

What Can We Learn about Energy Access and Demand from Mobile-Phone Surveys? Nine Findings from Twelve African Countries

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Abstract

This paper leverages the proliferation of mobile phones in Sub-Saharan Africa to conduct phone-based surveys on energy access and demand. The survey uses interactive voice recognition (IVR) surveys to ask questions on energy service provision, service quality, and demand in twelve African countries: Benin, the Democratic Republic of the Congo, Ethiopia, Ghana, Kenya, Mozambique, Nigeria, Rwanda, Senegal, Tanzania, Uganda, and Zambia.

From these findings, we draw several potential policy implications. First, both grid electricity and off-grid solutions currently are inadequate to meet many African consumers' modern energy demands. Second, grid and off-grid electricity are viewed by consumers as complementary, rather than competing, solutions to meet energy demand. Third, a market exists for off-grid solutions even among connected, urban Africans.

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1. Introduction

Access to electricity is a priority for both domestic policymakers and donors in Sub-Saharan Africa. Many countries have established national energy strategies, and a number of these strategies include targets and policies regarding electricity access.¹ Energy also has become a major policy priority for international partners. In 2014, US President Barack Obama launched Power Africa, a new initiative to support 60 million new connections and to increase generation capacity by 30,000 MW.² In 2015, the UK's Department of the International Development (DFID) introduced its own Energy Africa campaign to achieve universal energy access—with a particular focus on rural areas—by 2030.³

However, current data is insufficient to answer many of today's energy policy questions, such as which solutions to prioritize in specific settings (e.g., small-scale off-grid solutions like solar lamps versus large-scale off-grid solutions like mini-grids versus grid expansion versus grid maintenance).

The primary indicator used globally to measure energy access is the proportion of the population with access to electricity. This indicator is both limited in scope and poorly measured, relying on a patchwork of sources without clear or universal standards across different geographies.⁴

Importantly, this indicator fails to capture whether electricity service provision is adequate for household or commercial needs. There is widespread evidence of poor electricity service provision in many countries; scheduled outages also have become common in countries like Ghana and Zambia.⁵ The measure also fails to capture the differences between various electricity sources like small-scale off-grid solutions, large-scale off-grid solutions, or grid-based connections. Studies from Kenya have found that there were significant differences in energy consumption patterns between households with grid electricity and households with off-grid electricity, implying that households were using off-grid electricity differently than they would use grid electricity.⁶

More comprehensive data would be helpful for policymakers and donors to set the agenda for energy policy, especially around energy access and demand. Data on energy access could help measure gaps in service provision and quality, and data on energy demand could help policymakers prioritize different energy options. To improve data collection, the World Bank's Energy Sector Management Assistance Program unveiled a five-tier framework for

¹ International Energy Agency 2014. A more extensive description of selected energy politics and targets can be found in the International Energy Agency's Africa Outlook 2014. Examples of countries with explicit access targets are DR Congo, Mozambique, Nigeria, and Rwanda.

² Power Africa 2016.

³ Talbot 2015.

⁴ Energy Access Targets Working Group 2016.

⁵ Sladoje 2016; Moss 2015.

⁶ Lee, Miguel, and Wolfram 2016.

measuring and assessing energy access. Nonetheless, relying upon traditional data collection techniques, such as face-to-face household surveys, is extremely costly and time-intensive.⁷

Technologies like mobile phones offer new, low-cost data collection opportunities. Mobile phone penetration has risen exponentially in Sub-Saharan Africa and provides a powerful potential platform for citizen engagement. This paper leverages the proliferation of mobile phones in Sub-Saharan Africa to conduct mobile phone-based surveys on energy access and demand. More specifically, the survey uses interactive voice recognition (IVR) surveys to ask a series of questions on energy service provision, service quality, and demand in twelve African countries: Benin, the Democratic Republic of the Congo (DR Congo), Ethiopia, Ghana, Kenya, Mozambique, Nigeria, Rwanda, Senegal, Tanzania, Uganda, and Zambia. The surveys were conducted between July 2015 and December 2016.

Previous surveys have explored some of these questions in single country contexts. For instance, NOIPolls conducts regular surveys of energy service provision in Nigeria.⁸ Wolfram, Miguel, and Lee have explored energy access extensively in Kenya, including questions of whether grid and off-grid electricity sources are adequate for meeting consumer demand.⁹ This paper addresses important data collection and research gaps through the scope of questions asked and the range of countries covered. For some surveyed countries, there is little preexisting data on energy service provision and energy demand. The standardized nature of the survey also allows for cross-country comparisons and insights. Moreover, from a methodological standpoint, this paper offers new insights on the use of mobile phone-based surveys as a low-cost data collection tool in a range of contexts.

We identified **nine key findings** from the data:

1. Daily outages are a norm almost everywhere.
2. Satisfaction with service from the grid varies widely.
3. The grid is viewed as reliable for powering some household appliances.
4. In all countries, the majority desire a grid connection.
5. Connection costs and distance from the grid are the most common obstacles to grid electricity.
6. Demand is high for energy-intensive appliances, especially TVs.
7. On-grid customers still rely heavily on generators, especially in Nigeria.
8. Off-grid, non-generator electricity is inadequate for most respondents' energy needs.
9. Off-grid customers still desire grid electricity.

⁷ Energy Access Targets Working Group 2016.

⁸ See NOIPolls 2017.

⁹ Lee, Miguel, and Wolfram 2016.

Based on these data-driven findings, we draw several potential policy implications. First, both grid electricity and off-grid solutions currently are inadequate to meet many African consumers' modern energy demands. Second, grid and off-grid electricity can be complementary, rather than competing, solutions to meet modern energy demand. Third, there is a clear existing market for off-grid solutions among connected, urban Africans.

The remainder of the paper describes the methodology, highlights nine findings, and three initial policy implications. Section 2 briefly explains the methodology and outlines several cautions for interpreting the data. Section 3 presents the findings from the survey, and section 4 concludes with a number of potential policy implications. The annexes provide additional methodological information, including a deeper dive into the methodology, summary statistics, and a complete English-version of the survey questionnaire.

2. Methodology summary

Surveys were conducted using interactive voice recognition (IVR) between June 2015 and December 2016¹⁰ in twelve countries in Sub-Saharan Africa where the Power Africa Initiative was implementing or planning to implement activities: Benin, the Democratic Republic of Congo, Ethiopia, Ghana, Kenya, Mozambique, Nigeria, Rwanda, Senegal, Tanzania, Uganda, and Zambia.

In each country, the survey operator, Voto Mobile, used a random number generation system to obtain a list of potential mobile phone numbers that conform to target countries' mobile number formations, adjusting for specific geographic or mobile operator codes. The operator continued to call each number on the list until the survey collected 2,000 complete survey responses in each country, with the exception of Nigeria, where they collected 9,000 total complete survey responses.¹¹ The survey was translated into 28 unique languages to minimize the potential for systematically excluding certain demographic populations within the different countries. Each respondent was asked to select a language from a list of between two and five languages depending on the country.¹² After the language selection, the survey asked several demographic questions that cover geographic location, age, education level, and wealth indicators, as well as whether the household had access to grid-based electricity. The survey then bifurcates into two tracks: those with grid electricity and those without grid electricity. The full survey instrument can be found in Appendix III.

The survey methodology and sample considerations of representativeness are described in detail in Leo et al (2015), Leo and Morello (2015), and Morello and Leo (2016).¹³ Previous mobile-phone based surveys conducted in Afghanistan, Ethiopia, Mozambique, and Zimbabwe identified the following considerations for IVR surveys:

- ✓ IVR formats performed relatively well at reaching poor in focus countries.
- ✓ Rural women are consistently under-represented, particularly in Ethiopia.
- ✓ Samples from countries with higher mobile penetration rates were demographically closer to the actual population.
- ✓ Extrinsic incentives improve survey completion rates by 6 to 8 percent, although the effects vary across countries.

¹⁰ The surveys in Ghana and Tanzania were conducted in June and July 2015. The surveys in the additional ten countries were conducted between September and December 2016, and the instrument used in the later surveys included some revisions based on insights from the initial surveys.

¹¹ We chose to collect 7,000 extra observations in Nigeria to explore questions of sub-regional differences in energy access and demand. As described in Table 6 in Appendix II, the 7,000 additional observations decrease the sampling error significantly, although the national representativeness of the survey (indicated by the coefficient of variance) is much higher than other high-confidence countries.

¹² The full list of languages can be found in Appendix IV. Leo et al (2015) further the impact of linguistic fractionalization on survey responses.

¹³ Leo et al. 2015; Leo and Morello 2015; Leo and Morello 2016.

- ✓ The effect of linguistic fractionalization on the ability to obtain a nationally representative sample is somewhat unclear.

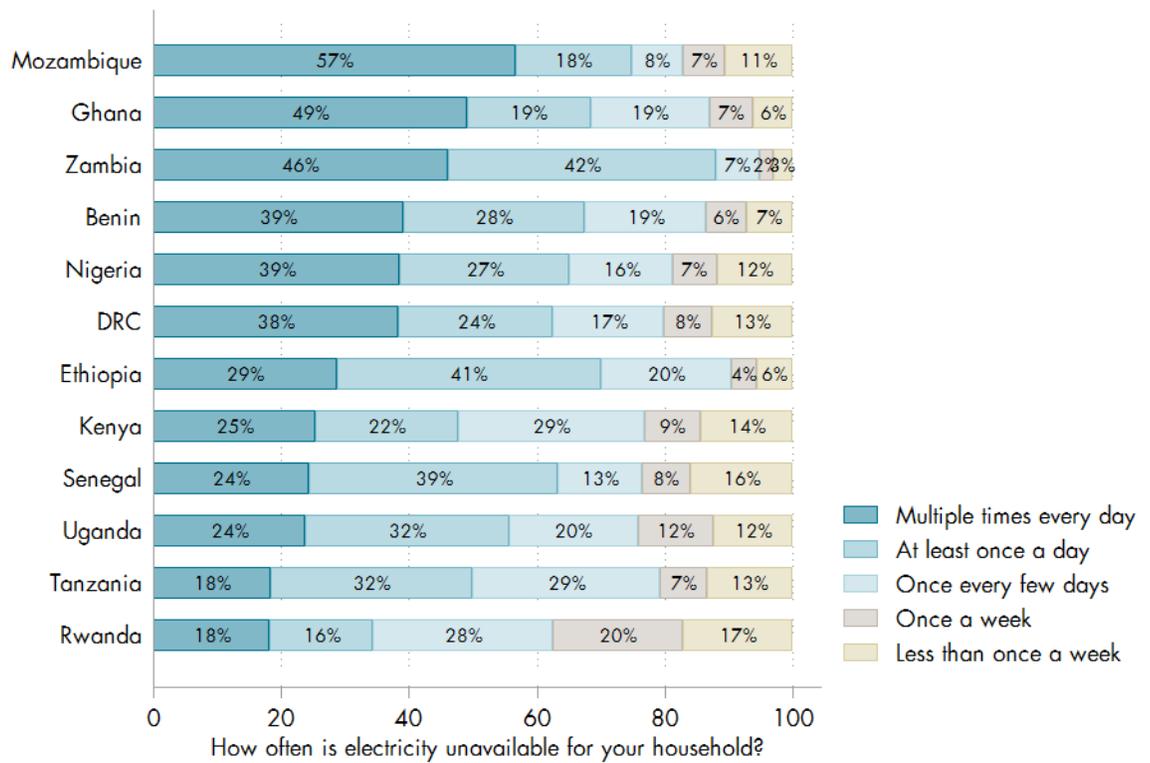
Mobile phone-based surveys remain an emerging survey technique in these African countries. These surveys serve as a pilot to test mobile phone-based surveys as an appropriate method for estimating electricity access rates. To answer this question, we compare post-weighted electricity access from the mobile phone-based survey to estimates of electricity access from other sources, including IEA, DHS, and Afrobarometer. Generally, we find mobile phone-based surveys capture electricity access rates, but only once we limit the sample to those with cell phone access. In Appendix I, we compare the results of the data to other sources (Afrobarometer, USAID's Demographic and Health Surveys, and the World Bank's Enterprise Surveys) and find that data for these questions is deeply inconsistent across various sources. Our confidence in the data varies considerably among the twelve countries and is affected by three factors: sampling errors, time variance, and possible first response bias. Appendix II provides a complete explanation of this research question and caveats to our findings.

