



THE SUSTAINABLE DEVELOPMENT GOALS CENTER FOR AFRICA

Building from the Last Mile

Spending on Lighting and Electricity in Rwanda





Note: This document was prepared by Gordon Shaw, Advisor on Energy

Introduction

With the high cost of extend the grid well established, small individual solar systems have shown great promise in meeting the energy need of the estimated 1.2 billion people worldwide that lack access (including 600 million in Africa). However, a systematic analysis of a potential market size for existing solutions has yet to be undertaken. In particular, there is little understanding about the differential of spending ability across the population. Five dollars a month is often cited as a realistic amount for most customers to spend, but there has been spotty data to back this assertion. Fortunately, many countries have large, vetted data sets that contain the answer to this exact question in the form of living condition surveys that track consumption in many different areas, including energy products. By analyzing these data sets, it is possible to get a very rich sense of market sizes at different price points.

The country to be analyzed for this report is Rwanda by using the Integrated Household Living Conditions Survey (EICV – French acronym) completed in 2013-2014. This survey collected data from just over 14,000 households that were chosen to be representative of the population. The EICV survey is the national income and expense survey for the population and is used to determine the poverty rate, change in access to services/utilities, and satisfaction with services, among others. It is a very comprehensive data set the offers answers to many questions about life in Rwanda.

Methodology

This analysis started with the micro data from the EICV 4 survey undertaken by the National Institute of Statistics Rwanda (NISR). The broader purpose of this survey is to provide a detailed look at various aspects of life in Rwanda, and reports are available from NISR that deal with different thematic areas. However, the data is very rich and thus can be used to explore many other issues not contained in the reports. What is of interest for the purposes of this analysis is the very detailed consumption data that was taken for the survey set of households. It should also be noted that the households were chosen to be representative of the population and thus give an excellent picture of the true consumption patterns of the entire population of Rwanda. The specific items of interest for the purposes of this analysis are energy related expenses. In particular, this analysis is looking at the amount spent by households on lighting and electricity.

To determine the amount spent on lighting/electricity, expenses for batteries, kerosene, candles, and electricity were summed for each household. The survey period for these expenses was varied depending on whether the household was in Kigali or not (Kigali = 30 days, Non-Kigali = 14 days). For households not in Kigali, the amount was adjusted to reflect a monthly consumption (30 days).

The original questionnaire was referenced to know the specific questions asked of the households to prevent misinterpretation of the data. NISR was also consulted to ensure correct interpretation of the data.

This report will use existing spending on energy to show energy spending broken down by decile of the population (population ordered by energy spending from low to high and broken into 10 equal segments). The quantile function in R was used to determine the spending level at specified percentiles. The midpoint of each decile was taken to give an average for each segment (5%, 15%,...,95%). The method used by the R function to determine the spending levels is linear interpolation. The households were then divided by whether they had a grid connection or not to be able to determine differences in spending between these two groups and because off-grid households are the target market for SHS in Rwanda.

The other crucial calculation that is needed is an expected market size at different price points. This gives an estimate of how many households could potentially afford different off-grid products. This was done only for the off-grid population and was determined by finding the number of households whose energy spending is equal or greater than the price point. This was completed for price points of \$1, \$3, and \$5. Percentage of households is calculated by dividing by the total number of off-grid households surveyed, and potential market size in households is calculated by multiplying the percentage by estimated number of off-grid households in Rwanda, using population and household size data. The percentage of off-grid households was calculated by dividing the number of off-grid households by the total number of households in the survey. This produced a value of about 82% which corresponds closely to the electrification rate in 2014 (~18%). Population and household size were both taken from the EICV survey.

As a check to verify the spending amounts seen are reflective of the ability of the population to pay for these services, an alternative way was used to calculate monthly energy spending. As part of the EICV survey, yearly consumption for a household is calculated, and this can be used as a proxy for income. A common estimate for energy expenses of similar populations is 5% of consumption so this was applied to the consumption data as a secondary estimate for energy expenses across the population.

Assumptions

Survey consumption was collected in Rwandan Francs (RWF), but to make the results understandable to an international audience these values were converted to USD using the exchange rate at the approximate midpoint of data collection, December 31, 2013. The exchange rate for this day was: 1 USD = 679 Rwandan Francs (source: exchangerates.co.uk).

