Unlocking clean cooking access via Appliance Financing

Final Report

Produced by: Okra Solar Pty Ltd

For: FCDO and Loughborough University

Date: 13/12/2024

'This material has been funded by UKaid from the UK government and is implemented by the Foreign, Commonwealth and Development Office; however, the views expressed do not necessarily reflect the UK government's official policies.'

Document Control Sheet

Issue Status	Author(s)	Reviewed By	Loughborough University Approved By	Issue Date
Final version	Indranil Roy			13/12/2024
Reviewed by		Simon Batchelor	Jane Spencer	
Approved			Jane Spencer	13/01/2025

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● Executive Summary

This project, a collaboration between Okra Solar and MECS, aimed to advance clean cooking adoption in rural, off-grid Nigerian communities by integrating e-cooking appliances with Okra mesh-grid electrification systems. The initiative focused on four primary objectives:

- Electrification of 150 households using tailored energy packages (XL and M kits).
- Deployment of e-cooking appliances, including rice cookers, advanced cookstoves, and electric pressure cookers.
- Establishment of three clean cooking restaurants to demonstrate appliance use and generate community interest.
- Data collection through baseline and endline surveys, remote energy monitoring, and user feedback.

The findings demonstrate the importance of tailored approaches, highlighting how cultural practices, energy availability, and financing models influence adoption rates.

Key insights include:

- the value of community engagement
- the potential of appliance financing to bridge affordability gaps
- impact of clean cooking restaurants in promoting behavior change and generating demand.

Challenges such as high capital expenditure, supply chain constraints, and the energy demands of e-cooking were identified as critical factors for scaling similar initiatives.

This project underscores the need for innovative solutions, partnerships, and ecosystem development to accelerate the adoption of clean cooking technologies, improving health outcomes, economic opportunities, and environmental sustainability in off-grid communities.

Contents

● Introduction

The high upfront cost of e-cooking appliances poses a significant barrier to clean cooking adoption in newly electrified rural communities. In 2020, Okra Solar, in partnership with MECS, tested an interest-free appliance financing model in rural Cambodia, allowing households to pay as little as $0.10/day for a rice cooker over 340 days. This project aims to replicate and expand the study in Nigeria by electrifying 150 households across three off-grid communities, each with varying energy tariffs and packages (XL kits: 1,100Wh/day; M kits: 420Wh/day).

Households were provided with e-cooking appliances to evaluate whether increased energy availability could reduce barriers to adoption and assess community interest in transitioning to clean cooking through appliance financing. Additionally, restaurants that demonstrated clean cooking practices while functioning as appliance retailers offered valuable insights into the model's scalability and cost-effectiveness. This approach was leveraged on GIZ findings, suggesting that commercial models are more effective in fostering a clean cooking transition. The aim was to validate that a continuous, shop-based model could drive adoption more successfully than one-time enrollment initiatives.

The original project proposal with MECS was focused on the following aims:

1. **Appliance Financing in Nigeria**
   This project explores Nigerian households' willingness to adopt e-cooking appliances through Appliance Financing, providing valuable data for future clean cooking initiatives. Conducted across diverse off-grid communities, the study examines how income levels and location affect adoption. Data on energy and appliance usage will be collected remotely, alongside surveys to measure changes in fuel consumption, clean cooking adoption, and satisfaction.
2. **Energy Access and Clean Cooking Transition**
   By providing different levels of energy access, the project assesses whether greater energy availability accelerates the shift to clean cooking and reduces reliance on traditional fuels. Insights will inform future clean cooking and energy access projects, emphasizing the importance of energy access tiers in driving transitions.
3. **Clean Cooking Restaurants with Appliances for Sale**
   The project tests a commercial approach to appliance financing by setting up a 'shop' in restaurants that demonstrate clean cooking. Community members can experience familiar meals prepared with clean cooking

appliances, fostering behavior change and demand. Sales data and appliance usage will reveal whether this ongoing availability model increases adoption compared to traditional pre-sign-up models.

The project was kicked off in February 2023 with the aims described above. Throughout the implementation, there were several changes made to the original project proposal based on learnings from the communities, geopolitical factors, engagement with the Energy Access Companies (EAC's) and Okra's product development. The following study describes the learnings that resulted in the deviations from original project plan and the conclusions from the implementation of this project.

Nigeria

Nigeria has one of the largest off-grid populations in the world, with over 80 million people living without access to energy.

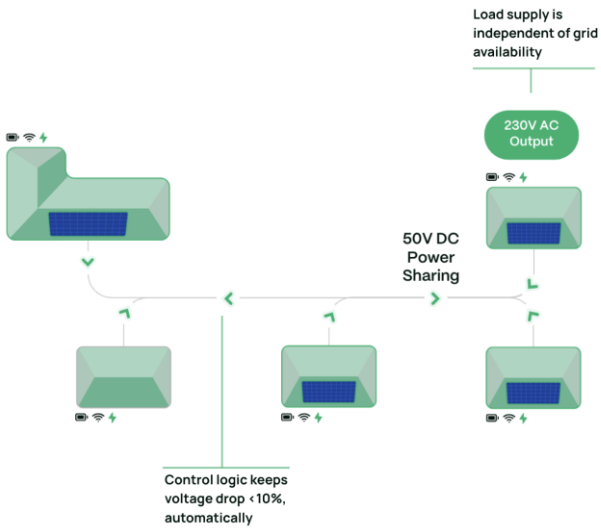
Okra mesh grids are transforming rural electrification by providing decentralized, scalable, and cost-effective energy solutions to these underserved communities. Due to the lack of available and reliable solar energy, cooking in rural Nigeria remains heavily reliant on traditional biomass fuels such as firewood and charcoal, which are deeply ingrained in cultural habits but pose significant health and environmental risks. E-cooking adoption in these areas is still in its early stages, held back by factors such as the high cost of appliances, limited awareness of their benefits, and cultural preferences for traditional cooking methods.

With the rapid growth in off-grid electrification investments encouraging private sector development of energy access solutions, targeted initiatives around

appliance financing and community engagement for PUE and e-cooking are emerging.

Okra Solar

Okra Solar expanded to Nigeria in 2021 with the aim of energising the offgrid population in Nigeria. This advances Okra's mission of unlocking opportunities through energy access. Building on the learnings from Cambodia, the Nigerian off-grid sector required Okra to adapt and refine its product to meet the unique needs and challenges of the sector, ensuring a more tailored and impactful approach.



These mesh-grids provide 1.2kW of power to every node in the mesh/ every household at as little as 50% of the cost of an equivalent traditional or centralised mini-grid. In addition, Okra has developed a lower-cost configuration of mesh grids known as Hub and Spokes to further reduce CAPEX while still providing sufficient energy access to households to power their needs. This was required as EACs were deploying systems that were oversized and the load growth of the households were not growing to the forecast levels. This reduced the sustainability of the project preventing further growth that would energise more communities. With these learnings, Okra defined 3 segments of users based on power and energy demands:

- Consumer:
  - Requiring up to 150W instantaneous power
  - Compatible with phone charging, lights, fans, LED TVs and small appliances with a max rating of 150W
  - Consuming up to 200wh of energy per day
  - Make up 70% of Okra users
- Prosumer:
  - Requiring up to 1.2kW instantaneous power
  - Compatible with fridge, freezers, kettles, blenders, speakers, larger appliances with a max rating of 1.2kW
  - Consuming up to 2.5kWh per day
  - Make up 27% of Okra users

- Commercial:
    - Requiring up to 3.6kW instantaneous power
    - Compatible with micromills, induction cookstoves, EPCs, water pumps, commercial PUEs
    - Consuming up to 8kWh per day
    - Make up 3% of Okra users

This study is an opportunity to investigate the correlation between Okra's affordable electrification technology, Nigeria's customer segments and clean cooking adoption.

● Methodology

Community Engagement

In depth surveys and community engagement with live demonstrations was performed to help us answer the following questions:

- What are the favourite foods that the community likes cooking?
- How do they like cooking it?
- How much fuel is consumed to prepare these meals?
- What equipment can be provided to make that cooking process less biomass dependant?
- What is the plan to train them how to use that equipment?

We were able to complete surveys in three communities - One community in the central Region of Nigeria (A Muslim Dominant Community) and two in the southern Regions (A Christian Dominant Community).

EAC	Community Name	GPS coordinate	Surveyed by
First Electric	Igbobini	6.510658, 4.819399	Okra solar
First Electric	Abababubu	7.094813, 5.010378	Okra Solar
Engie Energy Access	Nuwankosoma	9.353918, 6.125356	Okra Solar
Pam Africa	Ikoyi	7.344354, 4.170734	EAC
Creeds Energy	Bassa	8.6144743,9.2900969	EAC

We do not have any survey data on the selection criteria for the communities surveyed by the EAC.

We formally kicked off working on the project in Feb 2023, which unfortunately coincided with the Nigerian Primary and Local Government elections. During this

time, our team was advised that they should not go into the rural parts of the country for fear of potential terrorist activities.

This caused about a 45-day delay between our planned start date for completing baseline surveys. This presented a major blocker for completing Milestone 1 - Getting granular data on Affordability and Appliance interest.

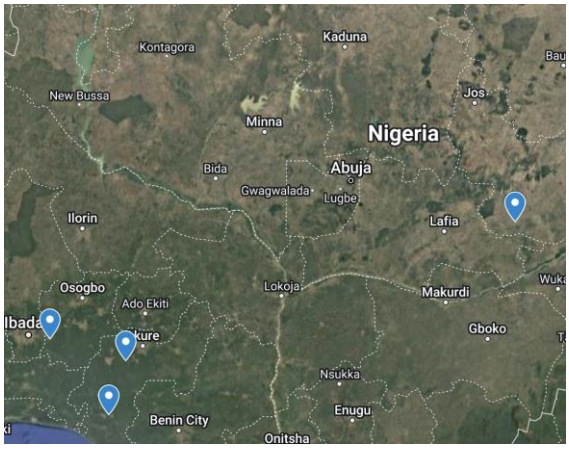
Site Selection

In February 2022, following the receipt of purchase orders from other projects, Okra decided to pre-purchase clean cooking appliances and energy equipment required for Milestone 2—establishing restaurants and community cooking co-ops. This strategic step aimed to generate demand and raise awareness around clean cooking. These locations were specifically chosen to serve as pilot sites for the implementation of clean cooking initiatives.

The site selection process was determined by evaluating several datapoints. The information evaluated was:

- Total # of hh in community
- Current and forecasted energy consumption
- Results from baseline survey
- EAC funding sources for scale-up
- EAC pipeline of communities to energise over the next 24 months

As community electrification is part of the study, the selected communities would be energised, and 3 clean cooking restaurants would be deployed in these 3 communities.



This involved:

- Energising 150 households with Okra mesh grid systems
- Setting up 3 clean cooking restaurants.

Further details on the 3 communities are found in the Results section.

Data Collection

Throughout the study, 2 formal surveys were conducted:

1. Open-ended baseline survey at the start of the project prior to any deployments;
2. Open-ended endline survey at the end of the project after all the equipment had been running for several months.

Baseline surveys were conducted by Okra staff on the ground in the communities.

Endline surveys were conducted by the community engagement officers who are community members employed by the EAC.

Survey questionnaires were constructed to be easy to understand and gather as much contextual information as possible from the communities. Surveys were conducted using Fulcrum to enable offline data collection due to intermittent connectivity in rural areas. Interviewers were trained to use the app and ask probing questions to extract more information from those being surveyed.

After implementation, data on their energy consumption trends are collected using Harvest, Okra Solar's remote monitoring platform that stores granular information about the solar generation assets. This enabled a deeper analysis of the users habits by analysing different timefilters for usage of the e-cooking appliances. Particular timefilters include:

- Prior to supply of e-cooking appliances
- 1 month after provision of e-cooking appliances
- 6 months after provision of e-cooking appliances
- Daily energy consumption to identify peak usage of appliances

These 3 data points will demonstrate the impact of e-cooking appliance adoption on key metrics:

- Average Consumption Per User (ACPU)
- Average Revenue Per User (ARPU)
- Repayments of appliances

This data is discussed in the following sections.

