	100	250	30	50	100	250	30	50	100	250
Angola	0	0	0	2	0	0	0	4	0	0	0	3
Botswana	3	4	9	27	8	12	22	47	5	7	15	36
Burkina Faso	15	26	54	81	27	42	68	88	24	38	65	86
Côte d'Ivoire	0	2	13	48	1	5	22	61	1	4	18	55
Ethiopia	0	0	3	22	0	1	5	36	0	1	5	34
Ghana	0	0	13	44	0	2	27	60	0	1	20	52
Madagascar	18	56	81	89	32	71	88	93	30	68	87	92
Malawi	0	1	5	36	1	4	17	61	1	4	14	57
Mali	0	0	6	48	0	1	17	64	0	1	15	60
Mozambique	1	2	8	59	2	6	21	81	1	4	17	74
Niger	0	2	7	53	3	9	25	76	2	8	22	72
Nigeria	0	0	5	23	0	0	12	39	0	0	10	33

	Urban				Rural				National			
kWh/month	30	50	100	250	30	50	100	250	30	50	100	250
Rwanda	13	25	44	67	29	49	71	88	27	46	67	85
São Tomé and Príncipe	0	1	7	54	0	1	9	58	0	1	8	56
Senegal	1	3	11	50	4	10	32	73	2	7	23	63
Sierra Leone	3	13	40	77	12	34	63	87	9	26	55	83
South Africa[a]	0	1	4	21	0	2	9	39	0	1	6	28
Swaziland	1	3	15	40	2	6	22	53	2	6	20	50
Tanzania	0	1	15	65	1	4	34	80	1	3	29	76
Togo	5	22	42	72	20	49	68	87	15	39	59	81
Uganda	3	11	33	65	8	23	52	79	7	20	47	76
Zambia	1	2	4	20	11	14	22	55	7	10	16	43
Median	1	2	10	49	2	6	22	63	2	5	19	59

Source: World Bank staff calculations based on utility information and household survey data.
a. Tariffs in Johannesburg are used. No allowance for free electricity is assumed for the purpose of these calculations.

Table A.18: Grid-electricity poverty headcount, percent of total population

	Urban				Rural				National			
kWh/month	30	50	100	250	30	50	100	250	30	50	100	250
Angola	0	0	0	4	0	0	0	21	0	0	0	11
Botswana	7	11	24	57	19	28	49	80	12	18	34	67
Burkina Faso	41	61	89	99	65	82	97	100	60	77	95	100
Côte d'Ivoire	1	5	29	80	4	12	46	92	2	8	38	87
Ethiopia	1	1	10	54	1	2	18	77	1	2	17	74
Ghana	0	2	38	85	2	6	65	95	1	4	52	90
Madagascar	50	92	98	100	77	98	100	100	71	97	99	100
Malawi	0	4	28	72	3	18	64	97	3	16	58	93
Mali	0	1	19	84	1	6	48	94	0	5	42	92
Mozambique	2	6	21	90	6	19	52	99	5	15	43	96
Niger	2	9	44	90	12	35	85	100	10	31	78	98
Nigeria	0	0	18	62	0	0	39	83	0	0	31	76
Rwanda	34	53	71	90	68	87	97	100	63	82	93	98
São Tomé and Príncipe	1	4	28	93	1	5	33	96	1	4	30	95
Senegal	3	8	33	94	11	29	75	100	8	20	57	98
Sierra Leone	13	43	85	100	45	82	98	100	33	67	93	100
South Africa[a]	1	3	14	47	1	6	29	79	1	4	20	59
Swaziland	2	7	28	62	4	12	40	80	3	11	37	76
Tanzania	1	2	42	95	3	13	75	99	3	10	66	98
Togo	16	55	81	97	53	88	97	100	39	76	91	99
Uganda	11	33	69	94	25	58	90	99	22	52	85	98
Zambia	5	8	14	48	34	42	57	90	24	30	42	75
Median	2	7	29	87	5	19	60	96	4	16	47	94

Source: World Bank staff calculations based on utility information and household survey data.
a. Tariffs in Johannesburg are used. No allowance for free electricity is assumed for the purpose of these calculations.