3. Main findings

3.1. Daily outages are the norm almost everywhere

Among those with access to grid electricity, at least half of the population cites electricity outages at least once one a day across almost all surveyed countries. Respondents in Mozambique, Ghana, and Zambia reported the highest prevalence of daily outages. The country with the lowest prevalence of frequent outages was Rwanda, where only 18 percent of respondents experienced multiple outages per day. In all countries, the vast majority reported at least one outage per week.

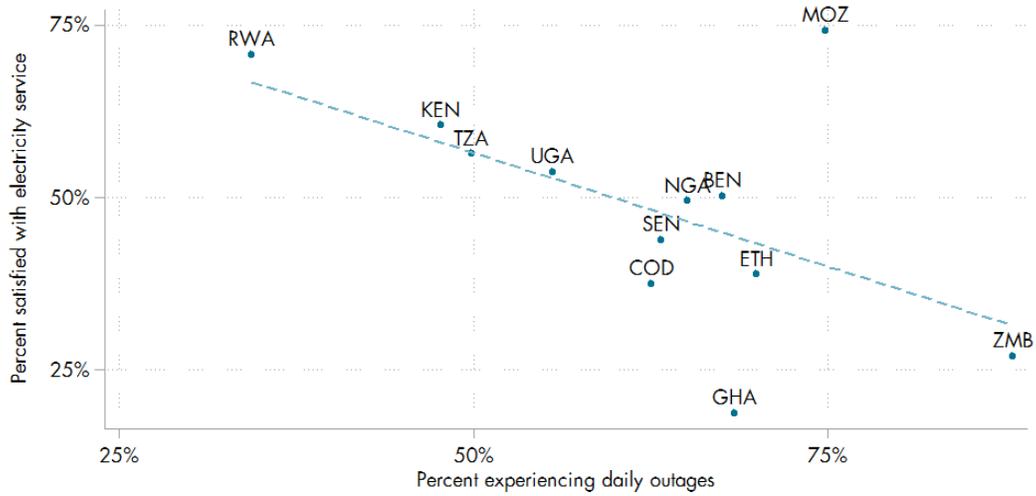
Figure 1: Frequency of outages by country



3.2. Satisfaction with service from the grid varies very widely

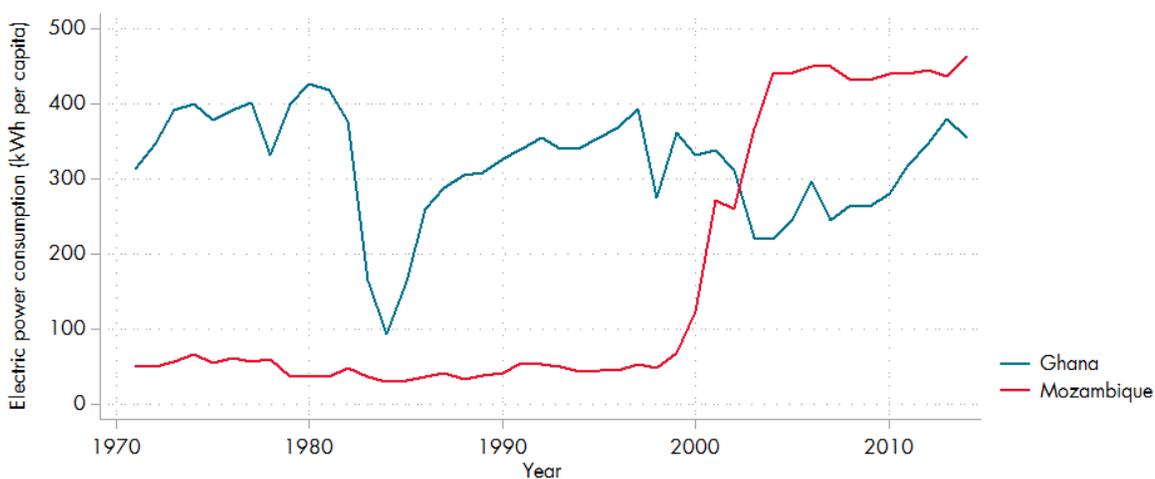
Reported satisfaction with grid electricity ran from Mozambique (74 percent satisfied) and Rwanda (71) at the high end to Ghana (19) and Zambia (27). Satisfaction with grid electricity appears correlated with the percentage of respondents experiencing daily outages. (Figure 2a).

Figure 2a: Comparison of percent reporting daily outages and percent unsatisfied with electricity service provision



Mozambique and Ghana are the two outliers. Mozambicans are more satisfied with their service than expected, while Ghanaians are far less satisfied with their service. These discrepancies suggest satisfaction may be tied to contextual factors like the history and politics of electricity service. Mozambique has made remarkable increases in electricity power consumption—from 48 kWh per capita in 1998 to 462 by 2014. By comparison, consumption in Ghana has hovered between 300 and 400 kWh per capita since 1970. Recently, Ghana has undergone scheduled outages to manage gaps in electricity generation capacity and consumer demand. Unsurprisingly, electricity service is a top political issue in Ghana.¹⁴ These contextual factors are likely influencing expectations of and satisfaction with electricity service.

Figure 2b: Electric power consumption in selected countries, 1970-2014

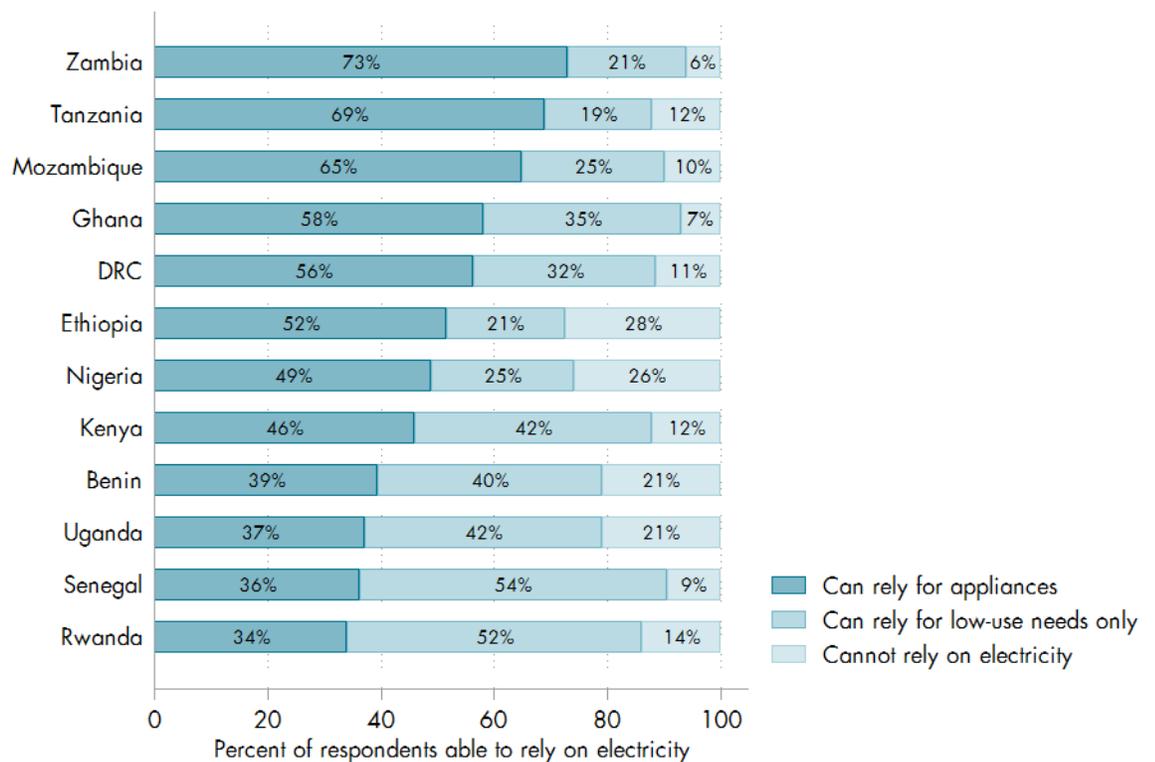


¹⁴ Moss and Gleave 2014; Moss 2015.

3.3. The grid is viewed as reliable for powering some household appliances

In several countries, more than half of the respondents reported not being able to rely on the grid for household appliances. We asked two separate questions on grid reliance: (1) whether the respondent could rely on grid-based electricity for basic, less energy-intensive appliances like lighting, fans, or radios and (2) whether they could rely on grid electricity for more energy-intensive appliances like refrigerators and televisions. These appliances often require higher wattages **and** connections to the electric grid or more powerful off-grid systems.¹⁵ In all surveyed countries, the majority of respondents were able to rely on grid electricity for low-wattage household needs, but a much smaller group reported that they rely on grid electricity for household appliances.¹⁶

Figure 3: Reported reliance on grid electricity by country



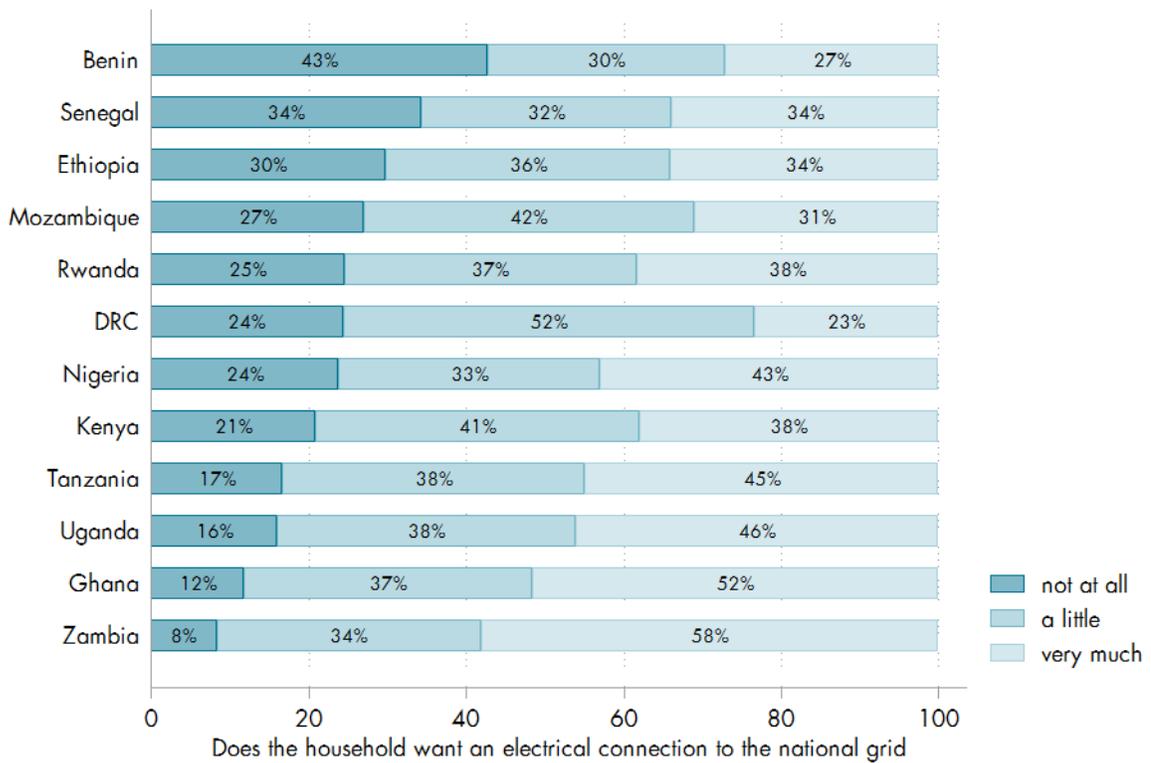
¹⁵ Lee, Miguel, and Wolfram 2016.