All electricity spending is included in this calculation even though the focus of the study is on lighting. Clearly, electricity will also be used for additional appliances, particularly for higher income customers; however, the primary use of the results is to assess the ability and willingness of people to pay for off-grid energy solutions. It is reasonable that higher income off-grid customers would be interested in purchasing and using other appliances (TV, fridge, etc.) and therefore using energy to power them, so for this reason the full amount spent on electricity is included.

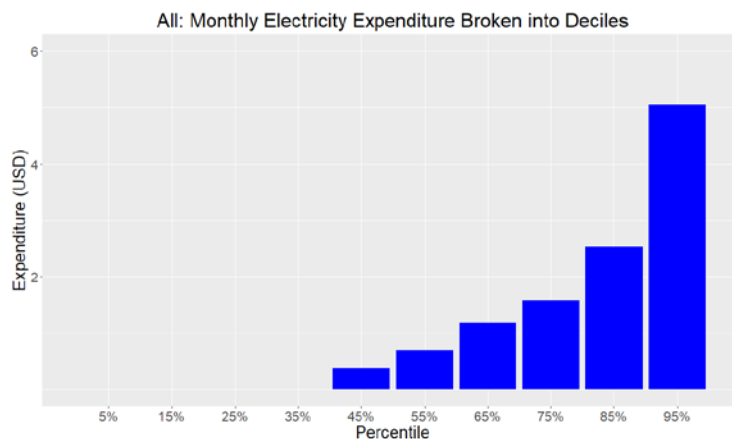
The market size analysis that was previously discussed is only completed for off-grid households because it is assumed that on-grid households will not be interested in these products. There are some grid reliability problems in Rwanda, particularly in rural areas so some customers that have a grid connection may also purchase a SHS, but this was assumed to be a small market.

This data is from 2013-2014 so it is a few years old at this point. It was assumed that the spending ability hasn't changed remarkably since that point due to the complexity and uncertainty of determining income increases across the spectrum of the population. The survey takes place every three years, and the data from the 2017 version is forthcoming in the second half of 2018. This analysis will be updated when this data is available.

Results

Energy related spending was shown to be very low among a large percent of the population, and this was especially true among the off-grid population that would be the target customers for off-grid products such as solar home systems. Spending by the overall population is presented first, followed by a breakdown of on-grid and off-grid households.

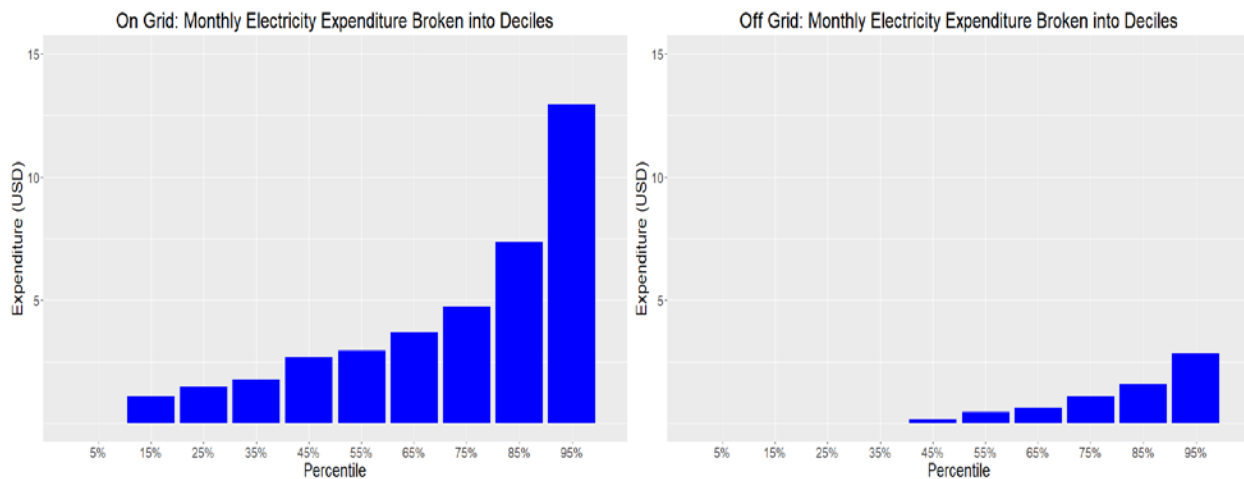
Whole Population





Monthly Energy Expenditure for Whole Population										
Percentile	5%	15%	25%	35%	45%	55%	65%	75%	85%	95%
Monthly Expense	\$0.00	\$0.00	\$0.00	\$0.00	\$ 0.38	\$ 0.70	\$ 1.18	\$ 1.58	\$ 2.52	\$ 5.05