• Results

Survey Results

As part of the study, 2 surveys were undertaken throughout the study period. Baseline survey on 04/2023 and endline survey on 08/2024. The section below details the results of these surveys.

Baseline survey results

The baseline survey provided the following results:

Total Surveys **19**

Demographic Overview						
	Average	Median		Max	Min	
Number of People in the house?	7.9	8		15	2	
Number of Children under 10 in the house?	3.4	3		12	0	
Number of Teenagers in the house?	1.5	1		5	0	
Age of Oldest Person in the house?	56.9	56		90	38	
Number of Females in the house?	4	4		10	1	
Number of Males in the house?	3.9	3		11	1	

Energy Demographic	
# HH surveyed with electricity	17
# HH surveyed without electricity	2

Commercial Activities	
# HH surveyed with commercial activities	8
# HH surveyed no commercial activities	11

Food Source	
Local Shop	10
Shop in local town (10Km away)	17
Self Grown	1
Far away town	1

Commercial Activity	
Agro Processing	2
Convenience Store	3
Tailor	1
Restaurant	1

How many people do you cook for?				
Average	Median	Max	Min	
13.7	9	80	2	
Average Amount of rice based meal per week		4.7		
Average Amount of Soup Meals per week		4.5		

Food Staple	
Swallow	10
Rice	8
Beans and Yam	1
Swallow Varients	
Cassawa Flakes	13
Eba	4
Eba	4

How do you cook meals?	Total	Percentage
I have a cooking appliance	9	47.37%
Open Fire	14	73.68%
I have an advanced cookstove	2	10.53%

How long does it take for you to prepare a single meal?			
Average	Median	Max	
2.421052632	2	7	

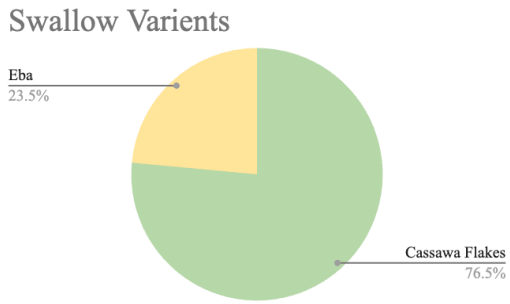
What do you use for fuel?	
Wood	9
Where do you get your Wood From	
Local Store	4
I chop it myself	4

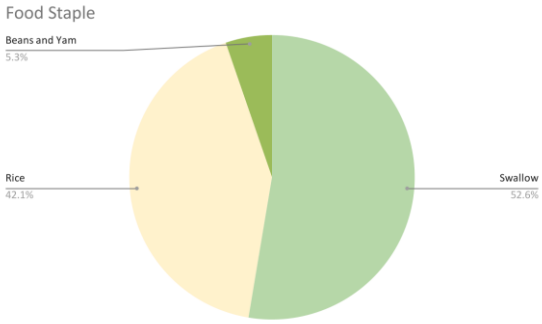
How often do you Generate Income	
Weekly	6
Monthly	9
Seasonally	3

Affordability	Total	Percentage
Can afford to pay 200 Naira per day	14	73.68%
Cannot afford to pay 200 Naira per day	5	26.32%

Interest	Total	Percentage
Wants to switch to Clean Cooking	16	84.21%

The data above informed us of the interest in e-cooking appliances in the surveyed community. The data collected around the food staples were also indicative of the type of e-cooking appliances that will meet their needs.





Endline survey results

In August 2024, endline surveys were conducted with 3 beneficiaries of clean cooking appliances.

Surveys were also conducted of community members in the community that were not provided with e-cooking appliances to gauge their perception and interest in e-cooking. All endline surveys were conducted by community engagement officers of the EAC's.

The results are summarised below.

Beneficiaries of clean cooking appliances

Below are the beneficiaries interviewed with clean cooking appliances. Due to coordination issues, we were only able to interview 4 beneficiaries:

Energy Developer	Community	Participant name	Appliances provided
First Electric	Igbobini, Ondo state	Faith Ototakovi *Clean cooking restaurant*	Hotplate, Electric pressure cooker, Kettle

Creeds Energy	Jos, Plateau state	Clement Dalang *Clean cooking restaurant*	Electric pressure cooker, hotplate, rice cooker, kettle
Engie energy access	Nuwankosoma, Niger state	Mamman Ndamina	Rice cooker

Due to challenging circumstances, we were unable to survey the clean cooking kitchen deployed with Pamafrica in Ikoyi, Ogun state and the other recipients of the clean cookstoves and rice cookers were not available during the survey period.

The survey responses are summarised in the table below:

Question	Clement dalang	Faith	Mamman
how_often_do_you_use_the_cooking_appliances	Alway	Twice daily	Not frequent
how_easy_is_it_to_use_the_clean_cooking_appliance	6	8	1
have_you_experience_any_technical_issues_with_appliances	no	yes	no
how_easy_is_it_to_maintain_and_clean_the_appliances	Very easy	easy	Very easy
would_you_go_back_to_using_your_previous_cooking_methods	no	no	yes
other_notes_food_ingrients	Because it reduces costs	Smokes from the open fire is already affecting my sight. But with this, I don't feel the pains as much again.	Its costly to maintain
how_have_your_fuel_costs_changed_since_these_appliances	Decreased	Decreased	Decreased
how_much_time_do_you_save_on_cooking_now	2	2 hours of time is saved	3
what_do_you_do_with_this_free_time	Not	Attending to customers. Also, I'm able to rest more.	N0
how_much_has_appliance_reduced_smoke_in_house	6	10	2
are_you_selling_more_meals_than_before	yes	no	no

why	Because am not using firewood again	Spending ability of the people has reduced because of the economic situation of the country.	Since it's not commercial it is used mainly for my family
how_many_meals_do_you_sell_per_day	50	30	0
how_satisfied_are_you_with_the_appliances	9	10	10
what_other_appliances_do_you_need	TV, pot, fan electric cooker		Because I enjoy using it
what_else_do_you_want_to_do_to_increase_business	to make the products available	Adding an freezer so as to start selling beer	The capacity of the product supply needed to be increase

Non-beneficiaries of clean cooking appliances

In addition to the beneficiaries, 24 community members were interviewed to understand the impact of the introduction of clean cooking appliances for non-beneficiaries.

We were able to interview:

- 4 participants in Nuwankosoma, Niger state (community where e-cooking appliances were demonstrated and distributed)
- 10 participants in Jos, Plateau state (community with clean cooking restaurant)
- 10 participants in Igbobini, Ondo state (community with clean cooking restaurant)

Demographic data is in the tables below:

Total # of surveys	**24**	
Cooking methods	**Total**	**Percentage**
Firewood	12	50.00%
Open fire	3	12.50%
Gas	3	12.50%
Firewood and charcoal stove	1	4.17%
Gas and open fire	3	12.50%

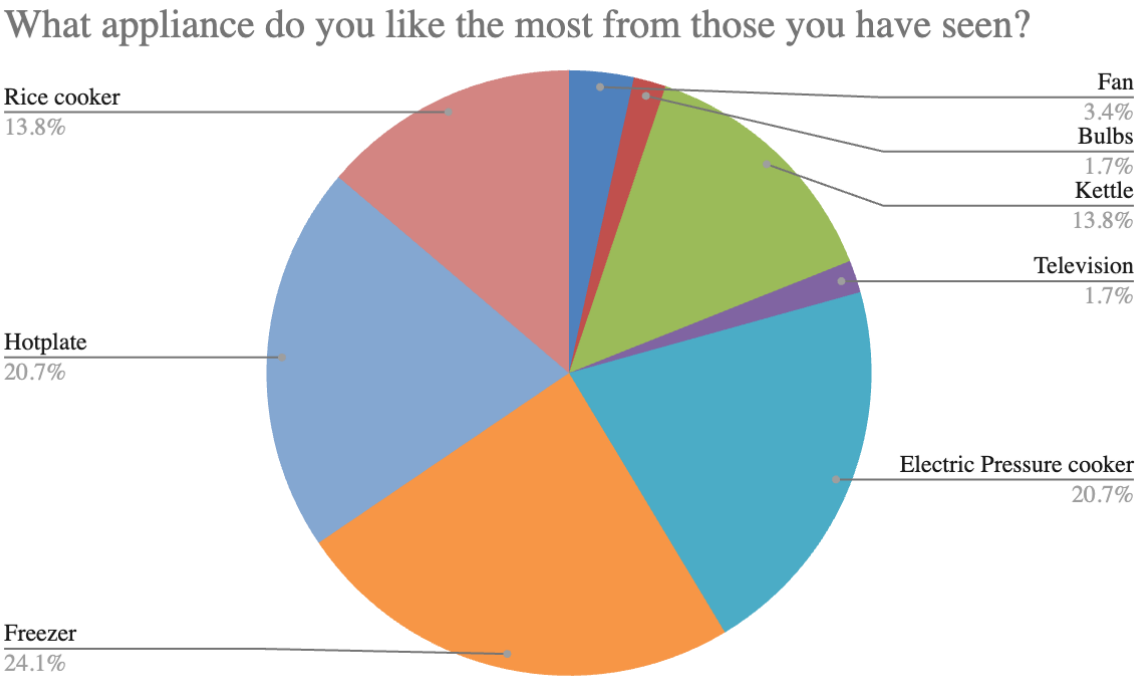
Number of hours spent cooking		
Average	**Max**	**Minimum**
3.75	7	2

2 hours	6
3 hours	8
4 hours	2
5 hours	3
6 hours	4
7 hours	1

How much money spent on cooking fuel now	
Range in Naira	**Frequency**
0	2
>0 & <5000	5
>5000 & <=10000	4
>10000 & <=20000	6
>20000 & <=30000	5
>30000 & <=40000	2

How concerned are you about the environmental impact of cooking	
Response	**Frequency**
Not concerned	7
Slightly concerned	5
Moderately concerned	5
Very concerned	7

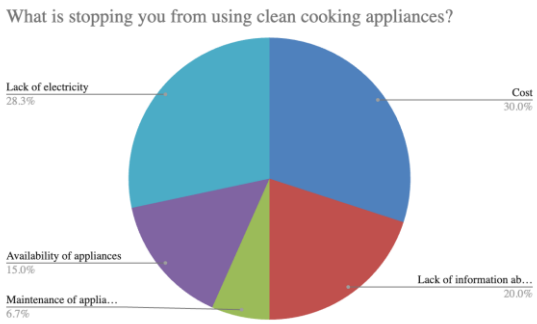
The chart below shows the demand for appliances from respondents. All appliances below are those that are already in the community or were demonstrated in the community as part of this study.

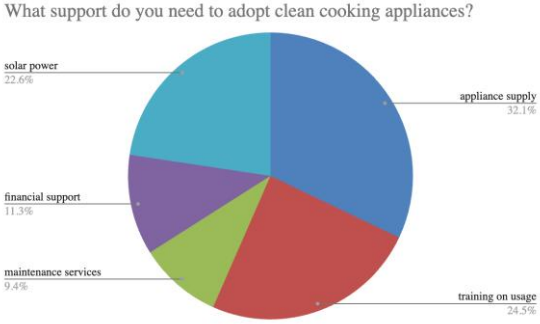


Respondents were also asked for their preferred payment methods of appliances.

How would you like to pay for clean cooking appliances	
Upfront payment	5
Installments	19

To understand the respondents' hurdles in clean cooking adoption, they were asked more open-ended questions. The charts below attempt to capture the sentiment that the surveyor gathered during the interviews.





The results will be analysed further in the following section.