¹⁶ A small selection of respondents reported being able to rely on electricity for appliances but was unable to rely on electricity for a fan, lighting, or radio. The only countries where this category represented more than 10 percent of the off-grid respondents were Ethiopia (13 percent) and Nigeria (10 percent). In figure 3, these respondents are included in the “can rely on appliances” category.

3.4. In all countries, the majority of unconnected desire a grid connection

Demand for the grid was highest in Zambia and Ghana, where over 50 percent said that they wanted an electrical connection very much. In all other countries except Senegal and Benin, demand appears to be high but less passionate; over two-thirds of respondents without an electric connection indicated that they wanted an electrical connection to the national grid either a little or very much (Figure 5).

Figure 4: Demand for the grid among off-grid respondents by country



In most countries surveyed, the difference in grid demand between urban/rural areas was not statistically significant, except in Kenya, where 40 percent of rural respondents wanted access to the grid very much, compared with 32 percent of urban respondents.

3.5. Connection costs and distance from the grid are the most common obstacles

When asked about the greatest obstacle to gaining access to the national grid, most respondents cited either the cost of electricity, the cost of connection, or the lack of proximity to the grid.¹⁷ However, there was no universal consensus in any country on the greatest obstacle, nor was there one obstacle that was consistently cited as the top obstacle across countries. This suggests that localized context determines the greatest obstacle, rather than country-specific differences.

Figure 5: Greatest obstacle to grid electricity by country

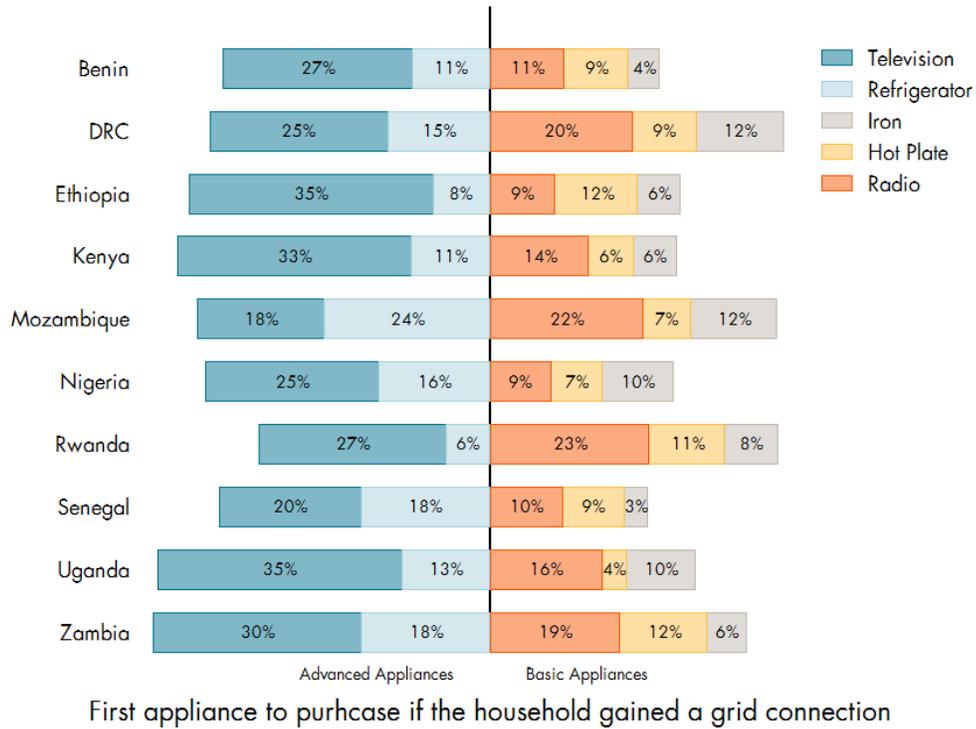


¹⁷ The responses were randomly ordered for each respondent.

3.6. Demand is high for energy-intensive appliances, especially TVs

Off-grid households indicate a high demand for energy-intensive appliances, particularly televisions and refrigerators. The survey also asked respondents what appliance they would like to purchase if they gained a grid connection (refrigerator, television, hot plate, radio, or iron). Respondents were also given two additional options—that they cannot afford any new appliances and that they already own all the aforementioned appliances. Televisions are the most common aspirational purchase across most surveyed countries.¹⁸ While it is difficult to rigorously test this finding, it does suggest that expanding electricity access could expand access to televisions and refrigerators in most countries.

Figure 6: Appliance demand by country¹⁹



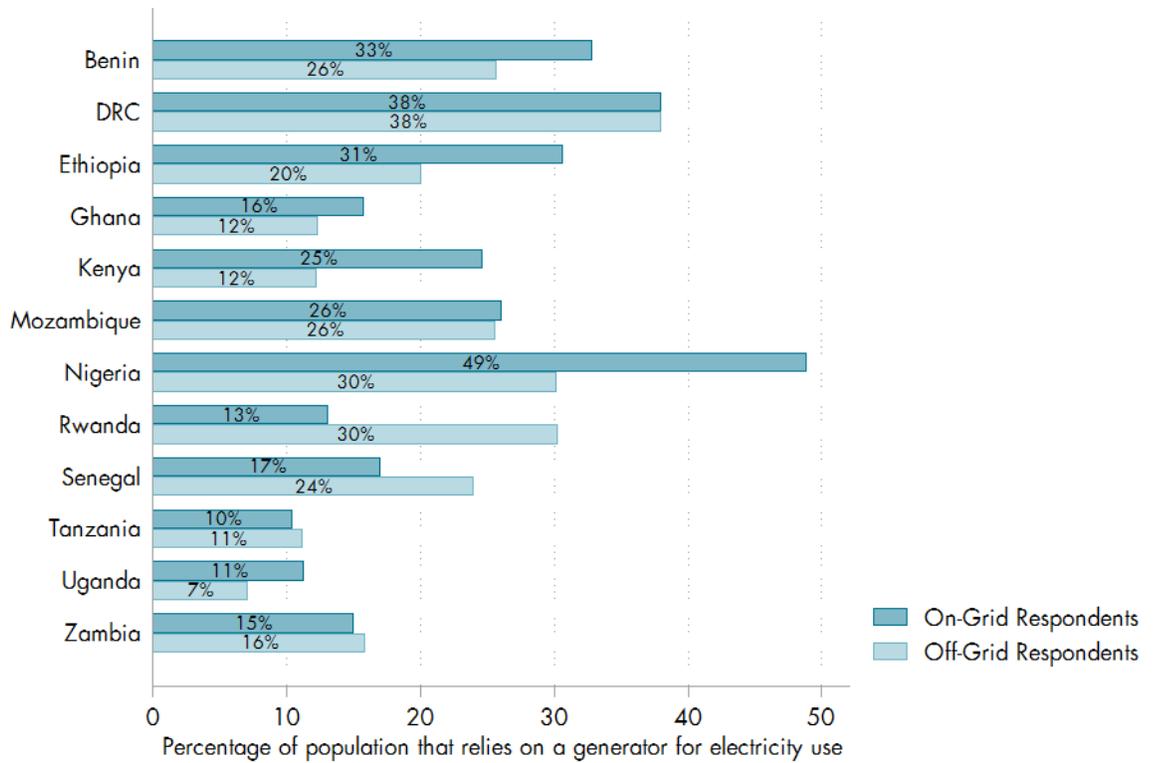
¹⁸ In Mozambique, the most common response was a refrigerator. In Benin and Senegal, the most common response was that the household could not afford any new appliances.

¹⁹ The responses were randomly ordered for each respondent. Because the surveys in Ghana and Tanzania were completed earlier and funded separately, we do not have responses to this question.

3.7. On-grid customers still rely heavily on generators, especially in Nigeria

The survey asked both on-grid and off-grid respondents if they relied on generators during power outages or for their regular energy use.²⁰ Nigeria was the most striking case; almost half of on-grid respondents relied on a generator during power outages. This is the highest of any other country. Generator reliance was higher among on-grid urban Nigerians (51 percent) than rural on-grid Nigerians (43 percent). The DR Congo and Benin also exhibit high levels of generator reliance, 38 percent and 33 percent of on-grid respondents, respectively.

Figure 7: Generator reliance among on-grid and off-grid respondents by country



Among off-grid respondents, significant proportions in DR Congo (38 percent), Rwanda (31 percent), and Nigeria (30 percent) relied on generators.

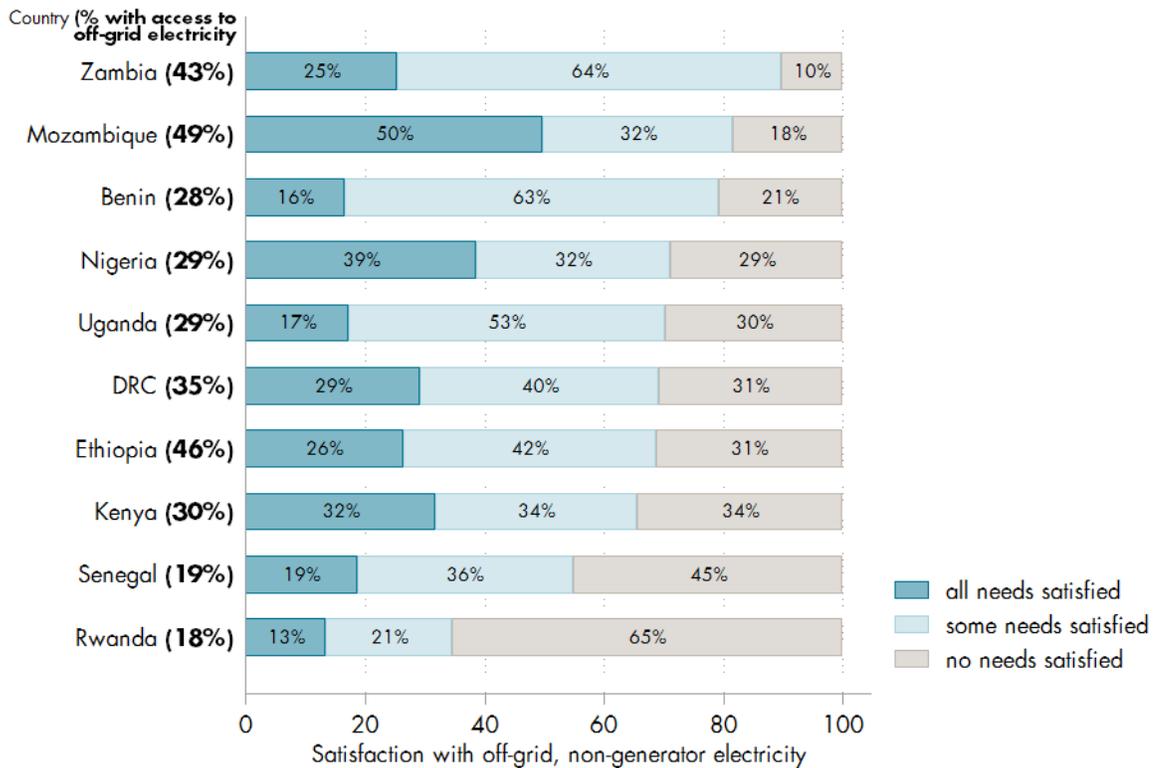
²⁰ The language for the generator reliance question differed slightly between the off-grid portion of the survey and the on-grid portion of the survey. On-grid respondents are asked if they rely on generators during outages, while off-grid respondents are asked if they rely on generators for their household electricity needs. The full text of the survey can be found in Appendix III.

