Quality of access to renewable energy in rural Sierra Leone

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In brief

- In Sierra Leone, just 5 percent of the population in rural areas has access to electricity.
- The United Nations Office for Project Services (UNOPS) is supporting the Government of Sierra Leone to increase access to electricity through the Rural Renewable Energy Project (RREP).
- This brief highlights the current capacity of the RREP mini-grids, their reliability, and community members' perceptions of the quality and reliability of the mini-grids.
- The average daily electricity consumption for residential users connected to the mini-grids in RREP communities, was 0.28 kWh. At the community level, the total average daily electricity consumption was 59 kWh.
- Less than 1 percent of respondents report disconnecting from the mini-grid. This number is quite low, indicating a high overall level of satisfaction.
- Most mini-grid connected respondents strongly agree (48 percent) or somewhat agree (24 percent) with that the mini-grid provided electricity is reliable.
- This brief points to policies which can improve the implementation of the RREP in Sierra Leone and elsewhere, contributing to better quality and reliability of electricity and its productive use in rural communities.

Policy motivation for research

Currently only 5 percent of the rural population in Sierra Leone has access to electricity. In areas where electricity is available, unreliable or poor-quality access to electricity may hamper the positive effects of electrification. At the macro level, it has been estimated that an increase of just one percent in outages reduces long-run GDP per capita by 2.86 percent in Sub-Saharan Africa. [1]

At the household level, if electricity outages are frequent, people may be less willing to invest in the productivity-increasing electric assets that enable the greatest economic gains from electrification.[2] If these assets are purchased, during electricity outages these assets cannot be used and productivity declines. Increasing access to reliable, quality electricity in rural Sierra Leone is a key concern to reduce poverty and achieve economic growth.

This aligns with the Government of Sierra Leone's Medium-Term National Development Plan for 2019-2023 (MTNDP), which highlights access to reliable electricity as a top priority. The United Nations Office for Project Services (UNOPS) is supporting the government in the implementation of the Rural Renewable Energy Project (RREP) project, worth over UKP40 million. This project – funded by the UK

[1] Andersen, Thomas Barnebeck, and Carl-Johan Dalgaard. 2013. "Power Outages and Economic Growth in Africa." *Energy Economics* 38 (July): 19–23. https://doi.org/10.1016/j.eneco.2013.02.016.

[2] Gertler, Paul J., Kenneth Lee, and A. Mushfiq Mobarak. 2017. "Electricity Reliability and Economic Development in Cities: A Microeconomic Perspective," December. https://escholarship.org/uc/item/96s8s43z.

Foreign, Commonwealth & Development Office (FCDO) – aims to provide access to off-grid solar electricity in up to 97 communities in Sierra Leone.

The project's implementation is being conducted in multiple phases. This policy brief brings insights from the impact evaluation of the first and second phases of the project, which provided communities across 14 districts of Sierra Leone with access to off-grid solar electricity through the construction of 97 mini-grids. This brief highlights the current capacity of the mini-grids, their reliability, and community members' perceptions of the quality and reliability of the mini-grids.

Overview of the research

The findings are based on data collected during baseline (2019) and follow-up (2021) surveys to evaluate RREP's impact on key development outcomes. To do this, a representative sample of households in communities where mini-grids have been installed was compared with a representative sample of households in statistically similar communities where no mini-grid was installed.

In total, the impact evaluation team interviewed 6,010 households across 14 of Sierra Leone's 16 districts to understand how access to electricity had impacted their livelihoods.

Key findings

Mini-grid capacity

The median kW of generation capacity installed in RREP communities is 36 kW. We see that most communities have less than 60 kW of generation capacity (87 percent).