Community electrification

Based on the survey results, the following communities were provided with okra mesh grids:

EAC	Community Name	# of households	Kit size	Date of commission	GPS coordinate
Creeds Energy	Bassa	50	M kit (0.42kWh/day)	August 2022	8.6144743,9.2900969
First Electric	Abababubu	25	XL kit (1.1kWh/day)	November 2022	7.094813, 5.010378
First Electric	Igbobini	25	XL kit (1.1kWh/day)	March 2023	6.510658, 4.819399
Pam Africa	Ikoyi	50	XL kit (1.1kWh/day)	October 2023	7.344354, 4.170734
	Total hhs	**150**			

All of the above households were deployed between February 2022 and October 2023. Since deployment of these systems, the EACs have also updated their tariffs over time. This change of tariff could be due to several factors such as:

- Feedback from community
- Feedback from EAC's investors
- Currency devaluation
- Change in EAC business model
- New information about income levels in community

Okra does not have any data on the specific reasons behind the tariff changes as these were done by the EAC at their discretion on the Harvest platform. All of the tariffs shown are valid as of November 2024.

First Electric

First Electric received financial support from this study for the purchase of 50 XL kits. They deployed 25 kits in Abababubu and 25 kits in Igbobini - both communities in Ondo state within close proximity of each other.

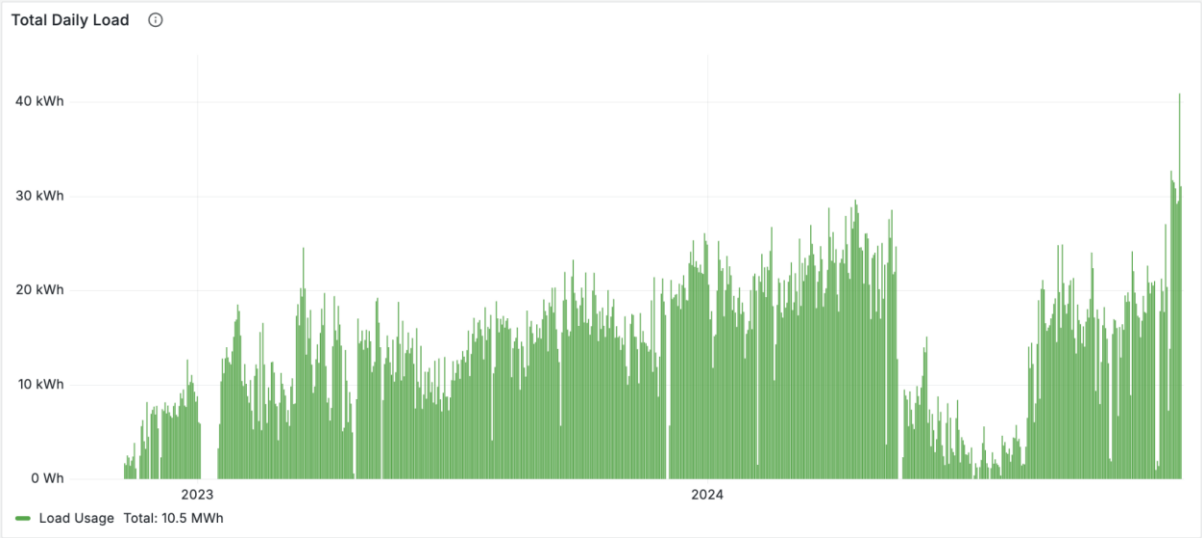
Map picture of community showing connections

Abababubu

Total # of connections	91
# of Kits breakdown	XL kits: 26 Spoke kits: 65
Configuration in community	10 XL kits are standalone 16 XL kits and 65 spoke kits are connected in Hub and Spoke configuration. H:S ratio of 1:4.
Energy Packages	XL kits: 2700Wh Spoke: 2700Wh
Tariffs charged	XL kits: ₦350/kWh Spoke kit: ₦150/day
Monthly ARPU *(last 12 months)*	₦1679.5
Daily ACPU *(last 12 months)*	701 Wh

In addition to the 25 XL kits funded by this study, First Electric purchased 1 XL kit and 65 spoke kits in addition to meet the community demands for electrification. It was found that the XL kits were not being utilised to their full potential, so they decided to energise more households in the community by installing spokes providing up to 200Wh/day.

The chart below shows the Total Daily Load of Ababubu from deployment until today (December 2024). Total Daily Load is the *Total energy consumption over the entire village, per day.*



Igbobini

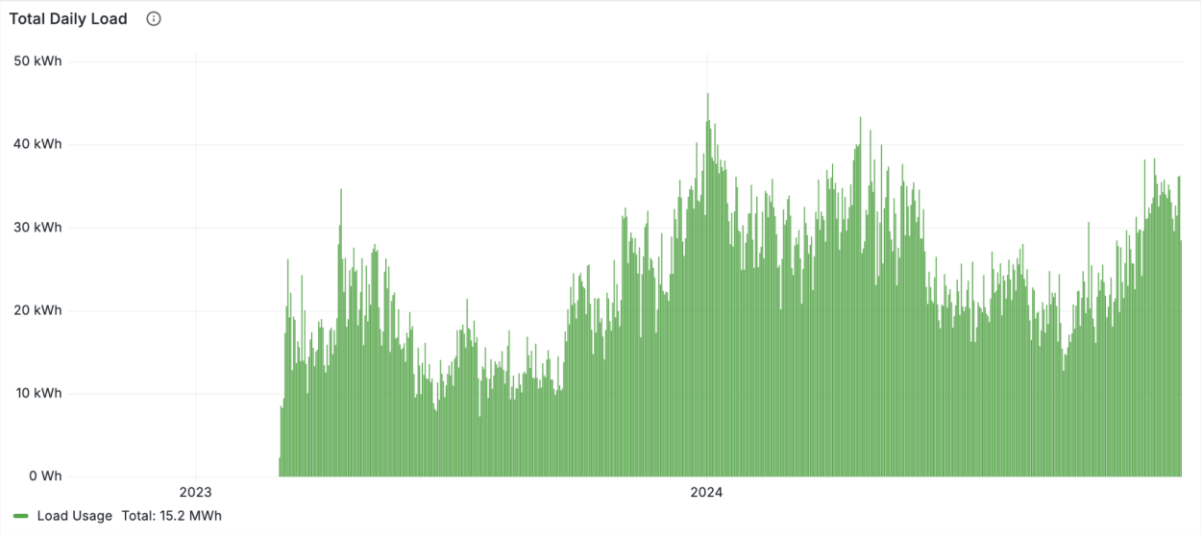
Total # of connections	26
# of Kits breakdown	XL kits: 25 3-stacked kit: 1
Configuration in community	All XL kits are standalone 3-stacked kit is powering a clean cooking restaurant
Energy Packages	XL kits: 2700Wh Spoke: 2700Wh Clean cooking restaurant: 7500Wh
Tariffs charged	XL kits: ₦350/kWh Spoke kits: ₦150/day Clean cooking restaurant: ₦184/day
Monthly ARPU *(last 12 months)*	₦8530.65
Daily ACPU *(last 12 months)*	1177 Wh

In addition to the 25 XL kits funded by this study, 1 clean cooking kitchen using a 3 stacked Okra kit was deployed in this community.

First Electric is using a mix of kWh and daily tariff in their project. They are also allowing their users to use the maximum amount of energy available to them.

Note: XL kits are designed with 2 days of autonomy hence Okra has rated them to 1.1kWh energy availability. If the EAC does not require this buffer, they can enable maximum consumption by setting the package sizes to be higher.

The chart below shows the Total Daily Load of Igbobini from deployment until today(December 2024). Total Daily Load is the *Total energy consumption over the entire village, per day.*



Pamafrica

Map picture of community showing connections

Total # of connections	107
# of Kits breakdown	XL kits: 60 Spoke kits: 47
Configuration in community	45 XL kits are standalone 15 XL kits and 47 spoke kits are connected in Hub and Spoke configuration. H:S ratio of 1:3.
Energy Packages	XL kits: 2400Wh Spoke kit: 200Wh

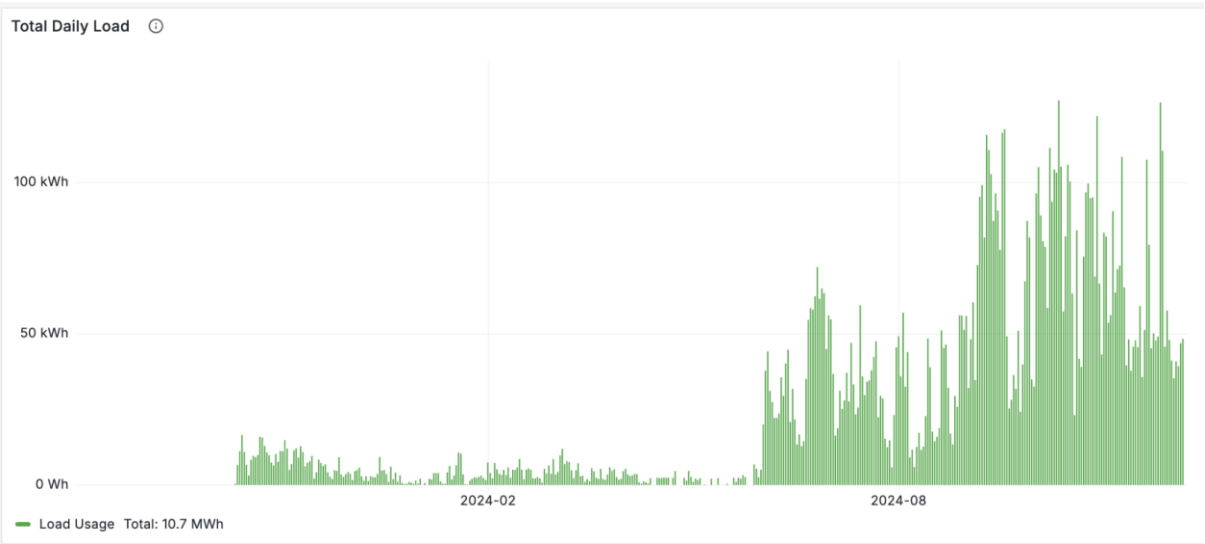
	Clean cooking restaurant: 4800Wh
Tariffs charged	XL kits: ₦1000/kWh Spoke kit:₦1000/kWh Clean cooking restaurant: ₦1000/day
Monthly ARPU *(last 12 months)*	₦6778.9
Daily ACPU *(last 12 months)*	735 Wh

In addition to the 50 XL kits funded by this study, Pamafrica purchased an additional 10 XL kits and 47 spoke kits to increase energy access in Ikoyi.

A clean cooking restaurant was also deployed by Pamafrica in the same community

Pamafrica is charging a mix of kWh and daily tariffs in this community. Some of the XL kits deployed with Pamafrica are also being used with their SoCool product that provides cold storage as a business for community members.More information can be found on their website here.