3.8. Off-grid, non-generator electricity is largely inadequate to fulfill respondents' energy needs

A minority of off-grid respondents report having access to off-grid, non-generator energy (e.g. solar kits). The countries with the highest prevalence of off-grid solutions are Mozambique (49 percent) and Ethiopia (43 percent).

Most say that these off-grid solutions fulfill some, but not all, of their energy needs. Strikingly, a significant proportion of respondents across the surveyed countries reported that their off-grid electricity solution did not fulfill *any* of their power needs. This includes almost two thirds (65 percent) of Rwandans with off-grid, non-generator electricity. On the other end of the spectrum, half of Mozambicans with off-electricity solutions say that those sources satisfy all needs.

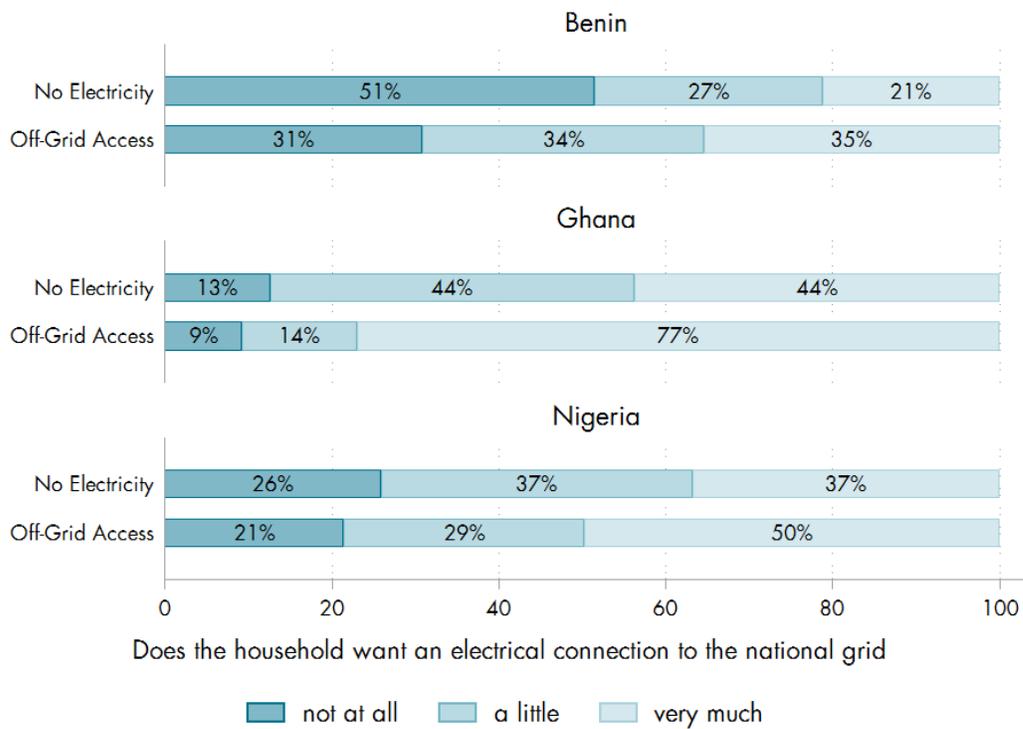
Figure 8: Satisfaction with off-grid, non-generator access by country



3.9. Off-grid customers still desire grid electricity

In most countries, off-grid respondents are not completely satisfied by off-grid electricity solutions and retain a high demand for grid electricity. Demand for the grid is significantly higher among off-grid households with some sort of off-grid electricity access (either generators or non-generator sources). In Ghana, 77 percent of respondents with off-grid access stated that they wanted grid electricity “very much” while only 44 percent of respondents with no access to off-grid electricity selected “very much.” A higher percentage of people selected “very much” if they had access to off-grid electricity in DR Congo, Kenya, Rwanda, Senegal, Tanzania, Uganda, and Zambia, although the difference was not statistically significant.

Figure 9: Comparison of grid demand by access to off-grid solutions in selected countries



4. Conclusions: Preliminary implications for policymakers

Based on these findings, we identify three implications for policymakers and partners with respect to electricity access, service provision, and demand.

(1) Both grid electricity and off-grid solutions are currently inadequate for modern energy demand.

Modern energy demand includes high-wattage appliances like televisions and refrigerators. However, *current options for electricity are often inadequate to meet these demands*. Grid electricity is often plagued with daily outages, and the consequence is high dissatisfaction in many countries. On the other hand, off-grid solutions may do little to satisfy households needs like televisions and refrigerators. Both of these trends suggest that policymakers and donors need to take Africans' demands for electricity seriously by simultaneously focusing on strengthening the grid and increasing the generating capacity of off-grid solutions, rather than simply focusing on extending access.

(2) Grid and off-grid electricity are seen as complementary solutions, rather than replacements.

Our surveys indicate that there is significant demand for off-grid electricity solutions among respondents with grid electricity, and there is also significant demand for grid connections among respondents with off-grid electricity solutions. This is evidenced by the high reliance on generators among respondents with grid electricity in some countries, and the high stated demand for grid electricity even among those with off-grid electricity. These findings indicate that *households do not view grid electricity and off-grid electricity as mutually exclusive alternatives to each other, but rather mutually reinforcing*.

To reflect this sentiment, *policymakers should not necessarily consider electrification as a binary choice between grid and off-grid electricity and assume that households will be satisfied with one of two options*. Instead, they should view these two types of access as complementary solutions filling two separate niches of the “modern electricity ladder”: grid electricity may still the best solution to meet high-wattage demand, while off-grid solutions are necessary to fill the gaps of unreliability and to transition energy-poor people into higher energy-consumption behavior.

(3) Until reliability improves, off-grid solutions have a market in urban areas.

The high percentage of urban, grid-connected Nigerians relying on generators is one consequence of frequent outages and high dissatisfaction with Nigeria's grid electricity. Nigeria's situation is a portent for the rest of the continent—if countries do not improve service provision, urban, grid-connected Africans will continue to become fed up and buy generators. Yet generators are extremely costly and produce exceptionally high levels of CO₂.²¹

²¹ Moss and Gleave 2014.

Current donor policies like the Power Africa and Energy Africa highlight the potential of off-grid home power systems and solar energy for rural and unconnected Africans,²² but there may be a market for these off-grid solutions among urban and/or grid-connected Africans. Similarly, there may be a large market for small African businesses, where power outages are a major constraint on the business climate.²³

²² DFID and Shapps 2015; Power Africa 2016.

²³ World Bank 2015.

Appendix I: Comparison of the survey findings with other sources

In this section, we compare the mobile phone-based survey findings to existing survey data from Afrobarometer and World Bank's Enterprise Surveys to assess our confidence in the data. We find some confidence in the data, although the differences in the data may be explained by differences in time and targets.

Source of comparisons

The mobile phone-based surveys are relatively unique in their scope and coverage, and there are few surveys that offer comparable data. The surveys with comparable data are Afrobarometer, Demographic and Health Surveys, and the World Bank Enterprise Surveys.

- **Afrobarometer:** Afrobarometer describes itself as a non-partisan research network conducting public attitude surveys on a range of topics.²⁴ In 2014/2015, Afrobarometer Round 6 explored the reach and quality of electrical connections through interviews with nearly 54,000 Africans in 36 countries, including all nine of the countries surveyed in the mobile phone-based surveys (all except DR Congo, Ethiopia, and Rwanda).²⁵ This data is one of the few available comparators with data on the reliability of service provision and satisfaction with providing electrical supply.
- **Demographic and Health Surveys:** USAID's Demographic and Health Surveys (DHS) collect a range of household-level and individual-level data in developing countries. The surveys are conducted once every five years. There is data for all twelve countries, collected between 2011 and 2016.²⁶ There some country-specific questions, including generator ownership.
- **Enterprise Surveys:** The World Bank's Enterprise Surveys offer firm-level data on a range of business environment topics, including several topics on infrastructure and service provision, including the number of outages per month and generator ownership.²⁷ There may be substantial differences in electricity provision between the firms and households. For example, grid electricity prices in Ghana, where the price of residential electricity is under half than that of industry.²⁸ Additionally, the most recent round of surveys—which are available for all countries surveyed in the mobile phone-based except Rwanda—were conducted between 2007 and 2016.²⁹

²⁴ About Afrobarometer 2017.

²⁵ Oyuke, Halley Penar, and Howard 2016.

²⁶ See the methodology section for a full list when each DHS dataset used was collected.

²⁷ World Bank 2015.

²⁸ International Energy Agency 2014, 66.

²⁹ The survey in Mozambique was completed in 2007; the surveys in DR Congo, Ghana, Kenya, Tanzania, Uganda, and Zambia were conducted in 2013; the surveys in Nigeria and Senegal were completed in 2014; the survey in Ethiopia was completed in 2015; the survey in Benin was completed in 2016.

Frequency of power outages

Afrobarometer offers perceptions-based data on how often electricity is actually available, and the Enterprise Surveys offer data on the number of electrical outages in a typical month. These data sources can be compared to the mobile phone-based data on the frequency of outage (Figure 1).

The comparison between all three data sources is in Table 1. The data is consistent appears consistent for some countries between Afrobarometer and other data. Of the nine countries, Senegal and Kenya are some of the best performers, with the fewest respondents experiencing regular outages in both surveys. However, the worst performers are inconsistent between the two surveys. In the Afrobarometer data, Nigeria was by far the worst (88.1 percent of respondents had electricity available half of the time or less often); whereas in the mobile phone-based data, Nigeria was a middling performer, ranking fifth in the percentage of respondents experiencing daily outages. In the mobile phone-based data, Zambia was the worst performer; whereas in the Afrobarometer data, Zambia was a middling performer. The Enterprise Survey data is inconsistent with both the Afrobarometer data and the mobile phone-based data.