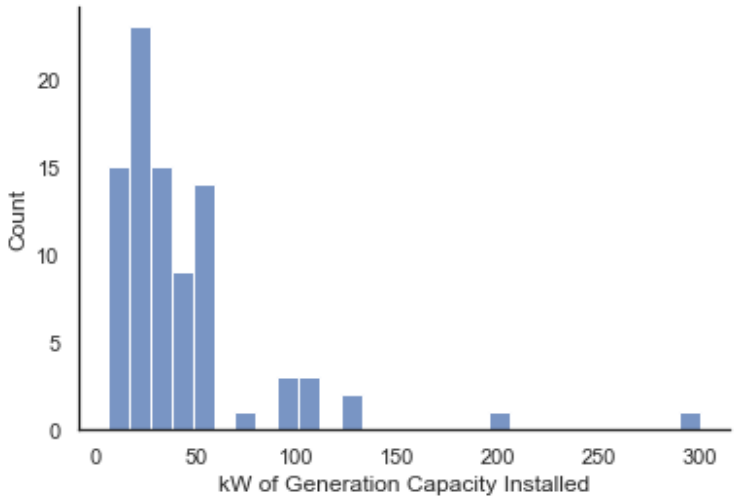


Figure 1. Generation Capacity in RREP Communities

This figure shows the distribution of the kW of generation capacity installed in the RREP communities (given the data available from the mini-grid operators). The majority of communities have a mini-grid capacity of around 60 kW or less.

The average daily electricity consumption for residential users connected to the mini-grids in RREP communities was 0.28 kWh. At the community level, the total average daily electricity consumption was 59 kWh, which is well below the generation capacity of most of the mini-grids being studied.

According to a calculation using the PV Watts Calculator, from the National Renewable Energy Laboratory, using default parameters and a location of Dakar, Senegal, a 36 kW solar array will generate 57, 393 kWh per year.[3] During the rainy season (May to November), the system generates 150 kWh per day on average. During the dry season (December to April), the system generates 170 kWh per day on average. This is above the total average daily electricity consumption of 59 kWh.

Though it is important to be aware of the timing of when large appliances are operated, so as not to over demand the mini-grids, this current estimate shows that there is, on average, enough capacity for the mini-grids to support more electric appliances than they currently support.

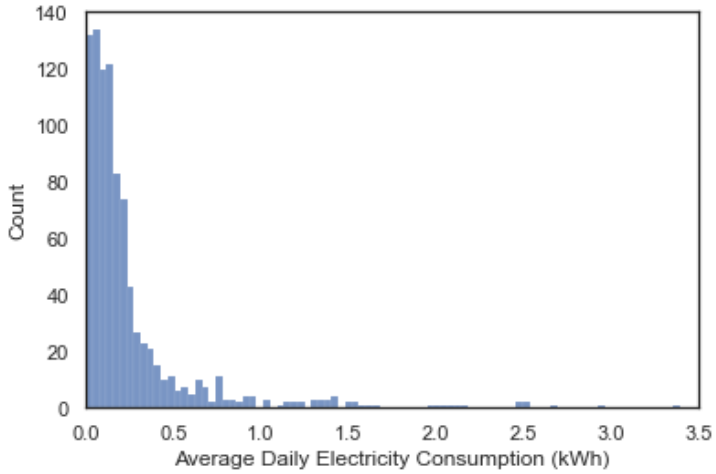
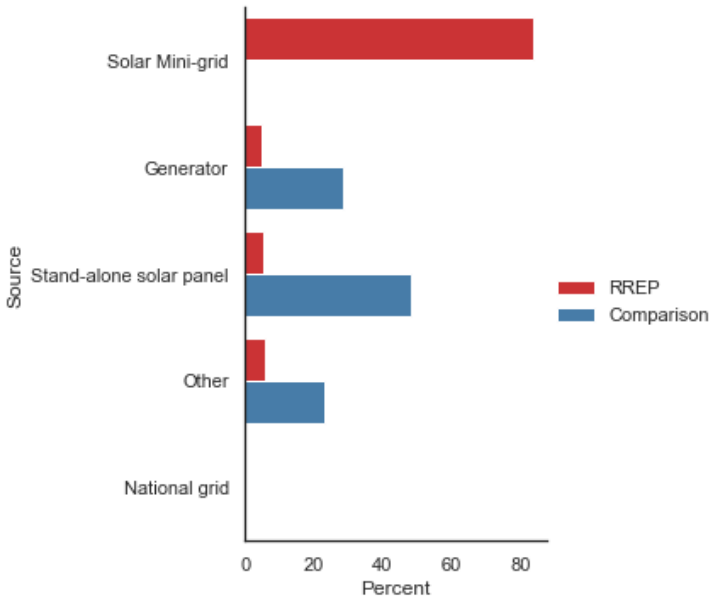


Figure 2. Average Daily Electricity Consumption (7 communities)

This figure shows the average daily electricity consumption (from the mini-grid) for households in seven RREP communities. The average daily residential electricity consumption among the seven communities is 0.28 kWh.