The chart below shows the Total Daily Load of Ikoyi from deployment until today (December 2024). Total Daily Load is the *Total energy consumption over the entire village, per day.*



Creeds Energy

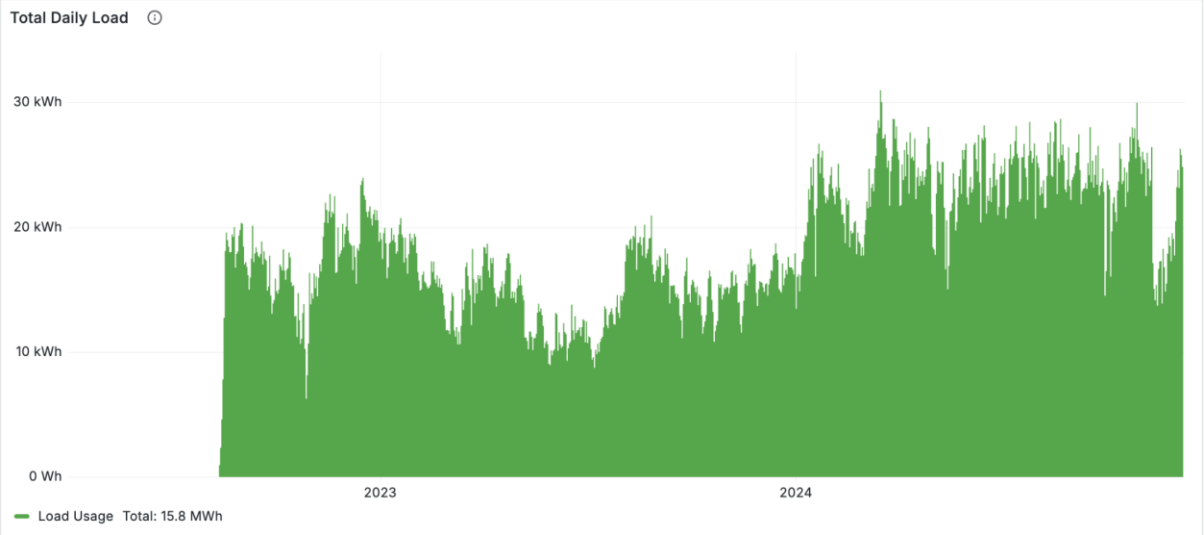
Map picture of community showing connections

Total # of connections	65
# of Kits breakdown	M kits: 54 Spoke kits: 65 3 stacked kit: 1
Configuration in community	45xM kits are standalone 9xM kits and 11 spoke kits are connected in a mixed Hub and Spoke configuration. H:S ratio of 1:2 or 1:1
Energy Packages	M kit: 500Wh Spoke kit: 500Wh
Tariffs charged	M kit: ₦200/day Spoke kit: ₦200/day
Monthly ARPU *(last 12 months)*	₦5808.58
Daily ACPU *(last 12 months)*	393 Wh

In addition to the 50 M kits funded by this study, Creeds energy purchased additional 9 M kits and 11 spoke kits to meet the community demands for electrification. Since the start of this study, Creeds energy has scaled up their electrification across the country to 1100 households across 6 states.

A clean cooking restaurant was also deployed by Creeds in a neighbouring community as part of this study.

The chart below shows the Total Daily Load of Igbobini from deployment until today (December 2024). Total Daily Load is the *Total energy consumption over the entire village, per day.*



E-cooking appliance testing and supply

From the survey data, we determined the types of appliances that communities will be interested in purchasing. We then sourced several of these appliances to test in our labs in Shenzhen, China to evaluate compatibility, functionality, and price.

Cooking appliances tested:

1. Advanced cookstoves
2. Induction cookstoves
3. Kettle
4. Electric Pressure cooker
5. Rice cooker

The results of testing the rice cooker and electric pressure cooker are detailed below:

Electric Pressure Cooker (EPC)

The results of the 2 variants of EPCs tested in our labs are shown below.

Supplier name	DH	Hotor
Item	EPC	EPC
product image		
volume	6L	6L
Power consumption	1000W	1000W
Power consumption by Pod test	1102W tested by Desmond	1220W max
Main materials of outer side	metal+plastic	plastic
net weight	4381g	4627.8g
cooking time	24minutes	18 minutes
Easy to be operated or not	yes, 2 indictor lights	yes, with 3 indicator lights which is obvious
safety	uper cover with metal part which is very hot, kids may get hurt	plastic case so not too hot
Other comments	lid rotation and pressure indication looks correct and easy to operate	indication on lid is a little bit confusing

Rice cooker

The results of the 2 variants of rice cookers tested in our labs are shown below.

Supplier name	DH	Hotor
Item	Rice cooker - Drum type	Rice cooker - similar to EPC type
product image		
volume	5.6L, bigger volume	5L
Power consumption	1000W	900W
Power consumption by Pod test	1180W tested by Desmond	around 1200W tested by Desmond. Everytime the test was stopped so we guess that the power consumption should have exceeded our system max. load.
Main materials of outer side	metal	plastic
net weight	1852g	3284g
cooking time	18 minutes	30minutes
Easy to be operated or not	yes	yes
mechanical structure	metal + has screw on bottom to fix which is reliable	plastic hook to combine body and bottom cover, which is not reliable, easy to be open and see the circuit and cables directly, easy to get opened during transportation in Nigeria

bottom structure image		
safety	very hot on the metal cover, user can get scalded easily	plastic cover, not too hot on the surface
Other comments	DH produced 3.2L rice cooker of similar type for LG group in south Korea, and also, they provide BS plug with sample quickly so they should have British clients	Need 1 week to get BS charger sample, very few international orders? not strong enough as when i receive the sample, the bottom plastic part gets departured and the internal wires and boards can be seen and touched easily.

These appliances were shipped to Nigeria to be deployed in 3 clean cooking restaurants. These clean cooking restaurants were used to showcase these appliances to the wider community and garner interest in individual appliance financing.

In parallel, Okra Solar was working with the suppliers to ensure they will be able to supply the quantities of appliances funded by this study. Several roadblocks were faced at this stage, and this is detailed in the Analysis section of this report.

Supply of appliances

The results from appliance testing and the baseline surveys provided us with the information required to source the appliances. Several challenges were faced in this regard:

- The timeline of the project would be extended as equipment would arrive in the country by March 2024 as sea freight takes significantly longer and this would have delayed deployment into June 2024.The primary driver of this difference stems from logistic complications involved with Nigeria. In

Cambodia we were able to get equipment from China into Cambodia in 45 days, whereas it takes around 120 days to sea freight equipment to Nigeria.

- The suppliers of appliances in China require minimum order quantities of at least a full container load. This was a major hurdle in sourcing this equipment from China. This would require significant financial resources and ability to distribute a full container load of rice cookers, EPCs and induction cookstoves if we were to procure this. *(enter MOQ quantities)*
- As the project was designed to supply appliances to existing communities powered by mesh grids,this limited the load rating of compatible clean cooking appliances that could be supplied. First Electric and Pamafrica communities had a maximum of 1.2kW load output, Creeds energy community had a maximum of 600W load output. This meant that any appliances exceeding this load rating would require additional Okra kits to power the appliances. Okra did testing to source appliances that would fit within these constraints.

The workaround we had was to order sample quantities and ship them via air freight to meet timeline and budget constraints. These appliances were used for training workshops in the communities.

Beneficiary testing an EPC, testing advanced cookstove (right)

Households with e-cooking appliances

The deployment included providing 3 rice cookers and 2 advanced cookstoves to beneficiaries in one community. The beneficiaries are below:

Customer ID	Customer Name	Okar Kit Size	Appliance Type	Date provided
NK-004	Abu Mathew	XL Kit(up to	Advanced	December

		1100Wh/day)	Cookstove	2023
NK-085	Aisha Abubakar	S Kit(up to 200Wh/day)	Advances Cookstove	December 2023
NK-037	Clement Okemiri	XL Kit(up to 1100Wh/day)	Rice Cookers	December 2023
NK-076	Mamman Ndaminna	XL Kit(up to 1100Wh/day)	Rice Cookers	December 2023
NK-082	Danladi Abubakar	S Kit(up to 200Wh/day)	Rice Cooker	December 2023

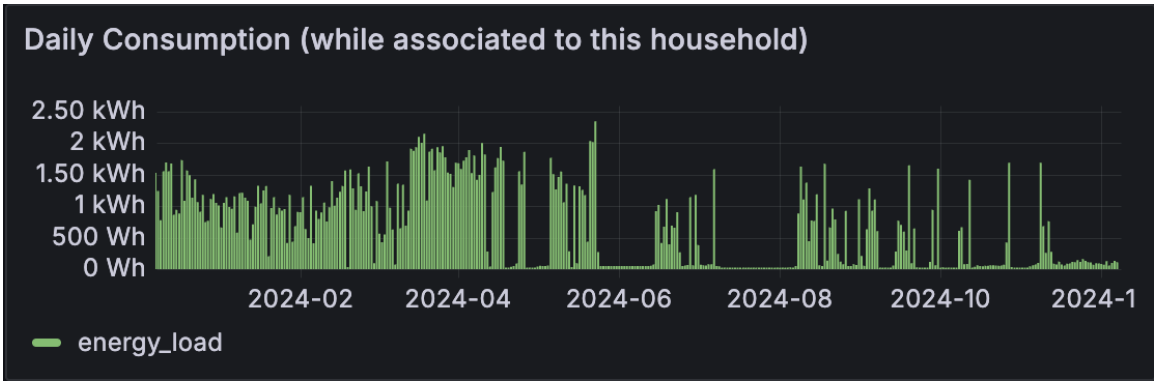
The way mesh-grids are designed is lean, giving users the amount of power output they need and then modularly scaling them as their demand grows. This is great for optimizing cost but also means that households generally start with low power availability.

Most cooking appliances require more than 1 kW of power input, however the majority of households on this site were limited to 600W power availability.
Thus, Advanced Cookstoves were supplied, which are stoves that use small pieces of wood or agricultural byproducts as fuel, assisted by a small 15W fan at the bottom powered by electricity. The fan increases the burn temperature and efficiency of the fuel used.

The charts below show the daily energy usage of each of the users provided with the e-cooking appliances. These results are discussed in further detail in the next section - Analysis of Results and Learning.

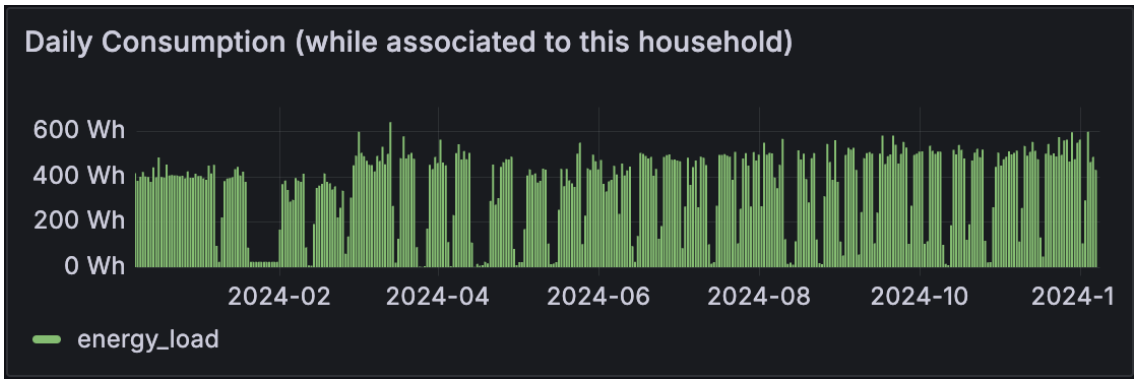
NK-004: Abu Mathew w/ Advanced Cookstove

Metric	Prior to e-cooking supply	1 month after e-cooking supply	6 months after e-cooking supply
Monthly ARPU (Naira)	₦4188	₦4985.8	₦2233



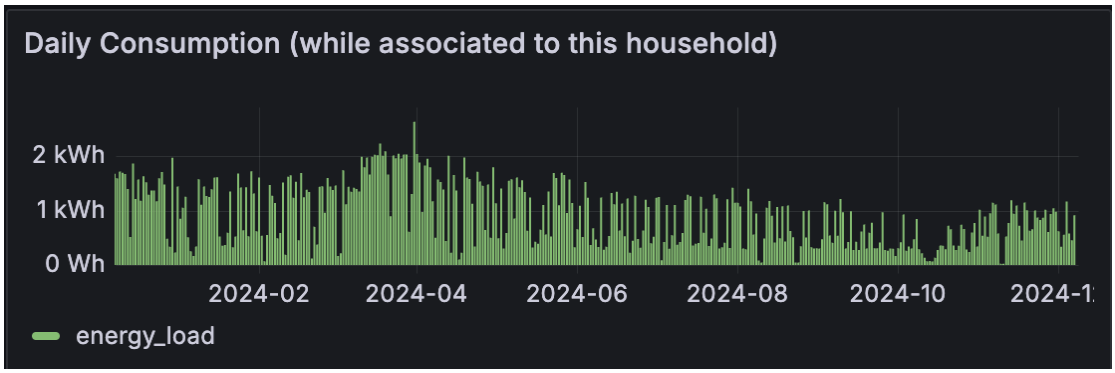
NK-085: Aisha Abubakar w/ Advance Cookstove