The differences in energy provision may be explained by environmental factors and policy changes and between the Afrobarometer surveys and the mobile phone-based data collection. As surveys in Nigeria have shown, there can be enormous swings in service provision over the course of several months.³⁰ The Afrobarometer survey was conducted in October 2014, whereas Zambia began experiencing regular energy cuts in July 2015.³¹ This also likely explains some of the differences between the mobile phone-based data and the Enterprise Surveys data, which date back as far as 2007 in the case of Mozambique.

Table 1: Comparison of electricity outage data

| Country | <i>Afrobarometer</i> | <i>Enterprise Surveys</i> | <i>Mobile Phone-Based Survey</i> |
|------------|--|---|------------------------------------|
| | Percent with electricity available half the time, occasionally, or never | Number of electrical outages in a typical month | Percent experiencing daily outages |
| Benin | 36.8% | 28 | 67.5% |
| DR Congo | - | 12.3 | 62.6% |
| Ethiopia | - | 8.2 | 70.0% |
| Ghana | 57.9% | 8.4 | 68.4% |
| Kenya | 22.8% | 6.3 | 47.7% |
| Mozambique | 38.6% | 1.6 | 74.8% |
| Nigeria | 81.6% | 32.8 | 65.1% |
| Rwanda | - | - | 34.3% |
| Senegal | 20.2% | 6 | 63.2% |
| Tanzania | 45.1% | 8.9 | 54.1% |
| Uganda | 64.5% | 6.3 | 55.6% |
| Zambia | 42.9% | 5.2 | 88.1% |

³⁰ NOIPolls 2015.

³¹ Sladoje 2016; Oyuke, Halley Penar, and Howard 2016, 21.

Satisfaction with grid electricity

Afrobarometer also offers data on respondents’ perceptions of how the government is handling providing a reliable supply of electricity, which can be compared to the mobile phone-based data on satisfaction with the reliability of electricity (Figure 2).

The comparison between the two data sources is summarized in Table 2. The Afrobarometer data is relatively consistent with the mobile phone-based data, with some notable exceptions. In both datasets, Kenya and Mozambique are the countries with the highest satisfaction. Nigeria and Senegal are both about 10 percent lower than East African counterparts, Uganda and Tanzania. Ghanaians were among of the most dissatisfied in both surveys.

There are some major inconsistencies in Benin and Zambia, but the variation in energy service over time may explain the differences—as the Afrobarometer collected data several years before the mobile phone-based surveys was conducted. The major shift in Zambian satisfaction is likely explained by the major power cuts in 2015 after the Afrobarometer was conducted. Respondents’ satisfaction with the reliability of electricity captures likely decreased following these power cuts. There may be similar dynamics at play in Benin.

Additionally, the two questions about the frequency of power outages may be capturing different nuances of outages; Afrobarometer captured the length of power outages whereas the mobile phone-based data captured the intermittent frequency of power outages.

Table 2: Comparison of electricity satisfaction data

| Country | <i>Afrobarometer</i> | <i>Mobile Phone-Based Survey</i> |
|------------|--|--|
| | Percent who say the government is providing a reliable electric supply badly | Percent unsatisfied with electricity reliability |
| Benin | 78.8% | 49.8% |
| DR Congo | - | 62.5% |
| Ethiopia | - | 61.2% |
| Ghana | 76.3% | 81.3% |
| Kenya | 38.4% | 39.5% |
| Mozambique | 51.2% | 25.8% |
| Nigeria | 68.5% | 56.6% |
| Rwanda | - | 29.3% |
| Senegal | 69.2% | 56.1% |
| Tanzania | 57.1% | 43.9% |
| Uganda | 57.7% | 46.3% |
| Zambia | 55.1% | 73.0% |

Availability of generators

The World Bank’s Enterprise surveys and DHS provide data on generator availability, as summarized in table 3. In general, the mobile phone-based data seems to significantly overestimate the percentage of households relying on generators as compared to DHS. However, there may have differences in how respondents understood the question. However, across all three data sources, Nigeria consistently had the highest rates of generator use.

Table 3: Comparison of generator availability data

| Country | <i>Enterprise Surveys</i> | <i>DHS³²</i> | | <i>Mobile Phone-Based Survey</i> | |
|------------|---------------------------|---|--|--------------------------------------|--|
| | Firms owning a generator | Has a generator or generating set (household has electricity) | Has generator or generating set (household has no other electricity) | Relies on generator (grid-connected) | Relies on generator (not grid-connected) |
| Benin | 59.9% | 10% | 12% | 32.9% | 25.8% |
| DR Congo | 59.5% | 12% | 3% | 38.0% | 38.0% |
| Ethiopia | 49.1% | - | - | 30.6% | 20.1% |
| Ghana | 52.1% | 3% | 3% | 15.8% | 12.4% |
| Kenya | 57.4% | - | - | 24.7% | 12.3% |
| Mozambique | 12.6% | - | - | 26.1% | 25.6% |
| Nigeria | 70.7% | 44% | 15% | 48.9% | 30.2% |
| Rwanda | - | - | - | 13.1% | 30.3% |
| Senegal | 64.2% | - | - | 17.1% | 24.0% |
| Tanzania | 43.0% | - | - | 9.4% | 9.2% |
| Uganda | 52.2% | - | - | 11.4% | 7.2% |
| Zambia | 27.3% | - | - | 15.1% | 15.9% |

³² DHS includes a question on having electricity for all surveys and includes a question on owning a generating set in selected countries. The question on “having electricity” simply asks the household if they have electricity and does not specify what type of electricity (grid or generator). Thus, it is possible that the household may answer yes if they have a generator but not grid electricity.

Appendix II: Using mobile phone surveys to estimate energy access

In this appendix, we explore the question of whether mobile phone-based surveys are an appropriate tool to collect data on energy service provision and demand. As mobile phone penetration rates increase across developing countries, mobile phone-based surveys are gaining momentum as a low-cost tool to gather data. Mobile phone-based surveys have been used to explore a variety of development questions, including citizen development priorities, socioeconomic surveys, standard of living, the economic impact of the Ebola crisis.³³ These surveys apply the mobile phone-based approach to the explore energy access.

Background

There are three factors to be aware of when considering this question: (1) a phone ownership is far from universal, (2) electricity access and mobile phone ownership are inherently linked, and (3) mobile phone ownership seems to precede electricity access.

First, mobile phone ownership is far from universal in developing countries. While mobile phone ownership has skyrocketed in recent years, most countries do not appear to have universal cell phone ownership. In all of the countries surveyed, less than 95 percent of the population has access to a mobile phone in their household (let alone individually own a mobile phone), according to DHS surveys. In addition, these gains in mobile phone ownership have not been universal. In many countries, young, educated, and English-speaking Africans are more likely to own a smartphone.³⁴

³³ Leo and Morello 2015; Demombynes, Gubbins, and Romeo 2013; Kastelic and Kastelic 2015; Croke et al. 2012.

³⁴ Street et al. 2015.

Table 4: Mobile phone ownership in surveyed countries

| Country | Mobile phone subscriptions (per 100 people); source: World Bank ³⁵ | Population living in a mobile phone household; source: DHS |
|------------|---|--|
| Benin | 85.6 | 73% |
| DR Congo | 53.0 | 43% |
| Ethiopia | 42.8 | 24% |
| Ghana | 129.7 | 86% |
| Kenya | 80.7 | 87% |
| Mozambique | 74.2 | 38% |
| Nigeria | 82.2 | 80% |
| Rwanda | 70.5 | 64% |
| Senegal | 99.9 | 94% |
| Tanzania | 75.9 | 82% |
| Uganda | 50.4 | 61% |
| Zambia | 74.5 | 70% |

Second, using mobile phone-based approaches to assess energy access presents an implicit challenge. Mobile phone users need a source of electricity to charge their cell phones. Therefore, the survey sample will be limited to people with some access to electricity to charge their phones, either in their household or in their community.

Despite this challenge, household surveys reveal that mobile phone access outstrips electricity access in many African surveys. Afrobarometer surveys found that mobile phone service is the most widely available type of infrastructure and precedes almost all other types of infrastructure, including electricity.³⁶ There is also a considerable group of people in the surveyed countries who have access to mobile phones despite not having access to electricity, according to Demographic and Health Surveys (DHS). For instance, 52 percent of Tanzanians and 50 percent of Ugandans do not have access to in-house electricity but someone in their household owns a mobile phone.

Methodology

Based on these three factors, we hypothesize that our surveys accurately assess energy access *among those with access to mobile phones*. To test this hypothesis, we compare post-weighted

³⁵ The table refers to the 2015 data.

³⁶ Leo, Morello, and Ramachandran 2015.

electricity access to actual electricity access rates for both the entire population and among people with mobile phone access from several sources.³⁷

Findings

Table 5: Energy access estimates

| Country | Access: mobile phone-based survey | Access: IEA ³⁸ | Difference: IEA | Access: DHS subsample | Difference: DHS subsample ³⁹ | Access: Afrobarometer subsample | Difference: Afrobarometer subsample ⁴⁰ |
|------------|-----------------------------------|---------------------------|-----------------|-----------------------|---|---------------------------------|---|
| Benin | 59% | 29% | +30% | 47% | +12% | 53% | +6% |
| DR Congo | 45% | 18% | +27% | 34% | +11% | n/a | n/a |
| Ethiopia | 61% | 25% | +36% | 55% | +5% | n/a | n/a |
| Ghana | 78% | 72% | +6% | 79% | -1% | 91% | -13% |
| Kenya | 36% | 20% | +16% | 33% | +3% | 47% | -11% |
| Mozambique | 69% | 40% | +29% | 55% | +15% | 72% | -2% |
| Nigeria | 55% | 45% | +10% | 58% | -3% | 97% | -42% |
| Rwanda | 28% | 27% | +1% | 34% | -5% | n/a | n/a |
| Senegal | 69% | 61% | +8% | 63% | +6% | 73% | -4% |
| Tanzania | 24% | 30% | -6% | 24% | 0% | 30% | -6% |
| Uganda | 22% | 19% | +3% | 18% | +4% | 37% | -14% |
| Zambia | 46% | 28% | +18% | 37% | +8% | 54% | -8% |

Our findings, presented in table 5, fail to reject this hypothesis. The mobile phone-based surveys overestimate grid electricity access in many of the countries, as represented by the statistics from the International Electricity Agency (IEA). The survey does estimate energy access within +/- 10 percent in Ghana, Nigeria, Rwanda, Senegal, Tanzania, and Uganda.

³⁷ We calculated demographic weights based on known population parameters from DHS for age, gender, education, location (urban or rural), and two country-specific asset ownership questions. We then calculated the weighted percentage of the population with access to grid electricity. These percentages are reported in Table 5.

³⁸ WEO - Energy access database 2014. The IEA access rate refers to the national electrification rate. IEA uses a range of sources, including DHS, the World Bank's Living Standards Measurements Surveys (LSMS), and data from national statistical agencies. For more information, see International Energy Agency 2016.

³⁹ DHS Program 2016. The DHS indicator refers to the percentage of the population with household electricity. The sample is restricted those that indicated that a member of their household has a mobile phone. data for Benin was collected between 2011 and 2012. The data for DR Congo and Zambia was collected between 2013 and 2014. The data for Ethiopia, Mozambique, Uganda was collected in 2011. The data for Ghana, Kenya, and Senegal was collected in 2014. The data for Nigeria was collected in 2015. The data for Tanzania was collected between 2015 and 2016.