[3] "PVWatts Calculator." n.d. Accessed July 14, 2022. https://pvwatts.nrel.gov/pvwatts.php.

Figure 3. Source of Electricity

This figure shows the source of electricity in RREP and comparison communities at follow-up. We see that in RREP communities the solar-mini grid is the most common source of electricity (84 percent). In comparison communities, stand-alone solar panels (48 percent) and generators are most used (28 percent).

In the follow-up survey, we see that the electricity source in RREP communities is more likely to be the solar mini-grid than any other source (84 percent). Comparison communities (those without mini-grids) are far more likely to use a generator (28 percent) or stand-alone solar panel (48 percent) to generate and access electricity.

Capacity of the mini-grid to support electric appliances

Appliance	Wattage	kWh (12 hours)	Percent of average rainy season capacity
Fridge (efficient)	100	1.2	0.8
Fridge (non-efficient)	400	4.8	3.2
LED Light Bulb	10	0.12	0.08
CFL Light Bulb	14	0.168	0.112
Incandescent Light Bulb	60	0.72	0.48
Electric Ceiling Fan (efficient)	55	0.66	0.44
Electric Ceiling Fan (non-efficient)	100	1.2	0.8

Source: energyusecalculator.com

The efficiency of appliances varies greatly, based on the appliance size and other factors. An efficient fridge will use just 2.4 kWh for 24 hours of operation. On the other hand, a less efficient fridge would use 9.6 kWh for the same duration of electricity use.

The average RREP mini-grid has 36 kW of generation capacity installed, and we can estimate the system will generate 150 kWh per day, on average during the rainy season. Running one efficient fridge for 24 hours would only take 1.6 percent of the system's daily generation capacity during rainy season, while running the non-efficient fridge for 24 hours would take 6.4 percent of the capacity.

On average, the RREP mini-grids have a total of 2 fridges (.79 mini-grid connected fridges per community reported in household surveys and 1 fridge, on average, reported by each clinic). We assume these fridges run for 18 hours a day and the fridges are 250 W (mid-range efficiency).

2 fridges * 250 W * 18 hours = 9000 Wh = 9 kWh for 18 hours of use

We estimate this is a total of 9 kWh used per day due to fridge operation in the average community currently, or 6 percent of the average system's daily generation capacity during rainy season.

If we were to add 10 fridges to each community, for a total of 12 fridges per community:

12 fridges * 250 W * 18 hours = 54000 Wh = 54 kWh for 18 hours of use

This is 36 percent of average system's daily generation capacity during rainy season (150 kWh).

Disconnections from the mini-grid

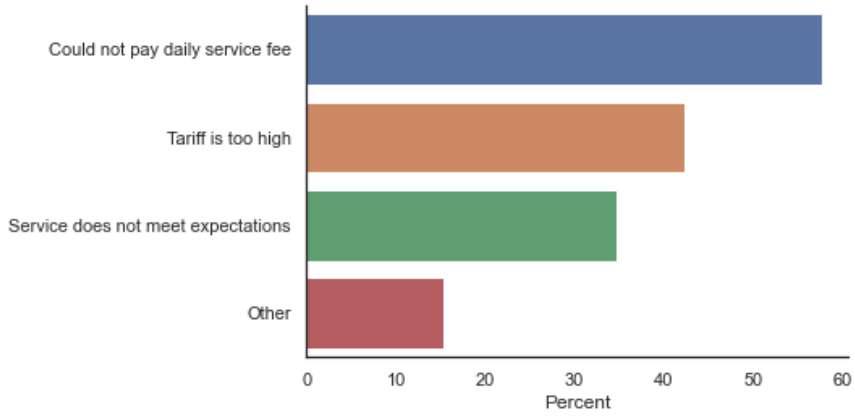


Figure 4. Reasons for Disconnecting from Mini-Grid

The most commonly cited reasons for why households disconnected from the mini-grid are because they could not pay the daily service fee (58 percent), or the tariff is too high (42 percent).