Metric	Prior to e-cooking supply	1 month after e-cooking supply	6 months after e-cooking supply
Monthly ARPU (Naira)	₦243	₦1388	₦3164



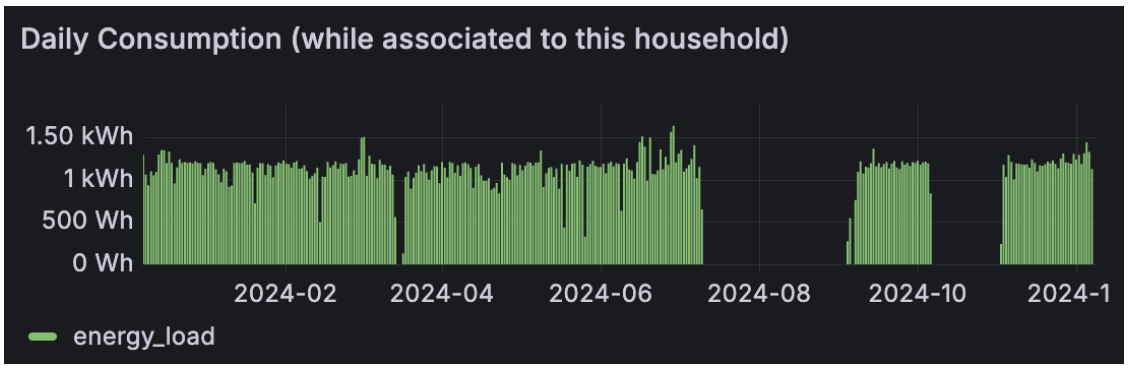
NK-037: Clement Okemiri w/ Rice cooker

Metric	Prior to e-cooking supply	1 month after e-cooking supply	6 months after e-cooking supply
Monthly ARPU (Naira)	₦3606	₦5351	₦5289



NK-076: Mamman Ndamina w/ Rice cooker

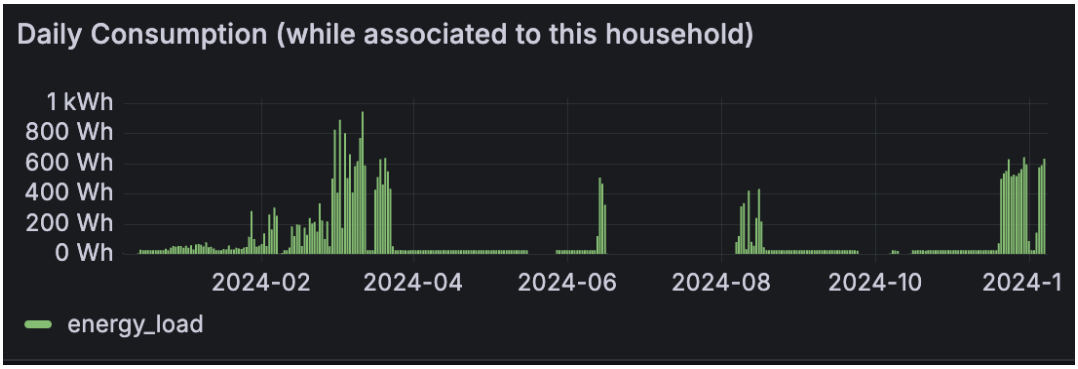
Metric	Prior to e-cooking supply	1 month after e-cooking supply	6 months after e-cooking supply
Monthly ARPU (Naira)	₦2396	₦4172	₦6592



NK-082: Danladi abubakar w/ Rice cooker

Metric	Prior to e-cooking supply	1 month after e-cooking supply	6 months after e-cooking supply
Monthly ARPU	₦651	₦81	₦632

(Naira)			



Clean cooking restaurants

The clean cooking restaurants were deployed with Okra Stacked Systems. Two kitchens were provided with a capacity of 3.6kW and one with a 2.4kW system. The primary technical risk was that the Okra stacked system was a new product in the pilot stage.

The main concern is about the operational behaviour of the Okra Pods. Our firmware team wrote a custom set of firmware code for pods installed in this stacked configuration which allows error handling to be done more safely (essentially shutting down all pods in the stack if any single pod has an error).

Another technical challenge we expect is instances where the pod is overloaded, which in most cases will result in a blown fuse. We have mitigated these challenges by supplying excess pods and fuses in each deployed site and also trained the local maintenance agents on how to replace pods and burnt fuses.

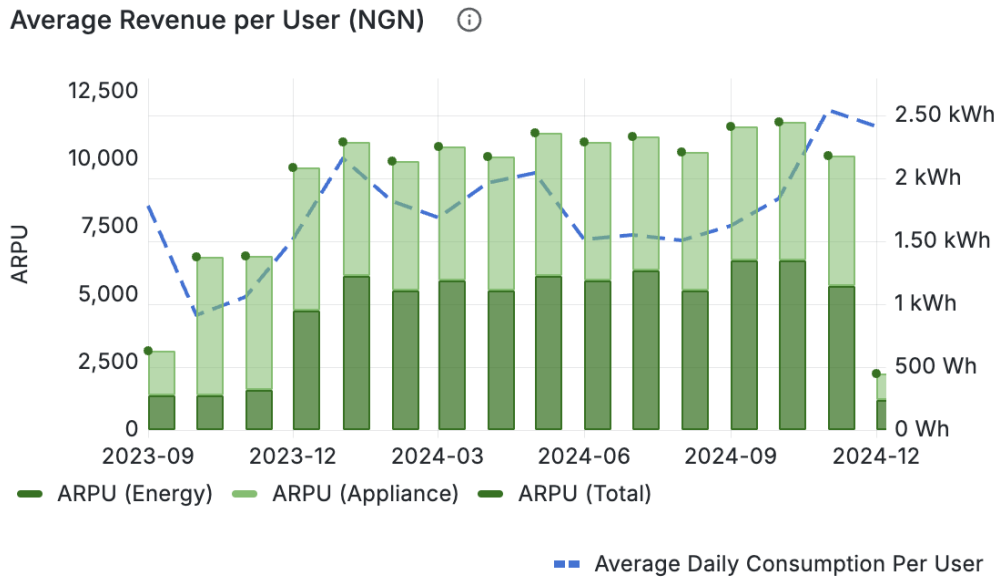
The following participants were provided with the clean cooking restaurant setup as part of this study:

Energy Developer	Community	Participant name	Appliances provided	Install date
First Electric	Igbobini, Ondo state	Faith Ototakovi	Hotplate, Electric pressure cooker, Kettle	September 2023
Creeds Energy	Jos, Plateau state	Clement Dalang	Electric pressure cooker, hotplate, rice cooker, kettle	November 2023
Pamafrica	Ikoyi, Oyo State	Saliu Basirat	Electric pressure cooker, hotplate, rice cooker, kettle	October 2023

The performance results of the clean cooking restaurants are shown below:

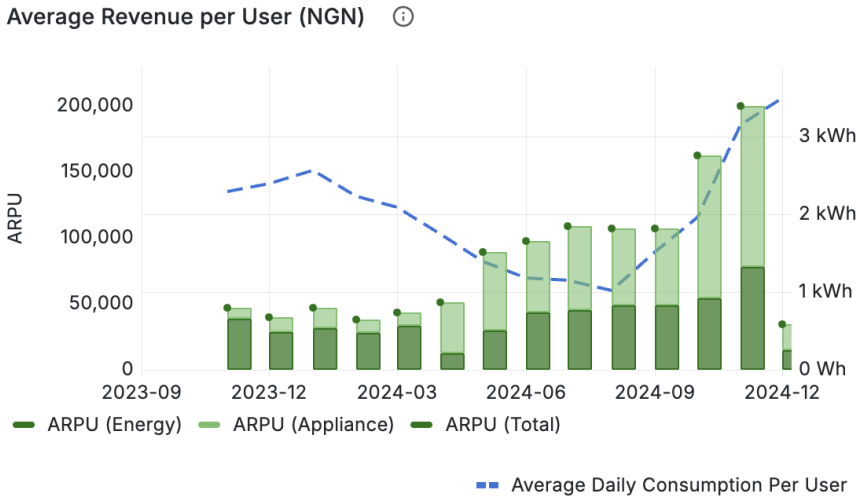
First Electric - Faith Ototakovi

- Monthly ARPU: ₦9009
- Daily ACPU: 1910 Wh



Creeds Energy - Clement Dalang

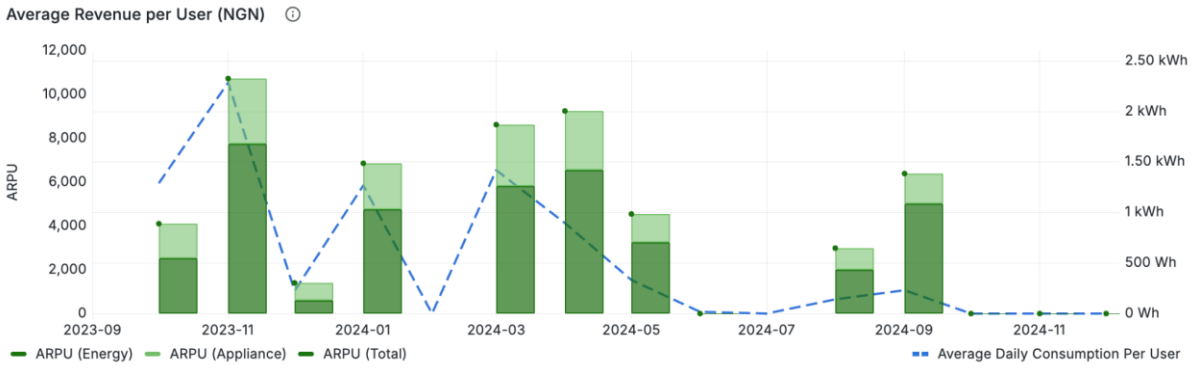
- Monthly ARPU: ₦83893
- Daily ACPU: 1830 Wh



The monthly ARPU is significantly higher for this EAC as they offered their system on a Lease-to-own model. This means that within 2 years, the user of the system will own the entire system provided they make the monthly payments. This is different from all other implementations of Okra systems that are on an Energy-As-A-Service model where the systems are owned and managed by the EAC while the user pays a tariff for energy consumption.

Pamafrica - Saliu Basirat

- Monthly ARPU: ₦4224
- Daily ACPU: 894 Wh



Note: This system has not been functional since October 2024 due to a fault in the Okra pod. The Okra pods are pending replacement. There have been delays as we do not currently have stock of okra pods in the country.

• Analysis of Results and Learning

Survey Data analysis

The surveys conducted provided us with important information about the community's habits and the perception of the appliances provided. As the surveys were performed by different people (okra and then community members) providing different levels of detail as the outputs.

Baseline data analysis

We learned a significant amount from the baseline survey and visiting the communities about their cooking habits.

We found that religion plays an important role in which food preparation is conducted.

In the North of Nigeria, which is Muslim majority - men and women lived in separate areas of the community. Women and Children on one side and men on the other side. Women would cook together in a community kitchen during the day using big pots capable of feeding up to 30 people. They would cook for all the men and children of the community.

From the survey data we collected NONE of the women in this community were interested in clean cooking appliances. Facilitating the adoption in this community will be the most challenging if we follow the traditional model of financing e-cooking appliances to households.

There is a stronger, cultural connection to the process of cooking together that caused apprehension when demonstrating an appliance that is intended to only cook for one family.

Based on this feedback, we concluded that it would be more beneficial to build a community clean cooking kitchen rather than a clean cooking restaurant.

In contrast to this approach to cooking in the Muslim-majority community in the North, the community we surveyed in the south was a christian-majority community. The approach to cooking here resembled much more what we saw in the study we did in Cambodia in 2020. Each household consisted of an average of 5 people, where women cook for the husband and children in their own home.