⁴⁰ Afrobarometer Data (Benin, Ghana, Kenya, Mozambique, Nigeria, Senegal, Tanzania, Uganda, Zambia), R6 2014. The Afrobarometer indicator refers to the percentage of the population with an electrical connection from the mains. This sample is restricted to those who indicated that they own a mobile phone.

However, once one limits the sample to those with mobile phones, the mobile phone-based surveys estimate grid electricity access relatively accurately. When compared to the DHS estimates of energy access among those with a mobile owner in their household, the mobile phone-based surveys estimate energy access within +/-10 percent in our surveyed countries except Benin, DR Congo, and Mozambique. The mobile phone-based survey estimates are within +/- 10 percent for five out of nine of the countries for the Afrobarometer estimates.

It should be noted that estimates of grid electricity access vary widely between sources. For example, Afrobarometer estimates that 97 percent of Nigerians with mobile phone access are connected to grid electricity, whereas DHS estimates that only 55 percent of Nigerians with mobile phone access are connected to the grid. This is likely indicative of the shortcomings of existing energy-access statistics, which are limited and potentially misleading.⁴¹ There are no clear and universal standards adopted by data sources of what constitutes “energy access,” so discrepancies between our surveys and other surveys may be partially explained by inconsistencies in energy access measurement.

Discussion

In the analysis of these surveys, we have identified three broader lessons for mobile phone surveys: (A) there is a high level of variance in sampling errors across countries, (B) there appears to be a relatively high time variance across countries, and (C) potential time variance. These should be taken into consideration when interpreting these results as well as for future mobile-phone based surveys.

A) Country-level variance in sampling errors:

There is a high level of time variance across countries in this the survey. Thus, we are confident in the results from some countries, including Kenya and Nigeria, but we are less confident in other countries—particularly Ethiopia and DR Congo. We determined confidence levels using the sampling error, which approximates the loss of the precision from the demographic weight’s design effect.⁴² Both the size of the sample and how closely the sample resembles the actual population influence the sampling error. The sampling error varies significantly across the surveyed countries, from 2.3 percent in Nigeria to 8.2 percent in Ethiopia.

⁴¹ Energy Access Targets Working Group 2016.

⁴² A full discussion of sampling error can be found in Leo et al. 2015.

Table 6: Categories of confidence of surveyed countries

| Category | Country | Coefficient of Variance | Number of responses | Sampling error |
|-------------------|------------|-------------------------|---------------------|----------------|
| Low-Confidence | Ethiopia | 12.80 | 1972 | +/- 8.20% |
| | DR Congo | 9.65 | 1574 ⁴³ | +/- 8.06% |
| Medium-Confidence | Benin | 7.60 | 1897 | +/- 6.60% |
| | Senegal | 6.13 | 1850 | +/- 6.12% |
| | Mozambique | 5.12 | 1948 | +/- 5.49% |
| | Ghana | 5.10 | 2018 | +/- 5.39% |
| | Tanzania | 6.41 | 2098 | +/- 4.83% |
| High-Confidence | Zambia | 2.09 | 1913 | +/- 3.94% |
| | Rwanda | 2.96 | 2337 | +/- 3.63% |
| | Uganda | 2.33 | 2462 | +/- 3.60% |
| | Kenya | 1.89 | 2000 | +/- 3.24% |
| | Nigeria | 3.37 | 8282 | +/- 2.30% |

B) High time variance

There seems to be a high level of time variance in energy provision, based on perception-based energy provision surveys. For instance, a Nigeria-based polling service (NOIPolls) conducts regular surveys on energy provision, which include questions on the number of hours of power supply and whether the power supply had improved. NOIPolls' data illustrates that power supply, or at least respondents' perception of it, can swing drastically over time.⁴⁴ Therefore, the assessments of electricity provision and satisfaction may vary considerably from month to month.

Mobile phone-based conducted over regular time intervals may be able to track changes in electricity provision and satisfaction where traditional, infrequent household surveys cannot.

C) Potential first-response bias

Several tests on the data indicate that respondents may be biased towards the first response in a list of potential responses. While the survey operator randomized the responses, it is indicative of a larger potential issue with accuracy, in that respondents are likely to choose the first response from a list rather than the most accurate response.⁴⁵

⁴³ Due to an error in the province selection of the DRC survey, the sample size is reduced slightly. For more, see Appendix III.

⁴⁴ The reported cumulative hours of power supply increased from 8.6 hours in July 2016 to 10.6 hours in August 2016, and perceptions of power improvement increased from 36 percent to 50 percent during the same period. Source: NOIPolls 2017.

⁴⁵ The survey operator randomized the responses to multiple response questions. This was used in three questions in the off-grid section: the greatest obstacle to the grid, the most important use of electricity in the

The survey operator experimented with the order of questions in several surveys and found that there was some first-response bias in questions about living in an urban or rural location; respondents were more likely to choose a “satisfied” or “very satisfied” option if the satisfied options preceded the unsatisfied options, and vice versa.⁴⁶

Additionally, we find further evidence of first-response bias in the Nigerian survey, which asked respondents to identify which geo-political zone they lived in. We did not randomize the survey options, and instead, we presented the responses in the alphabetical order. The results show significant bias towards the first options—North Central and North East. In fact, we supposedly oversampled North Central and North East by 18 and 13 percent, respectively. On the other hand, we significantly undersampled the percentage of the population living in South West—the last option—by 11 percent.⁴⁷

Table 7: Responses by geo-political zone in Nigeria

| Order in survey | Country | Number of survey responses | Percentage of survey responses | Percent of population ⁴⁸ | <i>Difference</i> |
|-----------------|---------------|----------------------------|--------------------------------|-------------------------------------|-------------------|
| 1 | North Central | 2,933 | 32% | 14% | +18% |
| 2 | North East | 2,461 | 27% | 14% | +13% |
| 3 | North West | 1351 | 15% | 26% | -11% |
| 4 | South East | 884 | 10% | 12% | -2% |
| 5 | South South | 685 | 8% | 15% | -8% |
| 6 | South West | 818 | 9% | 20% | -11% |

household, and the appliance that the household would buy first if they were to obtain access to the grid. The survey operator also randomized the order of responses for Likert scale response options, so half of the respondents were randomly assigned a positive to negative scale, and the other half of the respondents were assigned a negative to positive scale. This was used for questions about the satisfaction with grid electricity and whether an off-grid household wanted access to the grid. More detail can be found in Appendix II and Goertz 2017.

⁴⁶ Ibid. Goertz 2017. To address this in later surveys, we moved from four response options (very satisfied, satisfied, unsatisfied, and very unsatisfied) to two response options (satisfied and unsatisfied) but reduce the amount of time necessary to hear all options.

⁴⁷ This is despite the fact that cell phone access is actually higher in southern Nigeria than in northern Nigeria. A 2015 DHS survey found that cell phone access was 78, 66, and 67 percent in North Central, North East, and North West zones, respectively. Cell phone access was 88, 90, and 86 percent in South East, South West, and South South zones, respectively. This suggests that the mobile phone-based survey should have oversampled the southern zones of Nigeria rather than the northern zones of Nigeria.

⁴⁸ Anyaeche 2007.

Appendix III: Survey instrument

I. LANGUAGE SELECTION⁴⁹

If you would like to continue in [language], press 1.
If you would like to continue in [language], press 2.
If you would like to continue in [language], press 3.
If you would like to continue in [language], press 4.

II. INTRODUCTION

Hello. You have been randomly selected to participate in a survey representing [countrymen]. We're an independent research institution, and your answers will help inform important decisions for your country. The survey is only about 10 questions long and should only take 5 minutes to complete.

Please know that your answers will be kept strictly confidential.

III. TARGETING INFORMATION

[Benin]

(1-Benin) Do you live in a village or in a city?

If you live in a rural area or village, press one
If you live in Cotonou, press two.
If you live in Abomey-Calavi, press three.
If you live in another urban area or city, press four.

[DR Congo]

(1a-DR Congo) What province do you live in?

If you live in Kinshasa, press one
If you live in Bandundu, press two
If you live in Bas-Congo, press three
If you live in Kasai-Orientale or Kasai-Occidental, press four
If you live in Katanga, press five
If you live in Sud-Kivu or Nord-Kivu, press six
If you live in Equateur, press seven

⁴⁹ See Appendix IV for the respective list of languages for each of the surveyed countries.

If you live in Orientale, press eight
If you live in Maniema, press nine

(1b-DR Congo) Do you live in a village or a city?

If answered 1 for 1a (Kinshasa)

If you live in a rural area or village, press one
If you live in Kinshasa, press two
If you live in another urban area or city, press three

If answered 2 for 1a (Bandundu)

If you live in a rural area or village, press one
If you live in Kikwit, press two
If you live in another urban area, press three

If answered 3 for 1a (Bas-Congo)

If you live in a rural area or village, press one
If you live in Matadi, press two
If you live in another urban area or city, press three

If answered 4 for 1a (Kasai)

If you live in a rural area or village, press one
If you live in Mbuji-Mayi, press two
If you live in Kananga, press three
If you live in Tshikapa, press four
If you live in another urban area or city, press five

If answered 5 for 1a (Katanga)

If you live in a rural area or village, press one
If you live in Lubumbashi, press two
If you live in Likasi, press three
If you live in Kolwezi, press four
If you live in another urban area or city, press five

If answered 6 for 1a (Kivu)

If you live in a rural area or village, press one
If you live in Bukavu, press two
If you live in Goma, press three
If you live in Uvira, press four
If you live in another urban area or city, press five

[NOTE—THE RURAL AND URBAN RESPONSE OPTION ORDER WAS
RANDOMIZED FOR ALL RELATED COUNTRY SECTIONS]

[Ethiopia]

(1-Ethiopia) Do you live in a village or a city?

- If you live in a rural area or village, press one
- If you live in Addis Ababa, press two.
- If you live in Mekele, press three.
- If you live in another urban area or city, press four.

[Kenya]

(1-Kenya) Do you live in a village or a city?

- If you live in a rural area or village, press one
- If you live in Nairobi, press two.
- If you live in Mombasa, press three.
- If you live in Eldoret, press four.
- If you live in Kisumu, press five.
- If you live in another urban area or city, press six.

[Mozambique]

(1-Mozambique) Do you live in a village or a city?

- If you live in a rural area or village, press one
- If you live in Maputo, press two.
- If you live in Beira, press three.
- If you live in Nampula, press four.
- If you live in another urban area or city, press five.

[Nigeria]

(1a-Nigeria) What zone do you live in?

- If you live in North Central, press one
- If you live in North East, press two
- If you live in North West, press three
- If you live in South East, press four
- If you live in South South, press five
- If you live in South West, press six

(1b-Nigeria) Do you live in a village or a city?

- If answered 1 (North Central) for 1a*
- If you live in a rural area or village, press one

If you live in Abuja, press two
If you live in Ilorin, press three
If you live in Jos, press four
If you live in another urban area or city, press five

If answered 2 (North East) for 1a

If you live in a rural area or village, press one
If you live in Maiduguri, press two
If you live in Bauchi, press three
If you live in Gombe, press four
If you live in another urban area or city, press five

If answered 3 (North West) for 1a

If you live in a rural area or village, press one
If you live in Kaduna, press two
If you live in Zaria, press three
If you live in Sokoto, press four
If you live in another urban area or city, press five

If answered 4 (South East) for 1a

If you live in a rural area or village, press one
If you live in Onitsha, press two
If you live in Aba, press three
If you live in Nnewi, press four
If you live in another urban area or city, press five

If answered 5 (South South) for 1a

If you live in a rural area or village, press one
If you live in Port Harcourt, press two
If you live in Benin City, press three
If you live in Uyo, press four
If you live in another urban area or city, press five

If you answered 6 (South West) for 1a

If you live in a rural area or village, press one
If you live in Lagos, press two
If you live in Ibadan, press three
If you live in Oshogbo, press four
If you live in another urban area or city, press five

[Rwanda]

(1-Rwanda) Do you live in a village or a city?