The follow-up survey showed that less than 1 percent of respondents connected to the mini-grid in RREP communities report disconnecting from their meter. This number is quite low, indicating an overall level of satisfaction.

Although the reasons for disconnecting varied, most respondents reported difficulties paying for the service being the reason they disconnected. Other respondents reported confusion in communications with the operators.

> *"I was sick and taken to Freetown, so the operators came behind me and asked to pay but I was out of the town fighting for my health and there's no one to pay so they disconnected me from the solar mini-grid."*
>
> – Malekuray Makama resident

Reliability

From operator-provided reliability data, the average percent of time operating for all of the mini-grids (with data available) was 83.75 percent. From the histogram below, it is clear that the mini-grids in most communities are operating more than 60 percent of the time. However, there are a few outliers with a lower percent of the time in operation, around 40 percent.

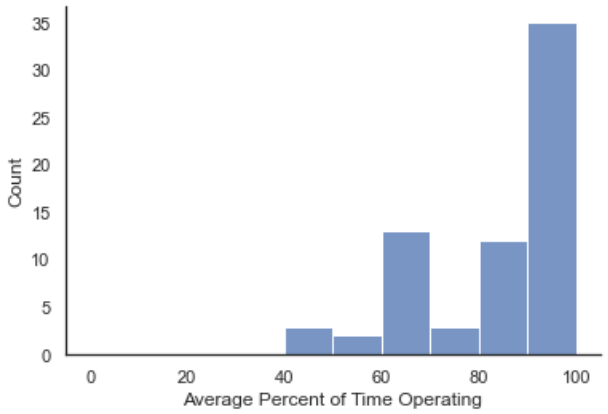


Figure 5. Average Percent of Time Mini-Grid Has Been Operating

This histogram shows the distribution of the average time that mini-grids operated since their initialization. 40 percent is the lowest average percent of time a mini-grid has been operating.

When respondents were asked to respond to the statement "The electricity from the mini-grid is reliable.", most respondents agreed or strongly agreed with this statement.

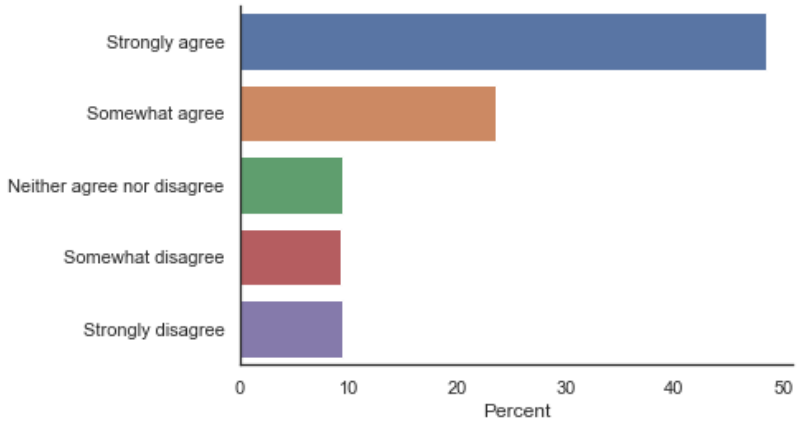


Figure 6. Perception of Electricity Reliability

This graph shows how respondents (at follow-up) respond to the statement "The electricity from the mini-grid is reliable." Most respondents strongly agree (48 percent) or somewhat agree (24 percent) with this statement.

Level of satisfaction

Among residents who were connected to the mini-grid, most respondents reported being very satisfied with the electricity connection in their communities. 43 percent of respondents stated they were very satisfied with their electricity connection, and 16 percent of respondents stated they were somewhat satisfied. 35 percent of respondents report not being satisfied with the electricity connection.