Broken Down By On/Off-Grid

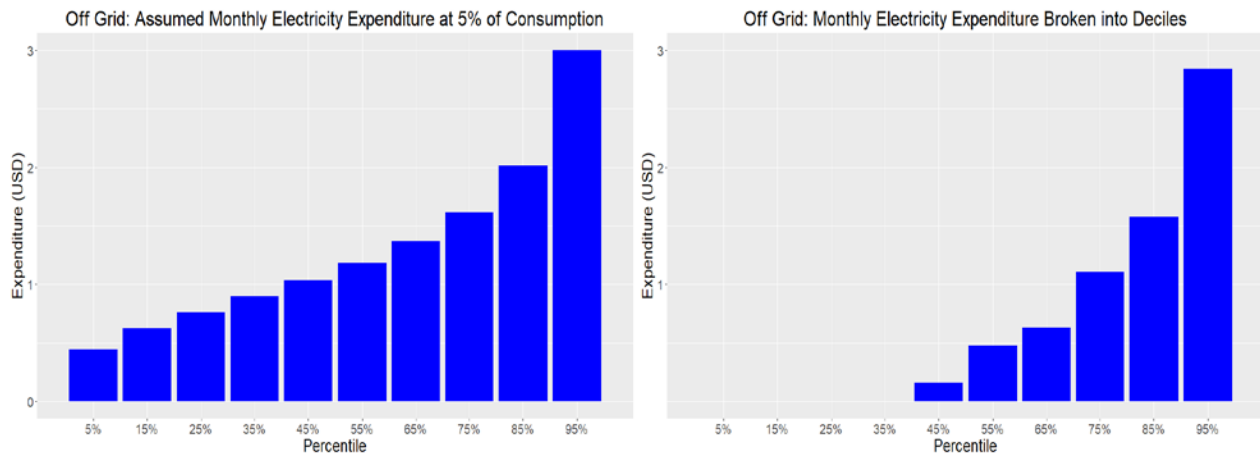


Monthly Energy Expenditure for On-grid Population										
Percentile	5%	15%	25%	35%	45%	55%	65%	75%	85%	95%
Monthly Expense	\$0.00	\$1.10	\$1.47	\$1.78	\$ 2.68	\$ 2.95	\$ 3.68	\$ 4.73	\$ 7.36	\$ 12.95

Monthly Energy Expenditure for Off-grid Population										
Percentile	5%	15%	25%	35%	45%	55%	65%	75%	85%	95%
Monthly Expense	\$0.00	\$0.00	\$0.00	\$0.00	\$ 0.16	\$ 0.47	\$ 0.63	\$ 1.10	\$ 1.58	\$ 2.84

Calculated Energy Expense Based on 5% of Total Household Consumption

The calculated expense is shown in comparison to a re-scaled version of the previously presented off-grid expenditure graph.



Calculated Monthly Energy Expenditure for Off-grid Population: 5% of Total Consumption										
Percentile	5%	15%	25%	35%	45%	55%	65%	75%	85%	95%
Monthly Expense	\$0.45	\$0.63	\$0.76	\$0.90	\$ 1.04	\$ 1.18	\$ 1.37	\$ 1.62	\$ 2.02	\$ 3.00

Market size at \$1, \$3, \$5 (Off-Grid Only)

The tables below show market size estimates using the energy expense data and calculated energy expenditure at 5% of total consumption.

Actual Energy Expense

Market Size in Off-grid areas Based on Energy Spending		
Price Point	Percent of Off-grid Population in Market	Total Estimated Market Size (households)
\$5	1.0%	20,377
\$3	4.0%	81,508
\$1	26.5%	539,988



Estimated using Total Consumption

Market Size in Off-grid areas Based on 5% of Total Consumption		
Price Point	Percent of Off-grid Population in Market	Total Estimated Market Size (households)
\$5	1.2%	24,452
\$3	5.0%	101,885
\$1	57.6%	1,173,710

Discussion

These results show very low energy consumption by a vast majority of the population of Rwanda. Spending like this will not be able to sustain the growth of the solar home system (SHS) industry that has recently taken off. In fact, based on these results the SHS market in Rwanda might be close to saturated already.