If you live in a rural area or village, press one

If you live in Kigali, press two.
If you live in another urban area or city, press three.

[Senegal]

(1-Senegal) Do you live in a village or a city?

If you live in a rural area or village, press one
If you live in Dakar, press two.
If you live in another urban area or city, press three.

[Uganda]

(1-Uganda) Do you live in a village or a city?

If you live in a rural area or village, press one
If you live in Kampala, press two.
If you live in another urban area or city, press three.

[Zambia]

(1-Zambia) Do you live in a village or a city?

If you live in a rural area or village, press one
If you live in Lusaka, press two.
If you live in Ndola, press three.
If you live in Kitwe, press four.
If you live in another urban area or city, press five.

(2-3) Asset Questions Country Specific

[Benin]

(2-Benin) What best describes the toilet at your house?

If you have somewhere you only use as a toilet, like a pit latrine or flush toilet, press one.
If you do not have a place at your home you only use as a toilet, press two.

(3-Benin) What best describes your home's type of walls?

If your walls are mud, cane, palm, trunks, bamboo, or stone, press one.
If your walls are cement or bricks, press two.

[*Democratic Republic of Congo*]

(2-DR Congo) What best describes your home's type of walls?

If your walls are bamboo, mud, cane, palm, or trunks, press one.

If your walls are cement, bricks, or adobe, press two.

(3-DR Congo) What best describes your home's type of roof?

If your roof is thatched or palm leaf, press one.

If your roof is metal, press two.

[*Ethiopia*]

(2-Ethiopia) What best describes your home's type of roof?

If your roof is thatch, leaf, or mud, press one.

If your roof is metal or corrugated iron, press two.

(3-Ethiopia) Do you or anyone at home own a chair?

If you or anyone at home owns a chair, press one.

If you or anyone at home does not own a chair, press two.

[*Kenya*]

(2-Kenya) What best describes your home's type of floor?

If your floor is earth, sand, or dung, press one.

If your floor is cement, press two.

(3-Kenya) What best describes your home's type of walls?

If your walls are dirt, mud, dung, bamboo, cane, palm, trunks, grass, or sticks, press one.

If your walls are cement, bricks, wood planks, stone, or corrugated metal, press two.

[*Mozambique*]

(2-Mozambique) What best describes your home's type of floor?

If your floor is earth, adobe, or clay, press one.

If your floor is cement, press two.

(3-Mozambique) What best describes the toilet at your house?

If you have somewhere you only use as a toilet, like a pit latrine or flush toilet, press one.

If you do not have a place at your home you only use as a toilet, press two.

[*Nigeria*]

(2-Nigeria) What best describes your home's type of walls?

If your walls are mud, palm, cane, palm, trunks, or stone with mud, press one.

If your walls are cement or bricks, press two.

(3-Nigeria) Do you or anyone at home own a fan?

If you or anyone at home owns a fan, press one.

If you or anyone at home does not own a fan, press two.

[*Rwanda*]

(2-Rwanda) What best describes your home's type of walls?

If your walls are mud, trunks, dirt, or uncovered adobe, press one.

If your walls are covered adobe, cement, bricks, or reused wood, press two.

(3-Rwanda) Do you or anyone at home have a bank account?

If you or anyone at home has a bank account, press one.

If you or anyone at home does not have a bank account, press two.

[*Senegal*]

(2-Senegal) What best describes your home's type of floor?

If your floor is earth, sand, or dung, press one.

If your floor is cement, ceramic tiles, vinyl, or asphalt, press two.

(3-Senegal) What best describes your home's type of walls?

If your walls are cane, palm, trunks, dirt, or stone with mud, press one.

If your walls are cement, bricks, or reused wood, press two.

[*Uganda*]

(2-Uganda) What best describes your home's type of roof?

If your roof is thatched, press one.
If your roof is iron sheets, press two.

(3-Uganda) Do you or anyone at home own a cupboard?

If you or anyone at home owns a cupboard, press one.
If you or anyone at home does not own a cupboard, press two.

[Zambia]

(2-Zambia) What best describes your home's type of roof?

If your roof is thatched or palm leaf, press one.
If your roof is metal, iron sheets, or cement, press two.

(3-Zambia) Do you or anyone at home own a sofa?

If you or anyone at home owns a sofa, press one.
If you or anyone at home does not own a sofa, press two.

IV. OTHER DEMOGRAPHIC INFORMATION

(4) Are you a woman or a man?

If you are a woman, press one.
If you are a man, press two.

(5) How old are you?

If you are less than 15 years old, press one.
If you are 15-24 years old, press two.
If you are 25-34 years old, press three.
If you are 35-55 years old, press four.
If you are more than 55 years old, press five.

(6) How much schooling did you attend?

If you attended no formal schooling, press one.
If you attended some primary school, press two.
If you finished primary school, press three.
If you attended some secondary school, press four.
If you completed secondary school, press five.
If you attended more than secondary school, press six.

V. Energy Access and Consumption Information

(7-Benin) Does your household have electricity from the national grid, such as from the Société Béninoise d'Énergie Électrique or SBEE?

If yes, press one.

If no, press two.

(7-DR Congo) Does your household have electricity from the national grid, such as Société nationale d'électricité or SNEL?

If yes, press one.

If no, press two.

(7-Ethiopia) Does your household have electricity from the national grid, such as the Ethiopian Electric Services or Ethiopian Electric Power Corporation?

If yes, press one.

If no, press two.

(7-Kenya) Does your household have electricity from the national grid, such as from Kenya Power?

If yes, press one.

If no, press two.

(7-Mozambique) Does your household have electricity from the national grid, such as from Electricidade de Moçambique or EDM?

If yes, press one.

If no, press two.

(7-Nigeria) Does your household have electricity from the national grid, such as one of the distribution companies or “discos”?

If yes, press one.

If no, press two.

(7-Rwanda) Does your household have electricity from the national grid, such as the Energy Water and Sanitation Authority or EWSA?

If yes, press one.

If no, press two.

(7-Senegal) Does your household have electricity from the national grid, such as from the Société d'Électricité du Sénégal or Senelec?

If yes, press one.

If no, press two.

(7-Uganda) Does your household have electricity from the national grid, such as from Umeme or the Uganda Electricity Distribution Company?

If yes, press one.

If no, press two.

(7-Zambia) Does your household have electricity from the national grid, such as from the Zambia Electricity Supply Corporation or Zesco?

If yes, press one.

If no, press two.

[If The Respondent Has An Electrical Connection]

(8a) When did your household get connected to the national grid?

In the last month, press one.

In the last six months, press two.

Within the last year, press three.

More than a year ago, press four.

(9a) Do you rely upon this source of electricity for a radio, fan, or lighting in your home?

If yes, press one.

If no, press two.

(10a) Do you rely upon this source of electricity for household appliances, such as a cooking stove, refrigeration, or air conditioning?

If yes, press one.

If no, press two.

(11a) How often is electricity unavailable for your household?

Multiple times every day, press one.

At least once every day, press two.

Once every few days, press three.

Once a week, press four.

Less than once a week, press five.

(12a) How satisfied are you with the reliability of electricity over the last month?⁵⁰

Unsatisfied, press two.

Satisfied, press three.

⁵⁰ The survey instrument used in Tanzania and Ghana also included responses for “Very satisfied” and “Very unsatisfied.”

[NOTE—THE RESPONSE ORDER WAS REVERSED FOR 50% OF THE COUNTRY SAMPLES]

(13a) Do you rely on a generator during power outages?

If yes, press one.

If no, press two.

[The Respondent Does Not Have An Electrical Connection]

(8b) Does your household rely upon a generator for household electricity needs?

If yes, press one.

If no, press two.

(9b) Does your household have access to electricity outside of the national grid, such as solar power, that is not provided by a generator?

If yes, press one.

If no, press two.

[10B IS ONLY ASKED IF RESPONDENT ANSWERS “YES” IN 9B]

(10b) How satisfied are you with this source of electricity outside of the national grid, such as solar power, that is not provided by a generator?

If it provides electricity for all of your households needs, press one.

If it provides electricity for some, but not all of your households needs, press two.

If it does not provide enough electricity for any household needs, press three.

(11b) How much does your household want an electrical connection to the national grid?

Very much, press one.

A little, press two.

Not at all, press three.

[NOTE—THE RESPONSE ORDER WAS REVERSED FOR 50% OF THE COUNTRY SAMPLES]

(12b) In your view, what is the greatest obstacle to your household from having such a connection? Please listen to all options before responding.

If you are unable to pay for the electricity, press one.

If you are unable to pay for the initial connection fee, press two.

If the power company would take too long to connect your house, press three.

If you don't have an electrical grid near your house, press four.

If you prefer to rely on other sources of electricity, press five.

If you have a different obstacle that prevents your household from having a connection, press six.

[NOTE—THE FIRST FIVE RESPONSES WERE RANDOMLY ORDERED,
WITH THE SIXTH ALWAYS REMAINING LAST]

(13b) What would be the most important use of electricity in your household?

To start or expand a business, press one.

To charge a mobile phone, press two

To study at night, press three.

For cooking, press four.

To improve safety, press five.

Any other reason, press six.

[NOTE—THE FIRST FIVE RESPONSES WERE RANDOMLY ORDERED,
WITH THE SIXTH ALWAYS REMAINING LAST]

(14b) If your household gained an electrical connection to the national grid, would you plan to purchase a new appliance?

If you would purchase a refrigerator, press one.

If you would purchase a television, press two.

If you would purchase a hotplate, press three.

If you would purchase a radio, press four.

If you would purchase an iron, press five.

If you cannot afford to purchase any new appliances, press six.

If you already own all the appliances you want or need, press seven.