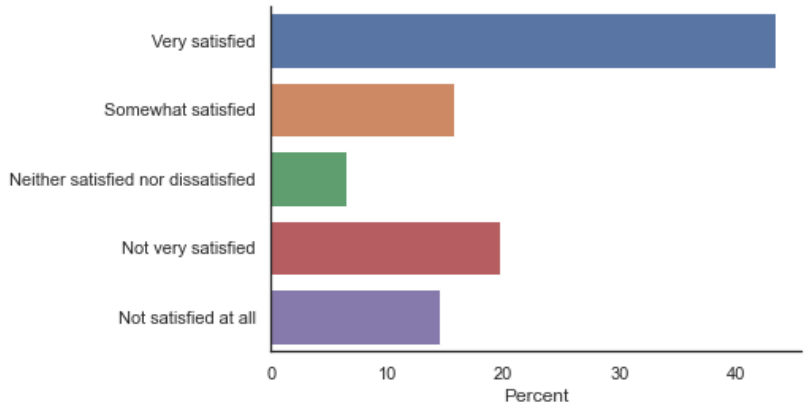


Figure 7. Satisfaction with Electricity to Connection

This graph shows how satisfied respondents (at follow-up) are with the electricity connection in their community. Most respondents report being very satisfied (43 percent) or somewhat satisfied (16 percent).

Barriers to connection

A total of 453 respondents answered the question asking about barriers to mini-grid connection. Of these 453 respondents, 322 responded with the "other" category. Many of these "other" responses indicated that there was no connection yet available in the community. Some respondents report they were not around during the registration process, and therefore were not able to connect to the mini-grid. Several respondents also report they are observing how the mini-grid works in their community first, before making the decision to connect.

> *"Those that connect are regretting, that's why we didn't connect. They pay for the lights but (there is) no light during the night. They always cry that they pay for top up they are not using."*
>
> – Konakridee resident

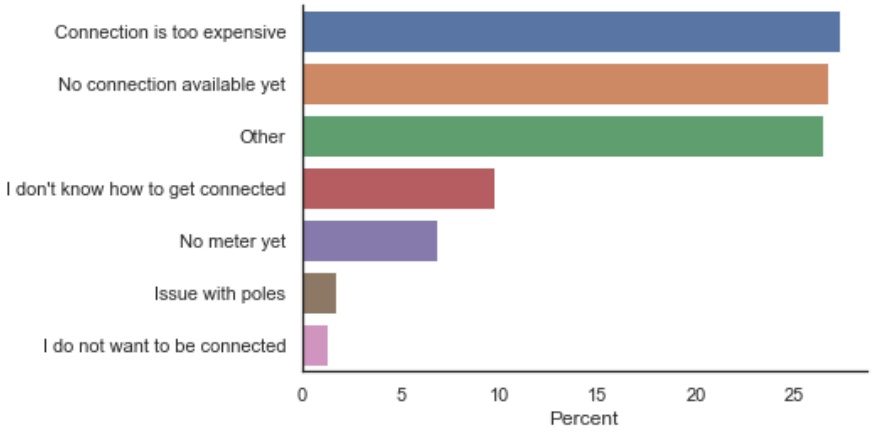


Figure 8. Reason Respondent Has Not Connected to the Mini-Grid

This graph presents the reasons that respondents say they have not yet connected to the mini-grid. The most common reasons are that the connection is too expensive, or no connection is available yet.

Among respondents who reported not wanting to connect to the mini-grid, 5 respondents said this is because they do not think the mini-grid is reliable, while 2 respondents said they do not want to connect to the mini-grid because they do not want to pay for electricity.

Reliability of agent

Respondents were asked to respond to the statement "the agent in my community is reliable to top up my electricity connection from the mini-grid." Nearly 80 percent of respondents agreed with this statement, showing a high level of trust.

