

# Title: Understanding Rwanda Household Electricity Demand

Stakeholder: Rwanda Energy Group (REG)

## **Brief Description:**

This study analyzes household electricity consumption from 2013 to 2019, utilizing data from prepaid electricity purchases provided by the Rwanda Energy Group (REG). We aim to answer two key questions:

1. How has household electricity consumption evolved over time?
2. How do fluctuations in electricity prices influence household electricity usage?

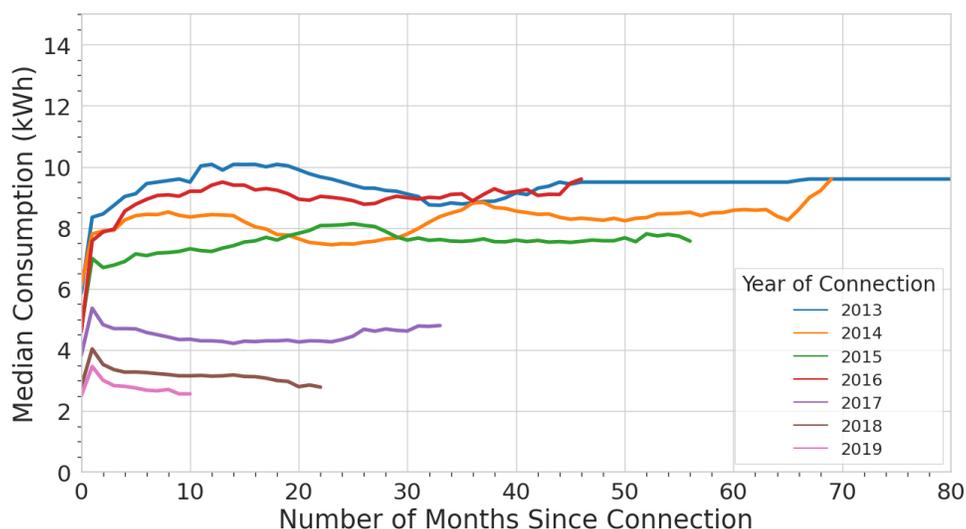
In collaboration with the Rwanda Energy Group, we signed memoranda of understanding to access and utilize sensitive customer consumption data for this study.

## **Technical Abstract:**

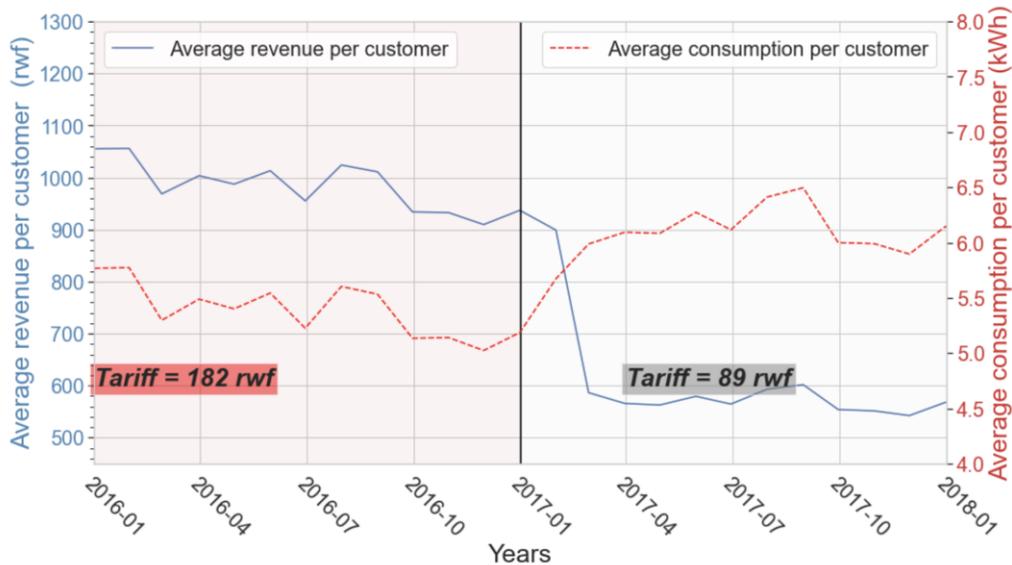
We used an innovative approach to look at the data, making it easier to analyze. The data shows that people who recently got electricity, often in rural areas, use less electricity than those who have had it longer and usually live in cities. This study also shows differences in electricity use levels between rural and urban areas.

When electricity prices were lowered for those using the least amount of electricity, people spent less on electricity overall. This suggests that people have other important expenses to consider.

The figure below shows newly connected customers use less electricity over time. Among homes, those connected after 2017 used less electricity than those connected in earlier years.