These results also cast doubt on the assumption by many in the off-grid energy space that these solutions will continue to take off organically and show the need for more efforts to bring down the price of these systems to the end customers. The effort to bring down these prices will need to be comprehensive but with a particular focus on financing and policy.

The results also show that a large percent of the population spends nothing on energy. The vast majority of these customers reported batteries/lantern, candles, or firewood as their primary source of lighting. For the cases of batteries and candles, it is likely that the survey period of 14 days in areas outside of Kigali did not capture this expenditure in some cases. For the case of firewood, it is likely that the expense is zero or very close to zero. Regardless of whether these households spend nothing or very little, they will fall well below the threshold to be able to purchase existing off-grid products.

The comparison between the calculated spending based on consumption and actual spending aligns well at the upper end, but lower consumption households spend significantly less than 5% of their total consumption on energy. This can be interpreted as higher income households in off-grid areas spending close to their limit on energy while lower income households spend less than expected in order to cover more basic needs. It also means that the most likely consumers of off-grid products will be forced to spend beyond a comfortable level in order to buy them. These potential customers may be willing to pay a slight premium for a solar system, but they will largely be limited by their available resources. On the other hand, 75% of the population spends \$1.10 or way less on energy per month, and it is therefore not realistic to expect them to adopt solutions that might cost \$5-6/mo.

Another important result is the vast difference between spending of on-grid and off-grid customers. At every decile, on-grid customers spend vastly more than off-grid customers. This likely means that the grid has already reached many of the more affluent households in Rwanda, and many of the current off-grid households will struggle to gain access to modern energy services without subsidies. This has policy implications as to whether the government will push grid electrification or put more focus on off-grid solutions to serve a large part of the population.

The estimated size of the markets shows that work must be done, and that a relatively small decrease from \$5/month to \$3 a month could make a huge difference with the market quadrupling. Even this will still include a relatively small percentage of the population, but if it is possible to get to \$1 a month, SHS can start to reach the potential that many have touted. At the moment, solar lanterns are close to the \$1/month price point, and they can potentially be a good option for many households. They won't provide as much light as a solar home system, but they will generally provide more light than lanterns with disposable batteries and with almost no waste (disposable batteries are rarely disposed of properly in rural areas which leads to potentially hazardous waste in the environment and potentially seeping into water supplies).

Recommendations and Future Work

The main conclusion from this work is that the price points for many off grid products are currently too high to be accessible to a large part of the population, and efforts to lower these prices should be taken very seriously by all stakeholders in this space. In addition, the data shows that many people will not be able to purchase any modern energy products with their current incomes. This leads to a crucial point that policies should be oriented to energy products and services that boost incomes. A common saying is that "there will be no development without energy," but the inverse is also true – for a large segment of the population, without development there will be no energy. Rather than one leading the other, these two things need to go hand and hand. Particularly in the area of agriculture, energy has a large potential to boost income through irrigation, off-grid cold storage, and agro-processing. Policies should incentivize innovations in these areas and other income producing areas because these will help boost people out of poverty.

This requires a change in mindset from considering government expenses to be subsidies to being investment projects. If government expenses are directed towards increasing incomes, these investments will pay off for the country in terms of GDP growth. Governments should work closely with businesses to develop different mechanisms (ex. guarantees, concessions) to attract and grow companies that can provide these services.

The first step for future work will be to undertake similar analyses for other countries across Africa. This will provide the background for providing more concrete policy recommendations to lower the price of these products and encourage policies that use energy to boost incomes. A key focus of this work will be to understand financing costs and gaps that currently exist, especially in regards to how these affect the final cost to the customer.

References

1. National Institute of Statistics of Rwanda (NISR). Rwanda - Integrated Household Living Conditions Survey (EICV4), 2013-2014, Cross-Sectional Sample Microdata. Retrieved January 12, 2018, from <http://microdata.statistics.gov.rw/index.php/catalog/75>
2. What was the US Dollar to Rwanda Franc historical exchange rate on 31 December 2013? Retrieved January 19, 2018, from https://www.exchangerates.org.uk/USD-RWF-31_12_2013-exchange-rate-history.html