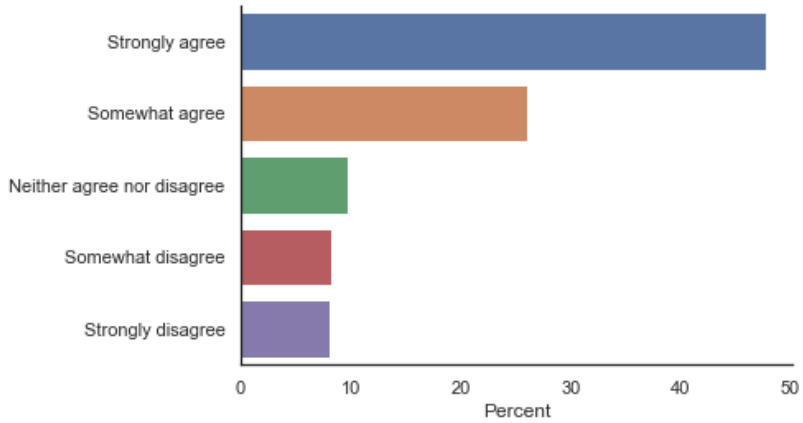


Figure 9. Reliability of Agent

This figure shows how respondents responded to the statement: "The agent in my community is reliable to top up my electricity connection from the mini-grid." Most respondents strongly agree (48 percent) or somewhat agree (26 percent) that the agent is reliable.

If the respondent were to make a complaint about the mini-grid, over 50 percent of respondents reported they would complain to the technician of the mini-grid. More than 30 percent of respondents would complain to the agent for the mini-grid.

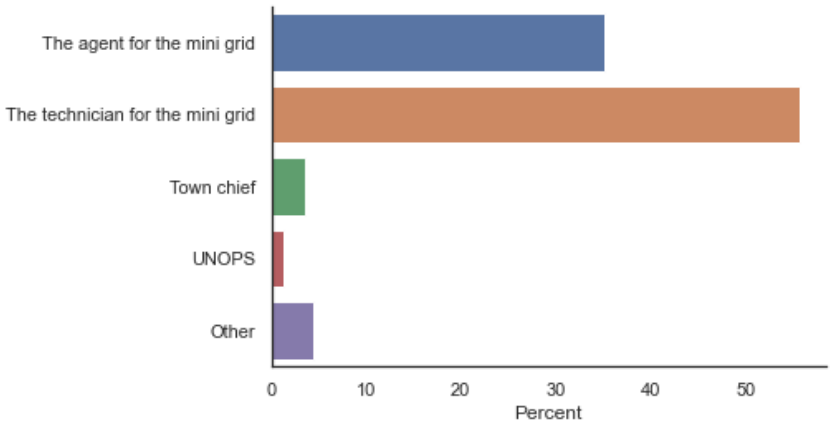


Figure 10. Who Respondents Would Complain About Mini-Grid Issues To

Most respondents report that they would go either to the technician of the mini-grid (56 percent) or the agent of the mini-grid (35 percent) to report issues.

Policy recommendations

Below are four recommendations targeted at both policymakers and UNOPS for continuation of work on the RREP and future projects.

1. **Invest in longer-term impact evaluations.** Evaluating the results of the RREP on a longer time scale will allow for more clear understanding of community perception of the mini-grids. It will also help us to understand how productive assets are being used with the electricity. The purchasing of productive assets, and the economic or health changes that result from their use, will take time.

2. **Increase electricity affordability.** Among respondents who have not yet connected to the mini-grid or who disconnected from the mini-grid, the cost of mini-grid powered electricity was the most frequent concern. Policies to increase the affordability of electricity would enable a greater number of community members to access the benefits of electrification.

3. **Increase electricity reliability.** Though the majority of RREP communities, according to operator-provided data, operate more than 60 percent of the time on average, there are some communities whose mini-grids operated for a lower percentage of time on average, even below 50 percent. Reducing the frequency of electricity outages in these communities is essential and may help encourage community members to invest in productive electric assets.

4. **Improve communication with stakeholders**. We recommend increasing the quantity and detail of communication with key stakeholders in and around RREP communities. This will ensure there are no misconceptions regarding the scope and goals of the project. In focus groups, there was confusion in RREP communities about the operators' responsibilities and the tariffs and fees for mini-grid use. Some surrounding communities also expressed disappointment because their communities were not selected for the programme. Communication will help to ease any potential future difficulties.

Acknowledgements

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Energy and Economic Growth

Applied Research Programme