Table A.19: Annual subsidies needed for monthly consumption of 30, 50, and 100 kWh

Subsidies	US$ million									% of cash collected		
Location	Urban			Rural			National			Urban	Rural	Total
kWh/month	30	50	100	30	50	100	30	50	100	30	30	30
Angola	0	0	0	0	0	0	0	0	0	—	—	—
Botswana	0	1	4	1	2	7	2	3	11	0.01	0.04	0.05
Burkina Faso	14	32	119	58	122	375	72	153	494	0.67	2.83	3.50
Côte d'Ivoire	1	4	55	2	10	88	3	14	143	0.01	0.03	0.04
Ethiopia	0	0	6	1	2	33	1	3	38	0.01	0.03	0.04
Ghana	0	2	118	1	4	166	1	6	284	0.00	0.01	0.01
Madagascar	10	70	256	60	316	987	69	386	1,243	0.88	5.54	6.42
Malawi	0	0	10	1	7	54	1	7	64	0.00	0.05	0.05
Mali	0	0	9	0	1	47	0	2	56	0.00	0.00	0.00
Mozambique	0	1	7	1	6	39	2	7	46	0.01	0.05	0.06
Niger	0	2	7	7	28	96	7	30	103	0.04	0.63	0.66
Nigeria	0	0	194	0	0	527	0	0	721	0.00	0.00	0.00
Rwanda	5	15	50	61	161	442	66	176	492	0.46	5.87	6.33
São Tomé and Príncipe	0	0	0	0	0	0	0	0	0	0.01	0.01	0.01
Senegal	1	6	37	4	16	87	6	22	124	0.02	0.07	0.09
Sierra Leone	2	12	62	10	40	139	12	52	201	0.59	2.76	3.35
South Africa[a]	1	7	67	1	7	67	2	14	135	0.00	0.00	0.00
Swaziland	0	0	2	0	1	4	0	1	6	0.00	0.01	0.01
Tanzania	0	2	82	3	16	374	3	18	456	0.00	0.03	0.03
Togo	4	27	81	15	68	153	19	94	234	0.18	0.77	0.95
Uganda	6	35	197	44	195	806	50	230	1,003	0.13	0.96	1.09
Zambia	1	1	3	12	17	32	13	18	36	0.01	0.14	0.15
Median	0	2	44	2	9	87	2	14	0	0.01	0.05	0.05

Source: World Bank staff calculations based on utility information and household survey data.

Note: Cash collected is the amount of revenue collected by the utility. — = data not available.

a. Tariffs in Johannesburg are used. No allowance for free electricity is assumed for the purpose of these calculations.

Table A.20 shows the percentage of grid-connected households reporting no expenditures on electricity.

Table A.20: Percentage of households connected to the grid with zero expenditures on electricity by quintile

	Urban					Rural					National				
Country	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Angola	59	54	51	43	37	100	81	63	81	71	73	60	53	47	39
Botswana	45	32	29	35	28	59	23	23	41	28	50	29	28	36	28
Burkina Faso	76	19	17	12	6	100		23	16	21	85	15	17	12	7
Ethiopia	21	22	31	35	46	19	9	11	5	10	20	16	26	25	38
Ghana	26	29	26	20	16	37	32	32	25	22	33	30	28	21	17
Malawi	5	38	47	23	19	—		19	34	19	5	35	42	25	19
Mali	0	23	16	8	10	86	34	53	15	5	55	26	21	9	9
Niger	0	0	14	4	6	0	0	0	0	0	0	0	7	3	6
Nigeria	2	3	4	1	2	5	5	9	9	9	4	4	6	4	4
Rwanda	46	22	25	6	10	23	12	20	17	10	29	17	22	12	10
Senegal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sierra Leone	0	0	4	0	1	37	0	0	0	0	6	0	4	0	1
South Africa	18	15	23	30	38	8	10	10	17	20	12	12	18	27	36
Tanzania	0	12	27	3	5	38	21	20	18	9	16	14	25	6	6
Uganda	82	74	30	23	24	100	100	81	25	19	88	92	40	24	23
Zambia	67	63	62	42	30	100	91	87	81	49	93	74	69	50	32
Total	13	14	18	17	19	11	11	13	14	12	12	12	16	16	17

Source: World Bank staff calculations using household survey data.