The figure below shows the impacts of 2017 price change on customers whose average monthly consumption was below 15kWh prior to the change. We note an increase in electricity consumption but an overall decrease in electricity expenditure.



## Title: The role of grid reliability in appliance ownership in Rwanda

Stakeholder: National Institute of Statistics Rwanda (NISR), Rwanda Energy Group (REG)

### Brief summary:

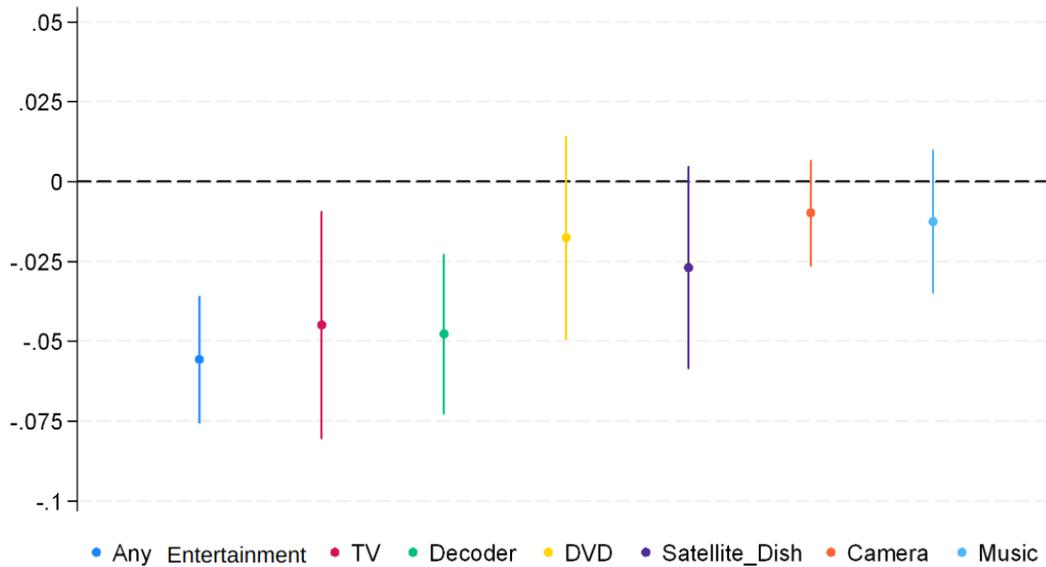
This study primarily investigates the impact of grid reliability on household electricity consumption. Additionally, it examines how various household income and non-income characteristics influence electricity usage.

We collaborated with two key partners for this project. The National Institute of Statistics Rwanda (NISR) provided us access to sensitive household survey data at their premises. We also received support from the Rwanda Energy Group (REG), which provided us with medium voltage level outage datasets.

### Technical Abstract:

This study looks at how reliable electricity is in Rwanda and how it affects what appliances people own and use. Using our unique dataset and an approach utilizing instrumental variables, the study shows that the reliability of electricity influences the types of appliances people choose to buy. Interestingly, the study found that the reliability of electricity doesn't change how much electricity is used by households who already own appliances. The study also looks at how household income and other factors influence appliance ownership and use.

This figure shows that households show a small but significant decrease in ownership of entertainment appliances as a result of unreliable electricity.



## Title: Electricity Outages in Uganda: Trends and Disparities

Stakeholder: Electricity Regulatory Authority (ERA)

### Brief Summary:

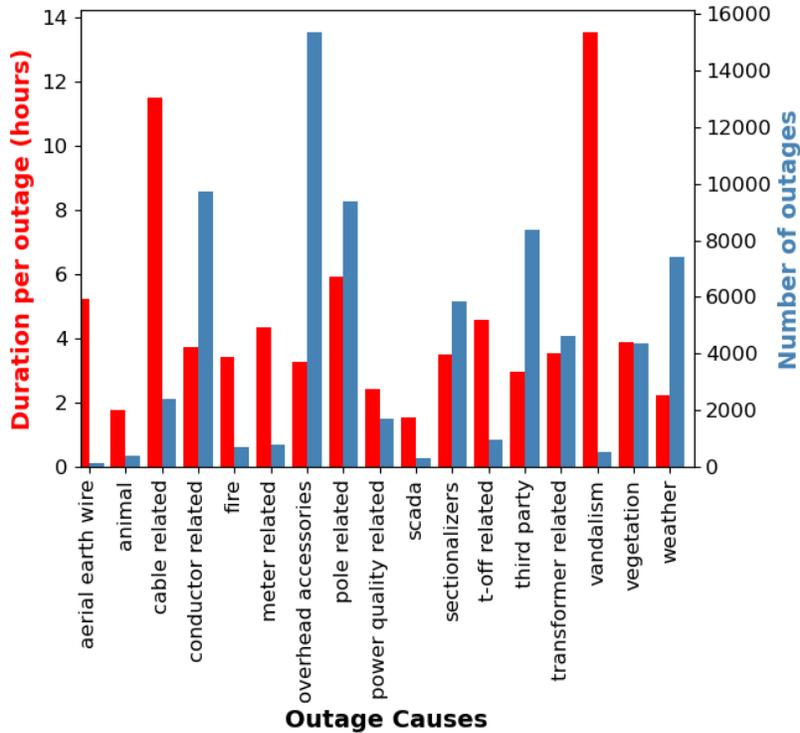
This study investigates the patterns of electricity outages throughout Uganda, analyzing daily medium-level outage data from 2015 to 2022. Additionally, it examines how rainfall affects electricity outages, emphasizing the grid's vulnerability to both regular and extreme rainfall.