From the survey data we collected ALL of the community members surveyed were interested in clean cooking appliances. This stands in stark contrast to the results from the Muslim community.

The responses from the two communities clearly indicate that two different approaches were needed to facilitate the uptake of clean cooking appliances.

As seen from the results in the prior section, 1 clean cooking community kitchen was implemented in the north (Creeds Energy) and 2 clean cooking restaurants were deployed in the south (Pamafrica & First Electric).

Endline data analysis

In August 2024, endline surveys were conducted in 3 communities and 4 recipients of e-cooking appliances. From the results, we gathered several insights.

The results analysis is categorised into 6 key insights - Appliance performance, Technical issues, Health and Economic impact, Environmental impact, Community feedback, Satisfaction. The key insights are summarised in the table below

The survey conclusions are categorised into 6 key insights - Appliance performance, Technical issues, Health and Economic impact, Environmental impact, Community feedback, Satisfaction.

The key insights are summarised in the table below:

Name of participant	Alias	Appliance performance	Technical issues	Health & Economic impact	Environmental impact	Community feedback	Satisfaction
Mamman Ndamina	NK-076	Ease of use: 1/10 Not frequent; primarily uses the rice cooker for boiling water during cold weather.	No technical issues	Health impact: 8/10 Reduced fuel costs, Appliances not used for commercial purposes.	Reduced use of wood and charcoal leading to less smoke in households.	The community would benefit from it.	Satisfaction rating: 10/10 The cooking capacity of the appliance needs to be increased.
Clement Dalang	BAM-001	Ease of use: 6/10 Uses all the appliances frequently, especially for commercial cooking	No technical issues	Health impact: 5/10 Reduced fuel costs, 50 meals/day making 12,000₦ daily. Reducing firewood led to increase # of meals sold per day.	Reduced use of wood and charcoal leading to less smoke in households.	Community has expressed interest in appliances	Satisfaction rating: 9/10 Would recommend it to others. Wants a TV, pot, fan, electric cooker and help with making the appliances available.
Faith Ototakovi	IG-042	Ease of use: 8/10 Uses the appliances twice daily, particularly the electric pressure cooker, which is described as efficient and rugged	Power cables of the kettle and hotplate got burnt.	Health impact: 10/10 Significant improvement in health, previously smoke from fire was impacting eyesight.Reduced fuel costs, 30 meals/day making 12,000₦ daily.	Reduced use of wood and charcoal leading to less smoke in households.	Community has expressed extreme interest in cooking appliances	Satisfaction rating: 10/10 Would recommend to others and wants to add freezer to sell beer.

Due to logistical issues, we were unable to survey the clean cooking kitchen deployed with Pamafrica in Ikoyi, Ogun state.

The survey data highlights the correlation between the frequency of e-cooking appliance use and user type, whether residential or commercial. Notably, IG-042 and BAM-001 reported higher usage as they operate clean cooking restaurants, leveraging the appliances for their businesses. In contrast, NK-076, a residential user in a Muslim-majority community, uses a 5L rice cooker to prepare meals for her household of 10. Due to the cooker's limited capacity, she must use it multiple times per meal, leading to higher energy costs that affect her adoption of e-cooking. Additionally, she primarily uses the rice cooker to boil and keep water warm during colder months, while continuing to prepare family meals on an open fire with larger pots, highlighting the practical challenges and cultural preferences that influence e-cooking adoption.

The analysis of the survey data highlights the importance of conducting more frequent and detailed surveys shortly after the demonstration of appliances. A midline survey conducted one-month post-demonstration would have captured

more immediate feedback from beneficiaries, as their experiences and usage patterns were still fresh.

Analysing the results of the non-beneficiaries, it is evident that the impact of demonstrating clean cooking appliances in the community and having champions using them regularly creates demand generation. When asked about the impact of seeing others using these appliances, they responded with the below comments(aggregated):

How has seeing someone else use clean cooking appliances changed you?	
no response	8
no change	3
Changed view due to efficiency and ease of use	10
Always wanted it for myself/Found solution to my problems	3
Additional comments (aggregated comments)	
Saves time	6
Keeps kitchen and pots clean	4
Want to experience using clean cooking appliances	4

When probed further as to the specific benefits the respondents perceived from using these appliances, responses are aggregated below:

What benefits do you want from using this appliance

Appliance type	Aggregated responses from respondents
Fan	Improved health
Bulbs	-
Kettle	to enable boil water,Environmental benefits,Improved health,Reduced fuel costs,Time savings
Television	to gain access to the external world
Electric Pressure cooker	Environmental benefits,Improved health,Reduced fuel costs,Time savings
Freezer	Cold drinks and preservation of food,Tastier food,For better satisfaction especially during hot weather and then as a new business opportunity
Hotplate	Environmental benefits,Improved health,Reduced fuel costs,Time savings
Rice cooker	Environmental benefits,Improved health,Reduced fuel costs,Time savings

Reduced fuel costs and time savings were frequently mentioned by respondents as key benefits of adopting clean cooking technologies. Patrons of clean cooking restaurants, including Idris Salihu, Lucky Mapayi, Funke Duyile, Iromidayomi, and Enoch, highlighted significant improvements in their eating environments. They reported reduced eye irritation and less smoke inhalation, which contributed to better overall health and comfort while eating at these restaurants. This demonstrates the positive impact of clean cooking solutions on both health and quality of life in communities.

Community Electrification analysis

Throughout the study period, community electrification efforts were significantly influenced by various external factors and government policies. Key challenges included:

- Election Period:
    a. Reduced income levels within communities.
    b. Logistical difficulties in accessing communities due to election-related disruptions.
- Currency Devaluation:
    a. The launch of a new currency in Nigeria caused a rapid devaluation of the Naira.
    b. Subsequent fiscal policies further weakened the Naira, reducing the purchasing power of community members.
- Fuel Subsidy Removal:
    a. The removal of the national fuel subsidy led to a sharp rise in fuel costs.
    b. This increase not only strained household budgets but also impacted accessibility to communities for project implementation.

These factors collectively placed significant economic and logistical pressure on community members, slowing load growth and affecting energy adoption.

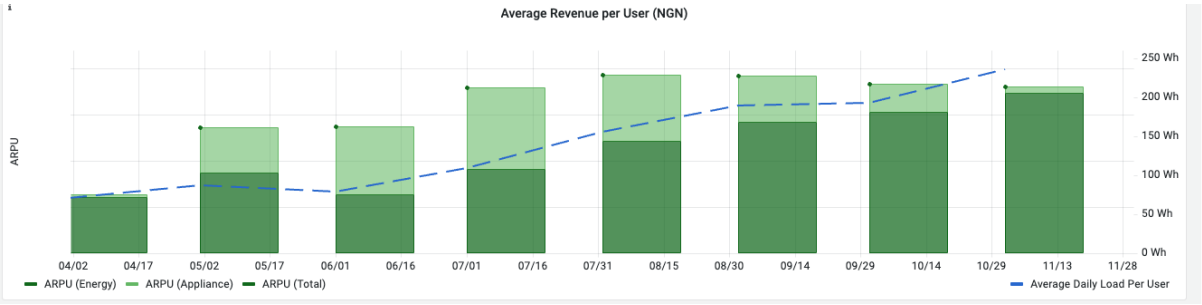
In response to these challenges, Energy Access Companies (EACs) adopted a dynamic approach by:

- Adjusting tariffs to ease the financial burden on their customers (offtakers).
- Maintaining flexibility to ensure continued energy revenue generation despite external pressures.

Despite these complex conditions, this adaptability of mesh grids has enabled the EAC's to continue seeing load growth in each of their communities.

E-cooking appliance analysis

The community in which the e-cooking appliances were supplied, Nuwanksoma, was seeing a marginal growth in ARPU. Despite this, the figure seemed to have flatlined around that level for a few months. Early efforts were already employed by the EAC to stimulate consumption by contacting low-consumption households to give top-up reminders, but it seemed difficult to move the needle.



Steady growth in ARPU seen at the beginning of the project (Data from Okra Harvest).

With the support of this study, we identified that providing e-cooking appliances would be a fruitful intervention, due to the massive residual health benefits from reducing the amount of smoke inhalation by women and children. However, the way mesh-grids are designed is lean, giving users the amount of power output they need and then modularly scaling them as their demand grows. This is great for optimizing cost but also means that households generally start with low power availability.

Connections in a mesh-grid can be chosen to have from 150W up to 3.6kW of output and for this design, 600W max output was selected. As many electric cooking appliances require more than 1kW and most households in Nuwankosoma having up to 600W load output, this presented limitations in implementing a broad range of e-cooking appliances as part of this study. Hence a mix of rice cookers and advanced cookstoves were selected for supply.

Evaluating the deployment for one month to analyze the performance of the systems and how the appliances improved energy consumption across the board shows the impact on ARPU.
On 04/12/2024, 2 Rice Cookers and 3 Advanced Cookstoves were brought to the community, ready to pilot. The initial results were great - not only were the households using the appliances themselves, they were even borrowing them from each other and overall consumption shot through the roof. This made it hard to track exact energy consumption as the appliances were being used between different households.

Here are the results we observed after the first month of usage:

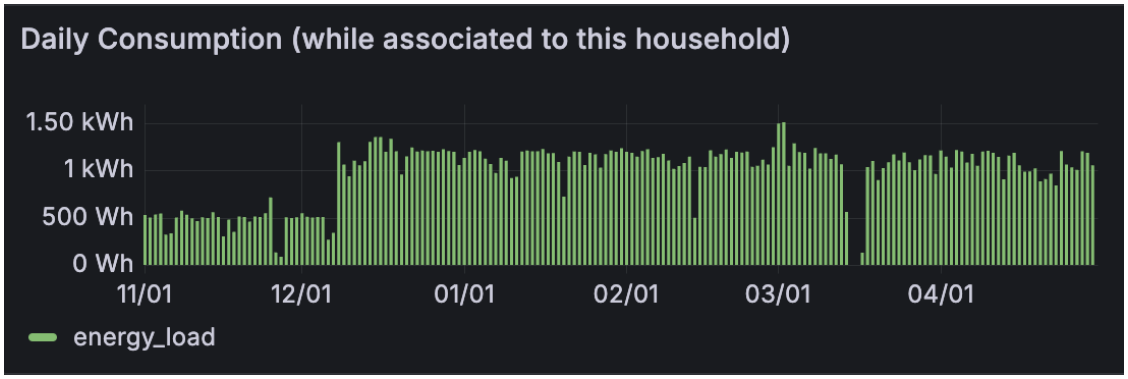
- **9.56KWh** average load increase vs target of 2.7kWh **(+254%)**
- **$2.61** ARPU increase vs target of $0.51 **(+412%)**
- **Higher rate of energy top-ups 6 months on from end of experiment**
- Over 33% of the households showed interest in purchasing the cookstoves

Customer ID	Previous Consumption	**Consumption in experiment month**	**Growth in consumption**	**Percentage Increase in Revenue**
🔥 NK-004	31.86kWh	**37.88kWh**	**6.02kWh**	**18.89%** ↑
NK-037	32.09kWh	**39.32kWh**	**7.23kWh**	**22.5%** ↑
NK-076	14.38kWh	**36.52kWh**	**22.14kWh**	**153.96%** ↑
NK-082	0.00kWh	**0.904kWh**	**0.90kWh**	-
🔥 NK-085	1.69kWh	**12.98kWh**	**11.29kWh**	**769%** ↑

Table showing results after first month of usage

Note that the usage increase was charged at varying tariffs, leading to a nonlinear revenue increase.