Note: Imputed values of free electricity in Ghana, South Africa, Uganda, and Zambia are excluded from expenditure on electricity. — = No households with non-zero expenditures on electricity; total = weighted average across all countries in the table.

The last two tables show the results of probit and least-squares regression analysis of the gender of the head of household.

Table A.21: Increase in the probability of the dummy dependent variable being 1 and percent increase (for log expenditure) for switching from male- to female-headed households

Dependent variable	All households	Urban households only			
Country	Urban dummy[a]	Expenditure dummy[b]	Electricity dummy[c]	Grid dummy[d,e]	Log expenditure[f,g]
Angola	—	—	—	—	—
Botswana	0.04	—	—	—	—
Burkina Faso	0.06	—	n.a.	—	—
Côte d'Ivoire	0.14	—	—	—	—
Ethiopia	0.12	0.10	—	—	16[g]
Ghana	0.13	-0.04	-0.02	-0.02[e]	-10[f,g]
Madagascar	0.10	0.06	0.09	0.08[d]	—
Malawi	-0.06	—	—	n.d.	—
Mali	0.07	—	—	0.09[e]	—
Mozambique	0.07	—	—	—	—
Niger	0.15	—	—	0.10[d,h], 0.12[e]	—
Nigeria	0.08	—	—	—	—
Rwanda	0.02	—	—	—	14[f]
São Tomé and Príncipe	0.11	0.08	—	n.d.	—
Senegal	0.23	—	—	—	—
Sierra Leone	0.04	—	—	—	—
South Africa	0.10	0.10	n.a.	0.02[e]	—
Swaziland	-0.10	—	—	n.d.	—
Tanzania	0.06	—	—	—	—
Togo	0.05	-0.06	-0.07	-0.05[d,e]	—
Uganda	0.07	—	—	—	—
Zambia	0.05	0.04	—	—	—
Median	0.07	0.06	-0.02	NA	NA

Source: World Bank staff calculations.

Note: — = statistically insignificant at 5%; n.d. = no distinction made for different sources of electricity; n.a. = not available (data not collected); NA = not applicable.

a. 1 for urban, 0 for rural.

b. 1 if spending on electricity is positive, zero otherwise (spending is zero or missing).

c. 1 for electricity (grid as well as off-grid, such as solar and diesel generators) as the primary source of energy for lighting or cooking, 0 otherwise.

d. 1 for electricity (excluding off-grid, such as solar and diesel generators) as the primary source of energy for lighting or cooking, 0 otherwise.

e. 1 for grid connection, 0 otherwise, for the 17 countries where the survey asked about the status of grid connection.

f. Logarithm of spending on electricity retaining all households with positive expenditure.

g. Logarithm of spending on electricity retaining only grid-connected households with positive expenditure.

Table A.22: Probability of increase and percent increase (for log spending) for rural female-headed households

Country	Expenditure dummy	Electricity dummy	Grid dummy[a,b]	Log spending[c,d]
Angola	—	—	—	24[a,b]
Botswana	0.07	0.09	0.09[a], 0.08[b]	—
Burkina Faso	—	—	—	—
Côte d'Ivoire	—	n.a.	—	—
Ethiopia	—	—	—	—
Ghana	0.11	0.11	0.11[a,b]	-10[a], -9[b]
Madagascar	—	—	—	—
Malawi	—	—	n.d.	—
Mali	—	—	0.10[b]	—
Mozambique	—	—	0.01[a]	—
Niger	—	—	—	—
Nigeria	0.14	0.10	0.08[a], 0.17[b]	—
Rwanda	—	—	—	—
São Tomé and Príncipe	—	—	n.d.	-25[d]
Senegal	0.24	0.23	0.23 [a,b]	35[c]
Sierra Leone	-0.003	—	-0.003 [a,b]	-49[d]
South Africa	—	n.a.	—	—
Swaziland	—	—	n.d.	—
Tanzania	—	—	—	—
Togo	—	—	—	—
Uganda	—	—	—	—
Zambia	—	—	-0.01[b]	—
Median	0.09	0.11	NA	NA

Source: World Bank staff calculations.

Note: For table headers, abbreviations, and footnotes, see Table A.21. Footnotes a–d correspond to d–g in Table A.21.

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