Our collaboration with the Electricity Regulatory Authority in Uganda was crucial for this study. They granted us access to outage data and provided technical guidance, helping to shape the direction of our research.

### Technical Abstract:

Using data from the national electricity regulator, the study focuses on Umeme, the utility that supplies electricity to over 90% of Uganda. The study found that even though power outages are shorter now, they are happening just as often, predominantly during the day. This suggests that the primary causes are maintenance challenges and not supply constraints. The most common cause of outages is failing equipment, and outages caused by vandalism take the longest to fix. The study also found that heavy rainfall can make power outages worse, especially during the rainy season. This shows that the electricity system is sensitive to the weather.

The figure below shows the average outage durations and total outage counts by different outage causes. We use a natural language processing technique called SetFit to classify outage descriptions into broad categories that are shown in the figure below.



Title: High resolution estimates of household electricity usage as a proxy for household overall expenditure

Stakeholder: Rwanda Energy Group (REG)

**Brief summary:**

This study evaluates the effectiveness of re-purposing electricity usage data collected by utilities as a proxy for household expenditure on necessities like rent, food, water, electricity and more.

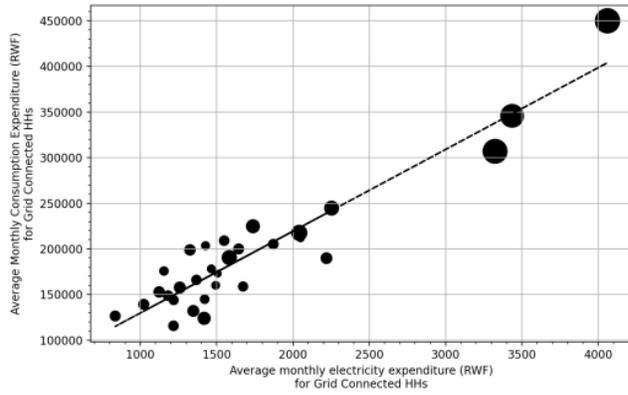
We are able to establish this relationship between electricity consumption and household economic well-being by utilizing electricity consumption data provided by the Rwanda Energy Group(REG) through our partnership.

**Technical summary:**

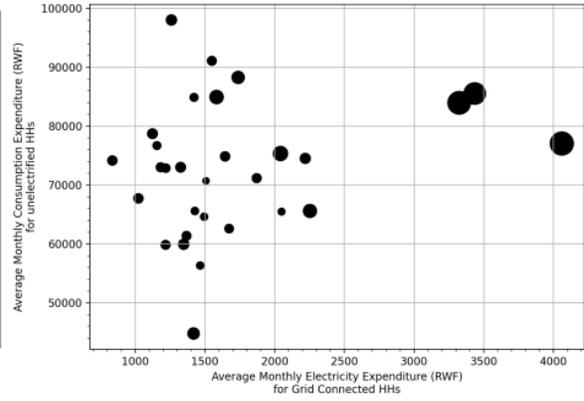
The study reveals a strong correlation between a household's electricity usage and their overall spending. Specifically, at the district level, there was a 0.4% difference in accuracy (MAPE) between the survey data and utility data. Additionally, the study introduces a method using Convolutional Neural Networks (CNNs) to predict building-level electricity consumption from image patches. Significant performance gains are observed with aggregation, where one can obtain high fidelity predictions at 1 sqkm resolution.

The figure below illustrates that electricity expenditure is highly correlated with overall household expenditure at the district level, with an adjusted R-squared value of 0.98. This

suggests that electricity consumption data can effectively serve as a proxy for overall household expenditure for grid-connected households.



(a) Grid connected (3589 households )



(b) Unelectrified (9778 households)