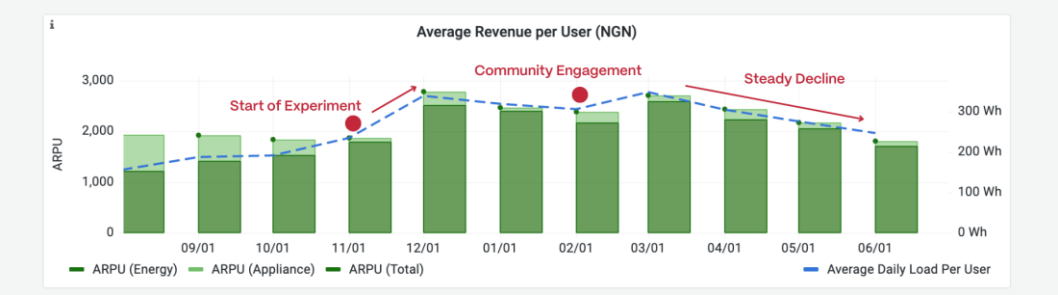
Chart below showing the daily consumption of one of the beneficiaries, Mamman Ndamina during the first week of rice cooker provision.



There is an evident spike of 3x in energy consumption due to the introduction of the rice cooker in the first month.

During the month of February, we started noticing a downturn, however we were unable to get out to site until March, when the EAC team did a Community Engagement exercise. This again excited members of the community, and we saw a small spike in consumption

again. However, during the exercise we learned that households had stopped using the appliances for the most part. The main complaint being the size of the cookstove and rice cooker.



Project revenue between 07/12/2023 - 07/01/2024

The pots used for cooking by the community are usually sized to cook for at least 6 - 10 people. As seen in the photo below, the advanced cookstoves and rice cooker are not designed to physically support such large cooking pots, even though their heat output is sufficient.

To address the community's cooking preferences, we developed a plan to fabricate a larger tripod that would enable users to mount large pots over the cookstoves, allowing them to cook in a manner more aligned with their traditional practices. However, since March, this plan has not yet been implemented. Additionally, the community's heavy reliance on agricultural income has further influenced consumption patterns, particularly following the end of the harvest season. These two factors have contributed to the decline in consumption observed in the chart above.

Typical size of an advanced cookstove

Unfortunately, Advanced Cookstoves are still on the expensive side compared to rice cookers. They offer a route to adopting clean cooking for community members with lower power systems but come at a cost of between $70 - $120 per unit (average of $95).

With a 25% Margin to the developer that then leads to an average sales price to end users of $118.75.

	Value	**CALC**
A - AVG COGS: Advanced Cookstove	$95	AVG (70-120)
B - AVG Sales Price (@ 25% Margin)	118.75	=A+(A*0.25)
C - Payback Period (Months)	24	
D - Payback Months	4.95	=B/C'
E - Amount to be Paid per Day ($USD)	$0.16	=D/30
F - Naira Equivalent per day	₦268.84	=E*1630

For reference, a rice cooker or pressure cooker can be bought for around $35 - $45 by the developer and then sold to the households at 100 Naira/day under a similar payment plan. In comparison, the price of the Advanced Cookstove at $95 or 268 Naira/day is rather high.

These results leave the EAC at a crossroads: spend more for Advanced Cookstoves that use less power, are less clean, but are compatible with regular systems, or spend more to upgrade to a larger system that is capable of outputting 1.2 or 2.4kW and save money on the rice cooker instead.

Clean Cooking Restaurants analysis

The clean cooking restaurant beneficiaries were provided their appliances on financing. EAC's determined the repayment plan and signed agreements with each beneficiary.

First Electric: Faith Ototakovi, IG-042

The financing plan for the appliances is shown below:

Appliance Name	Consumers	Repayment Rate	Full Price
Freezer 205L	1	NGN 113.00	NGN 130,848.00
Fan - 13W	1	NGN 12.00	NGN 13,536.00
Rice Cooker	1	NGN 12.00	NGN 13,536.00
2 Plate Hotplate	1	NGN 10.00	NGN 8,000.00
Kettle	1	NGN 6.00	NGN 8,000.00
Electric Pressure Cooker	1	NGN 12.00	NGN 13,536.00

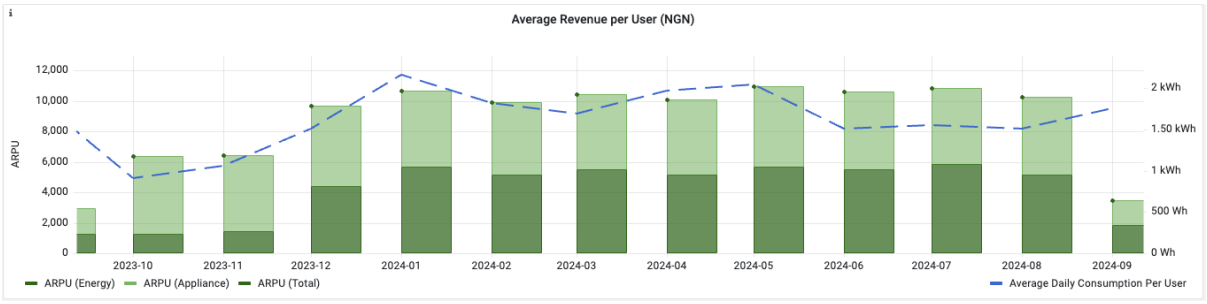
Each appliance above is on a daily payment schedule for a period of 1-2.5 years. These amounts were selected based on the incomes of the restaurant owners.

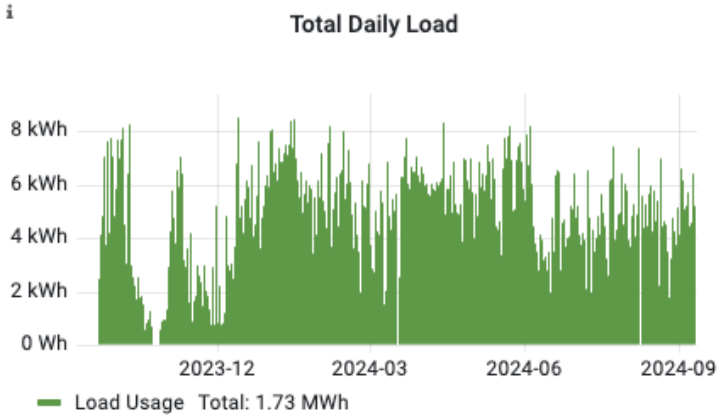
The table below shows the impact on ARPU and ACPU with the provision of appliances.

	With cooking appliance	**Without cooking appliance**
Average monthly ARPU	8680₦	6991₦
Average daily consumption per hh	4.86kWh	1.05Wh

With a 350% increase in ACPU, energising clean cooking kitchens shows promise in increasing overall ARPU for the community. The disadvantage remains in the CAPEX of the energy system required to power such appliances resulting in a payback period of more than 20 years.

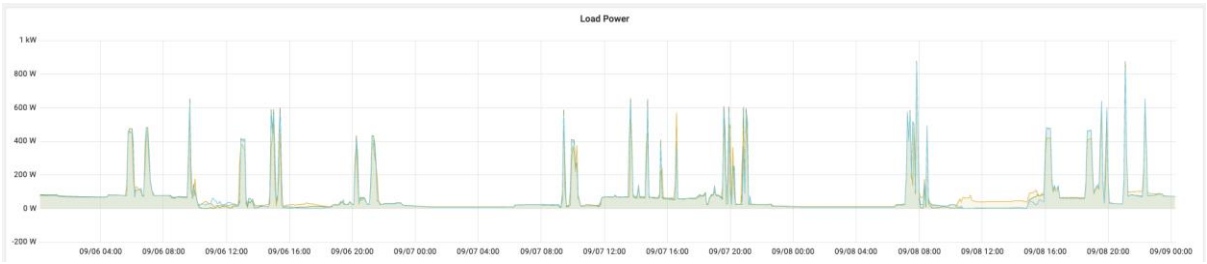
The charts below show ARPU and loads for the entire period since appliances were installed.





The analysis of the daily load data indicates that the system has the capacity to provide up to 8 kWh/day. However, current usage only accounts for approximately 24% of its available daily capacity. This underutilization highlights a significant portion of unused energy, suggesting that the system may be oversized relative to the current energy demand.

The chart below shows the peak usage on a daily basis when the appliances are used the most.



Analysing the chart above, it appears that the appliances are used during the hours of 0800 - 2100.

The consumption peaks during meal times

- Morning: 0800 - 0900
- Afternoon: 1300 - 1600
- Evening: 1900 - 2100

Extrapolating from the load usage, the appliances are used more during afternoon and evening to prepare meals rather than the morning meals. As the peaks occur

periodically throughout the day, there are opportunities to design a more optimal system using the mesh grid to reduce the CAPEX while enabling this level of energy consumption.

Creeds Energy: Clement Dalang, BAM-001

The financing plan for the appliances is shown below:

Mecs Freezer	1	NGN 264.00	NGN 163,560.00
Mecs Double Plate	1	NGN 23.00	NGN 14,100.00
Mecs EPC (8L)	1	NGN 45.00	NGN 28,500.00
Mecs Kettle	1	NGN 18.00	NGN 11,280.00

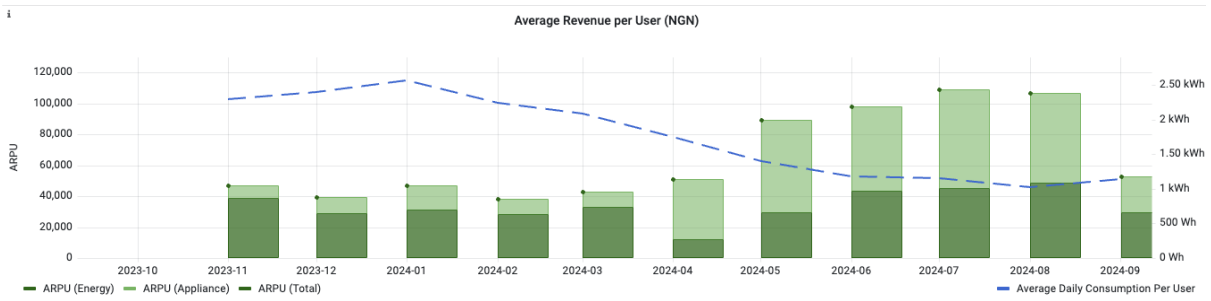
Each appliance above is to be repaid in less than 2 years on a daily basis. These amounts were selected based on the incomes of the restaurant owners.

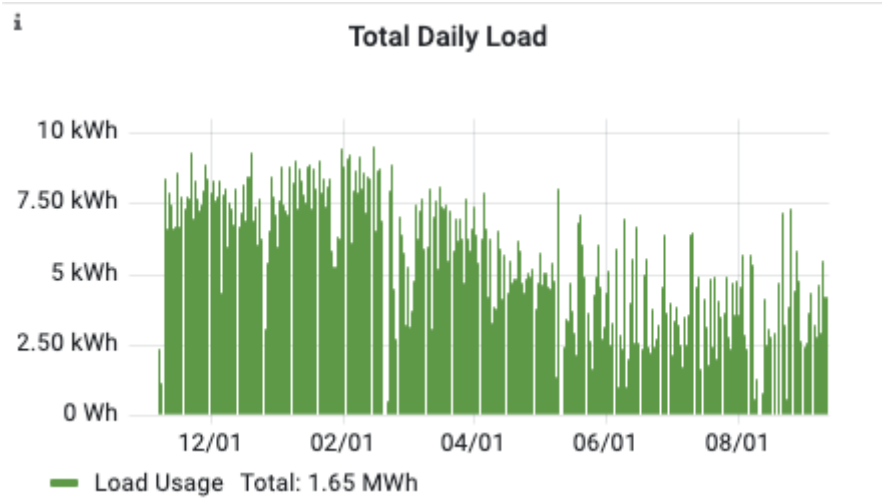
The table below shows the impact on ARPU and ACPU with the provision of appliances.

	With cooking appliance	**Without cooking appliance**
Average monthly ARPU	65736₦	44055₦
Average daily consumption per hh	5.32kWh	1.27kWh

Note: The ARPU above is skewed as a flat rate that is being charged by Creeds as the system is on a Lease-to-Own model.