[NOTE—THE FIRST FIVE RESPONSES WERE RANDOMLY ORDERED,
WITH THE SIXTH AND SEVENTH ALWAYS REMAINING LAST]

Appendix IV: Survey languages

| Benin | DR Congo | Ethiopia | Ghana |
|--------|----------|----------|---------|
| Adja | French | Amharic | Dagbani |
| Fon | Kikongo | Oromo | English |
| French | Lingala | | Ewe |
| Yoruba | Swahili | | Twi |

| Kenya | Mozambique | Nigeria | Senegal |
|-----------|------------|---------|---------|
| English | Changana | English | French |
| Kiswahili | Chuabo | Hausa | Serer |
| Kikuyu | Portuguese | Igbo | Wolof |
| Luo | Makua | Pidgin | |
| | | Yoruba | |

| Rwanda | Tanzania | Uganda | Zambia |
|-------------|----------|-----------------|-----------|
| English | English | English | Chewa |
| French | Swahili | Luganda | English |
| Kinyarwanda | | Luo | Ichibemba |
| | | Runyale-Rukinga | Tonga |
| | | Runyoro-Rutooro | |

Appendix V: Survey results by country

Table 8: Unweighted demographic statistics

| Question | Response | Benin | DRC | Ethiopia | Ghana | Kenya | Moz. | Nigeria | Rwanda | Senegal | Tanzania | Uganda | Zambia |
|-----------------------|--------------------|-------|-----|----------|-------|-------|------|---------|--------|---------|----------|--------|--------|
| Location | Rural | 37% | 17% | 32% | 38% | 48% | 36% | 37% | 63% | 36% | 46% | 55% | 30% |
| | Urban | 63% | 83% | 68% | 62% | 52% | 64% | 63% | 37% | 64% | 54% | 45% | 70% |
| Gender | Female | 22% | 23% | 26% | 36% | 32% | 29% | 32% | 31% | 28% | 27% | 31% | 36% |
| | Male | 78% | 77% | 74% | 64% | 68% | 71% | 68% | 69% | 72% | 73% | 69% | 64% |
| Gender/location | Rural female | 8% | 4% | 8% | 14% | 17% | 11% | 11% | 20% | 9% | 11% | 17% | 11% |
| | Rural male | 29% | 13% | 24% | 24% | 31% | 24% | 26% | 42% | 26% | 35% | 38% | 20% |
| | Urban female | 14% | 19% | 19% | 22% | 15% | 18% | 21% | 11% | 18% | 16% | 13% | 26% |
| | Urban male | 49% | 64% | 50% | 40% | 36% | 46% | 42% | 26% | 46% | 39% | 32% | 44% |
| Age | Age 15-24 | 49% | 44% | 41% | 57% | 46% | 54% | 50% | 45% | 42% | 55% | 52% | 52% |
| | Age 25-35 | 36% | 33% | 38% | 29% | 34% | 30% | 33% | 40% | 29% | 28% | 29% | 29% |
| | Age 35-55 | 13% | 19% | 18% | 9% | 16% | 13% | 13% | 14% | 23% | 14% | 16% | 17% |
| | Age 55+ | 2% | 5% | 2% | 5% | 3% | 2% | 4% | 2% | 6% | 3% | 3% | 2% |
| Education | No formal | 17% | 5% | 8% | 10% | 8% | 10% | 24% | 9% | 26% | 5% | 9% | 11% |
| | Primary some | 20% | 9% | 20% | 18% | 22% | 17% | 16% | 34% | 27% | 28% | 26% | 30% |
| | Primary completed | 11% | 8% | 14% | 21% | 14% | 12% | 6% | 16% | 8% | 21% | 16% | 11% |
| | Secondary some | 21% | 14% | 9% | 15% | 13% | 28% | 11% | 17% | 13% | 14% | 15% | 13% |
| | Secondary complete | 11% | 25% | 11% | 17% | 19% | 19% | 18% | 14% | 9% | 19% | 15% | 20% |
| | Post plus | 20% | 38% | 37% | 19% | 24% | 14% | 24% | 10% | 17% | 13% | 18% | 15% |
| Wealth measure | No wealth measures | 20% | 22% | 16% | 11% | 36% | 21% | 16% | 29% | 28% | 23% | 19% | 15% |
| | 1 wealth measure | 35% | 27% | 51% | 26% | 24% | 55% | 38% | 49% | 40% | 38% | 45% | 39% |
| | 2 wealth measures | 44% | 51% | 33% | 63% | 40% | 24% | 46% | 22% | 31% | 39% | 37% | 47% |
| Electrical connection | No connection | 37% | 44% | 30% | 19% | 58% | 23% | 36% | 63% | 34% | 58% | 62% | 42% |
| | Connection | 63% | 56% | 70% | 81% | 42% | 77% | 64% | 37% | 66% | 42% | 38% | 58% |

Table 9: Summary statistics of grid-connected respondents

| Question | Response | Benin | DRC | Ethiopia | Ghana | Kenya | Moz. | Nigeria | Rwanda | Senegal | Tanzania | Uganda | Zambia |
|--|------------------------|-------|-----|----------|-------|-------|------|---------|--------|---------|----------|--------|--------|
| When did your household get connected to the national grid? | In the last month | 24% | 33% | 24% | 11% | 15% | 18% | 14% | 13% | 19% | 16% | 15% | 10% |
| | In the last six months | 14% | 21% | 9% | 7% | 22% | 14% | 12% | 10% | 11% | 20% | 26% | 15% |
| | In the last year | 10% | 14% | 8% | 8% | 15% | 9% | 11% | 14% | 8% | 19% | 19% | 10% |
| | More than a year ago | 51% | 33% | 59% | 73% | 48% | 59% | 62% | 63% | 62% | 44% | 40% | 64% |
| Do you rely upon this source of electricity for a radio, fan, or lighting in your home? | No | 24% | 16% | 41% | 11% | 17% | 12% | 36% | 16% | 12% | 24% | 26% | 13% |
| | Yes | 76% | 84% | 59% | 89% | 83% | 88% | 64% | 84% | 88% | 76% | 74% | 87% |
| Do you rely upon this source of electricity for household appliances, such as a cooking stove or television? | No | 61% | 44% | 48% | 42% | 54% | 35% | 51% | 66% | 64% | 35% | 63% | 27% |
| | Yes | 39% | 56% | 52% | 58% | 46% | 65% | 49% | 34% | 36% | 65% | 37% | 73% |
| Do you regularly pay for the electricity? ⁵¹ | No | | | | | 5% | | | | | 16% | | |
| | Yes | | | | | 95% | | | | | 84% | | |
| How often is electricity unavailable for your household? | Multiple times per day | 39% | 38% | 29% | 49% | 25% | 57% | 39% | 18% | 24% | 23% | 24% | 46% |
| | At least once a day | 28% | 24% | 41% | 19% | 22% | 18% | 27% | 16% | 39% | 31% | 32% | 42% |
| | Once every few days | 19% | 17% | 20% | 19% | 29% | 8% | 16% | 28% | 13% | 24% | 20% | 7% |
| | Once a week | 6% | 8% | 4% | 7% | 9% | 7% | 7% | 20% | 8% | 8% | 12% | 2% |
| | Less than once a week | 7% | 13% | 6% | 6% | 14% | 11% | 12% | 17% | 16% | 13% | 12% | 3% |
| How satisfied are you with the reliability of electricity over the last month? | Satisfied | 50% | 37% | 39% | 19% | 60% | 74% | 43% | 71% | 44% | 56% | 54% | 27% |
| | Unsatisfied | 50% | 63% | 61% | 81% | 40% | 26% | 57% | 29% | 56% | 44% | 46% | 73% |
| Do you rely on a generator during power outages? | No | 67% | 62% | 69% | 84% | 75% | 74% | 51% | 87% | 83% | 91% | 89% | 85% |
| | Yes | 33% | 38% | 31% | 16% | 25% | 26% | 49% | 13% | 17% | 9% | 11% | 15% |

⁵¹ This question was removed in the later surveys after consultation with partners.

Table 10: Summary statistics of off-grid respondents

| Question | Response | Benin | DRC | Ethiopia | Ghana | Kenya | Moz. | Nigeria | Rwanda | Senegal | Tanzania | Uganda | Zambia |
|---|----------------------------------|-------|-----|----------|-------|-------|------|---------|--------|---------|----------|--------|--------|
| Does your household rely upon a generator for household electricity needs? | No | 74% | 62% | 80% | 88% | 88% | 74% | 70% | 70% | 76% | 91% | 93% | 84% |
| | Yes | 26% | 38% | 20% | 12% | 12% | 26% | 30% | 30% | 24% | 9% | 7% | 16% |
| Does your household have access to electricity outside of the national grid, such as solar power, that is not provided by a generator? | No | 72% | 65% | 54% | 86% | 70% | 51% | 71% | 82% | 81% | 72% | 71% | 57% |
| | Yes | 28% | 35% | 46% | 14% | 30% | 49% | 29% | 18% | 19% | 28% | 29% | 43% |
| How satisfied are you with this source of electricity outside of the national grid, such as solar power, that is not provided by a generator? | No needs satisfied | 21% | 31% | 31% | | 34% | 18% | 29% | 65% | 45% | | 30% | 10% |
| | Some needs satisfied | 63% | 40% | 42% | | 34% | 32% | 32% | 21% | 36% | | 53% | 64% |
| | All needs satisfied | 16% | 29% | 26% | | 32% | 50% | 39% | 13% | 19% | | 17% | 25% |
| How much does your household want an electrical connection to the national grid? | Not at all | 43% | 24% | 30% | 12% | 21% | 27% | 24% | 25% | 34% | 20% | 16% | 8% |
| | A little | 30% | 52% | 36% | 37% | 41% | 42% | 33% | 37% | 32% | 36% | 38% | 34% |
| | Very much | 27% | 23% | 34% | 52% | 38% | 31% | 43% | 38% | 34% | 44% | 46% | 58% |
| In your view, what is the greatest obstacle to your household from having such a connection? Please listen to all options before responding. | Cost of electricity | 21% | 24% | 19% | 7% | 24% | 22% | 18% | 30% | 25% | 14% | 28% | 17% |
| | Cost of connection | 19% | 12% | 21% | 28% | 26% | 19% | 16% | 24% | 18% | 17% | 25% | 32% |
| | Time to connect | 8% | 15% | 14% | 21% | 14% | 21% | 14% | 7% | 11% | 9% | 6% | 10% |
| | No grid nearby | 25% | 23% | 30% | 27% | 23% | 26% | 24% | 21% | 22% | 32% | 27% | 26% |
| | Prefer other sources | 14% | 16% | 12% | 11% | 7% | 10% | 13% | 7% | 8% | 12% | 7% | 8% |
| | Any other obstacle | 12% | 10% | 4% | 6% | 6% | 3% | 17% | 12% | 16% | 16% | 8% | 7% |
| What would be the most important use of electricity in your household? | Charge phone | 20% | 23% | 26% | 12% | 16% | 26% | 19% | 30% | 19% | 12% | 25% | 19% |
| | Cooking | 11% | 10% | 5% | 4% | 6% | 8% | 7% | 8% | 9% | 4% | 6% | 9% |
| | Improve safety | 12% | 13% | 15% | 21% | 18% | 19% | 17% | 16% | 28% | 22% | 20% | 15% |
| | Start/expand business | 9% | 26% | 14% | 21% | 19% | 21% | 24% | 21% | 13% | 30% | 21% | 25% |
| | Study at night | 26% | 20% | 15% | 22% | 23% | 14% | 23% | 18% | 19% | 17% | 17% | 23% |
| | Any other reason | 22% | 8% | 24% | 18% | 18% | 12% | 10% | 7% | 11% | 15% | 11% | 10% |
| If your household gained an electrical connection to the national grid, would you plan to purchase a new appliance? | Hotplate | 9% | 9% | 12% | | 6% | 7% | 7% | 11% | 9% | | 4% | 12% |
| | Iron | 4% | 12% | 6% | | 6% | 12% | 10% | 8% | 3% | | 10% | 6% |
| | Radio | 11% | 20% | 9% | | 14% | 22% | 9% | 23% | 10% | | 16% | 19% |
| | Refrigerator | 11% | 15% | 8% | | 11% | 24% | 16% | 6% | 18% | | 13% | 18% |
| | Television | 27% | 25% | 35% | | 33% | 18% | 25% | 27% | 20% | | 35% | 30% |
| | Already own all appliances | 10% | 10% | 11% | | 12% | 12% | 13% | 3% | 6% | | 6% | 6% |
| | Cannot afford any new appliances | 28% | 8% | 19% | | 17% | 5% | 20% | 23% | 33% | | 17% | 10% |

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