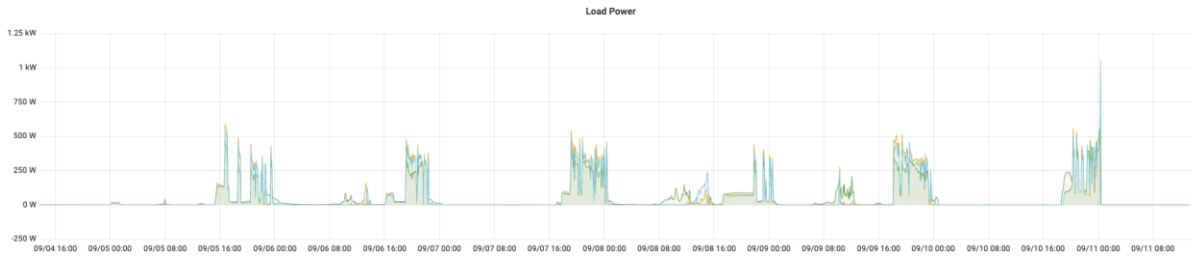
Charts below show ARPU and Loads for the entire period since appliances were installed.





The analysis of the daily load data indicates that the system has the capacity to provide up to 8 kWh/day. However, current usage only accounts for approximately 22% of its available daily capacity. This underutilization highlights a significant portion of unused energy, suggesting that the system may be oversized relative to the current energy demand.

The chart below shows the peak usage on a daily basis when the appliances are used the most.



Analysing the chart above, it appears that the appliances are mostly used between the hours of 1700 - 0100

This usage peaks at night time which illustrates that most cooking occurs at night using the battery storage.

Extrapolating from the load usage, the appliances are used more during night time to prepare meals. This is when energy is being used from the battery. This user has a different trend to Faith and the design of the mesh grid system could be optimised to feed excess energy from surrounding systems, which may not be in use at night, to the restaurant thus reducing the need for extra batteries at the restaurant. This could be one way to reduce CAPEX of the system.

Pamafrica: Saliu Basirat,PA-009

The financing plan for the appliances is shown below:

Appliance Name	Consumers	Repayment Rate	Full Price
Freezer 205L MECS	1	NGN 113.00	NGN 130,848.00
EPC 8L	1	NGN 25.00	NGN 22,560.00
Rice cooker	1	NGN 25.00	NGN 13,536.00
Single Hot Plate	1	NGN 25.00	NGN 7,896.00
Kettle	1	NGN 25.00	NGN 9,024.00

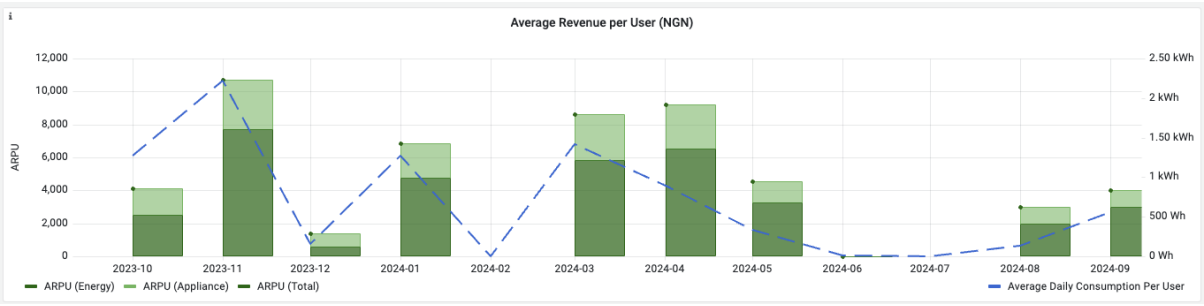
Each appliance above is to be repaid in less than 2 years on a daily basis. These amounts were selected based on the incomes of the restaurant owners.

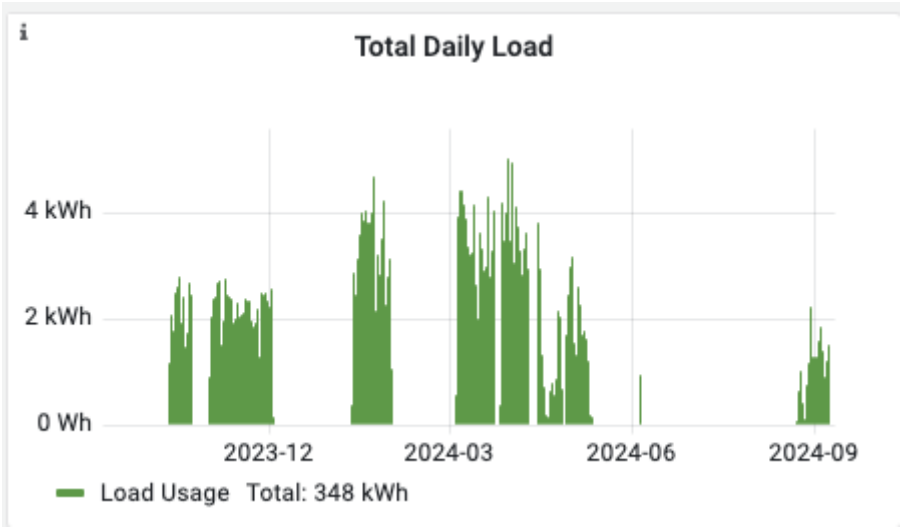
The table below shows the impact on ARPU and ACPU with the provision of appliances.

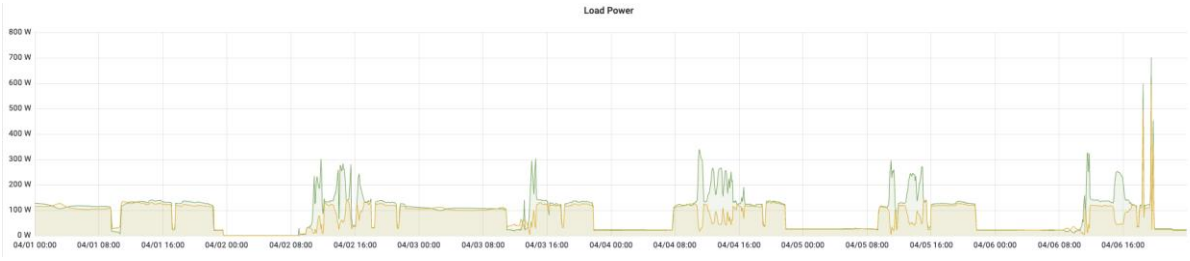
	With cooking appliance	**Without cooking appliance**
Average monthly ARPU	5251₦	14024₦
Average daily consumption per hh	2.5kWh	0.923kWh

Note: This system has been offline due to technical issues for 6 months this year due to technical faults. This has impacted the usage of cooking appliances.

Charts below show ARPU and Loads for the entire period since appliances were installed.







Analysing the chart above, it appears that the appliances are mostly used between the hours of 0900 - 2100

This usage peaks between 1000-1200 and 1300-1500 which indicate the cooking prior to meal times. The system also is used to charge other devices and lighting as there is a constant load throughout the day.

Similarly to Faith and Clement, there are opportunities to explore around optimising the mesh grid system design to reduce CAPEX while still enabling enough power for these appliances.

Conclusion

This report documents the outcomes of a two-year project aimed at advancing clean cooking and energy access in three rural off-grid communities in Nigeria. The project successfully electrified 150 households, supplied e-cooking appliances (rice cookers and advanced cookstoves) to five households, and established three clean cooking restaurants across three communities. The findings and learnings from this study provide critical insights into the challenges and opportunities associated with scaling clean cooking solutions in rural Nigeria.

Financing of Appliances: Appliance financing proved essential for adoption, given the limited financial capacity of rural, off-grid communities. Seasonal incomes suggest that financing schemes should be aligned with harvest seasons to maximize affordability and uptake.

High CAPEX Costs: The capital expenditure (CAPEX) required for systems capable of powering e-cooking appliances remains a significant barrier. Systems designed to support appliances with over 2 kW capacity increase costs substantially, making such projects unviable without grant funding. Despite higher energy usage from e-cooking, current consumption patterns and tariffs are insufficient to achieve a payback period under 10 years.

Cultural Variations in Cooking Habits: Nigeria's diverse cultural and religious practices necessitate tailored approaches to e-cooking adoption. For example:

- Muslim-dominant communities often cook communally for larger families (6–20 people), requiring larger pots and higher-capacity appliances.
- Christian-dominant communities typically have smaller family units (5–7 people) and prefer smaller cooking appliances for individual households.

Limited Local Supply and Knowledge: A lack of local suppliers for e-cooking appliances, particularly in rural areas, has hindered adoption. This gap also reflects limited awareness of the benefits and possibilities of e-cooking. The introduction of clean cooking restaurants was effective in generating interest and dispelling myths about e-cooking within communities.

Supply Chain Challenges: Sourcing e-cooking appliances remains a significant challenge due to:

- Minimum order quantities (MOQs) required by manufacturers (e.g. full container loads from China).
- Long shipping timelines (at least 120 days) and high import tariffs.
- These factors demand substantial investment from distributors. However, emerging local suppliers in Nigeria are beginning to offer cost-effective solutions, which energy access companies should prioritize for their projects.

These challenges resulted in our inability to establish the appliance store that was a part of the original study proposal.

Energy Requirements of E-Cooking: The energy demands of e-cooking appliances exceed the capacity of Okra mesh grid systems in a cost-effective manner. This limits household adoption due to insufficient power supply. Introducing advanced cookstoves as an intermediary solution could bridge this gap, as they require less energy while maintaining financial viability for electrification projects.

Community Engagement: Continuous community engagement is critical for successful appliance adoption. Energy access companies play a vital role in leveraging their relationships with community leaders and understanding local customs to guide implementation strategies effectively.

Impact of Clean Cooking Restaurants: The deployment of clean cooking restaurants has significantly increased energy consumption within communities, enhancing the financial viability of electrification projects for developers. These restaurants also serve as income-generating opportunities for community members while promoting clean cooking practices.

In conclusion, this project highlights the transformative potential of integrating clean cooking solutions with rural electrification efforts. However, scaling these initiatives requires addressing key barriers such as high CAPEX costs of solar equipment, supply chain challenges, understanding local cultural habits, and limited local knowledge. By leveraging innovative financing models, strengthening local supply chains, and fostering continuous community engagement, clean

cooking adoption can be accelerated across rural Nigeria, contributing to improved health outcomes, economic empowerment, and environmental sustainability.

● Looking forward

Since the inception of this study in 2022, Okra Solar's roadmap has evolved significantly as we continue to refine our approach to scaling clean energy solutions in rural Nigeria. Through this project, we have gained valuable insights into the complexities of supply, distribution, and maintenance of e-cooking appliances. It has become evident that these activities require a dedicated team or a specialized partner organization to ensure successful implementation.

Our core strength lies in the innovation and deployment of Okra mesh-grid technology, which enables reliable energy access for rural communities. Recognizing this, we have made the strategic decision to focus exclusively on energy access solutions while partnering with local organizations to handle the supply and distribution of appliances. This shift allows us to catalyze ecosystem development by leveraging the expertise of local partners.

Following this study, we have partnered with Afrimash, a Nigerian distributor specializing in appliances ranging from e-cooking devices to agricultural equipment. Afrimash has extended appliance financing options to our mesh-grid communities, facilitating load growth and improving affordability for end-users. This partnership ensures that all clients deploying Okra mesh grids now have access to Afrimash's distribution and financing services.

Looking ahead, our strategy is centered on building strong partnerships to drive ecosystem development and maximize impact. By collaborating with organizations that specialize in complementary areas such as appliance supply and financing, we aim to accelerate clean cooking adoption while focusing on our mission of expanding energy access. This approach not only strengthens the sustainability of our projects but also ensures that rural communities can fully benefit from modern energy services and the opportunities they unlock.

Appendices

- Appendix I: Baseline Survey
- Appendix II: Endline Survey
- Appendix III: Link to MECS kitchen video