Document Control Sheet

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Executive Summary

PowerGen Renewable Energy is a leading developer and operator of microgrid renewable energy systems across sub-Saharan Africa. To date PowerGen has connected over 15,000 homes and businesses to renewable, reliable AC power across Tanzania, Kenya, Sierra Leone, and Nigeria.

This MECS-TRIID project falls under PowerGen's broader mandate to empower its customers with equipment, financing and training needed to adopt productive uses of energy (PUE) and move up the energy ladder. With MECS' support, PowerGen has conducted a first-of-its-kind, real-world test of electric cooking in the context of a rural African microgrid.

Under the scope of this project, Electric Pressure Cookers (**EPCs**) were delivered to customers at 2 microgrid sites in the Singida region of central Tanzania. These sites were targeted for the study because they offered significantly lower electricity rates compared to most rural microgrids, thereby making the EPCs cost-competitive with relatively inexpensive and ubiquitous charcoal.

PowerGen's specific activities under the MECS-TRIID project during the study period included:

- Building a partnership with TaTEDO, a Tanzania-based renewable energy NGO and local distributor of EPCs
- Procuring the EPCs and testing for quality, product-market fit and compatibility with microgrid customers
- Traveling to two microgrid sites to conduct marketing, sales, and end-user training
- Providing a loan facility to improve affordability of the EPCs to customers
- Conducting follow-up with EPC customers to understand their impressions
- Leveraging remote monitoring data from PowerGen's smart metering system to gauge the impact of EPCs on customer electricity consumption

Early indications from these activities have been very positive. Qualitatively, EPCs demonstrate a **strong product-market fit** for AC microgrid customers in Tanzania. Many staple foods are compatible with EPCs without requiring large shift in behaviour. Off-the-shelf EPCs are plug-and-play with 240V AC power provided by the minigrid. Customers love that the EPCs save them time while adding minimal amounts to their electricity bills.

Since receiving EPCs, households in the study consumed an additional **2.6 kWh per month** through the end of January. This represents an increase of 19.5% in consumption compared to the prior 3 months, demonstrating a clear appetite for MECS among microgrid customers. Follow-up surveys found that both the loan facility and in-person training were crucial to customer uptake.

That being said, this study is limited by a short duration and a small and geographically specific sample size. Our recommendations for follow up studies are to:

- Offer EPCs across a wider variety of microgrid customers to confirm product-market fit
- Test different kWh price points to more deeply understand willingness to pay
- Study the longer-term impacts of EPCs on customer consumption and revenues
- Study the longer-term impacts of EPCs on microgrid economics technical performance

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1. Introduction

The persistence of wood and charcoal cooking in rural sub-Saharan Africa brings a number of destabilizing socioeconomic and environmental challenges to the region, including:

- Deforestation, particularly from charcoal production
- Respiratory disease from indoor air pollution
- Opportunity cost from time spent gathering biomass and tending cookstoves

It is well documented that the negative effects of biomass cooking have an outsized impact on women and children. Inefficient cooking practices, such as three stone fires or uninsulated charcoal stoves, accentuate the challenges above. Although efficient wood or charcoal cookstoves are a step in the right direction, to truly solve all the challenges associated with biomass cooking, we believe a *complete* transition to modern energy cooking services is required.

According to CrossBoundary Energy Access, microgrids are the least-cost solution for providing electricity access to 100 million rural Africans. The expansion of microgrids across the African continent as a rural electrification solution has unlocked the opportunity to directly transition rural communities from biomass cooking directly to modern energy cooking services. This transition also represents an opportunity for microgrid developers to bolster consumption of its customers and strengthen the business model of distributed micro-utilities.

In PowerGen's existing Tanzanian microgrid communities, charcoal remains the fuel of choice, and we have observed little to no adoption of electric cooking. This is largely because:

- Charcoal remains quite inexpensive in rural Tanzania
- By necessity, microgrid electricity rates are reflective of their installation costs, and are therefore significantly more expensive than nationally-subsidized utilities
- microgrid customers lack access to electric cooking appliances.
- There is low awareness of electric cooking, and those who are aware often assume that electric cooking appliances and their operating costs are prohibitively expensive
- Biomass cooking is ingrained in Tanzania culture, and cooking with electricity requires significant behaviour change

1.1 Aims of the Project in line with DFID Priorities

- *Strengthening resilience* by averting deforestation in the face of climate change and reducing reliance on diminishing biomass resources

- *Promoting global prosperity* by moving people up the energy ladder and avoiding the health and safety downfalls of biomass cooking

- *Helping the world's most vulnerable* by introducing zero-emission, time-saving EPCs to the challenges above that disproportionately affect women and children

- *Delivering value for money* by using off-the-shelf cooking appliances paired with AC microgrids, so customers are not required to purchase expensive power generation equipment or batteries to receive these services

1.2 Objectives of the Project

- To test and deliver business model innovations that enable rapid uptake of electric cooking among customers of PowerGen's AC microgrids

To develop an understanding of the use case for EPCs in a microgrid context and how distribution of EPCs to microgrid customers affect their ability to consume electricity

2. Methodology

This project deployed EPCs to two PowerGen mini-grids sites in the Singida region of central Tanzania.

The sites were specifically selected due to their lower-than normal tariffs for microgrids, making electric cooking more cost-competitive with charcoal.

Community	Region	Population	microgrid Customers	microgrid Installation Date	Solar Capacity (kWp)
Londoni	Singida	8858	203	10/30/2016	19.08
Saranda	Singida	1735	95	2/2/2018	6.36

2.1 Data collection:

Qualitative surveys were used to gather usage and consumer behaviour data. 22 of the 25 customers who initially purchased EPCs were interviewed by CLASP in person for the survey. The surveys were delivered in two parts;

- a baseline survey was carried out by PowerGen staff, in October 2019, prior to sale of an EPC, see Appendix A
- a follow on survey to understand the customer perceptions was carried out in person, by a team of CLASP researchers, see Appendix B. The follow on survey captures customers who had been using their EPC for a one month period

Consumption data for the households was captured by PowerGen's smart electricity meters.

As the study considers a small sample in a very specific context, it is not intended to be a representative sample. Further research is required to bear out the directional results and conclusions discussed in this report.

2.2 Assumptions made

- One "sack" of charcoal is 30-50 kgs

- Increase in customer load at the meter level is primarily due to use of EPCs

2.3 Outline of the Concept

How this project is helping to solve a modern energy cooking problem

- Due to their extremely high energy efficiency, EPCs can displace charcoal and/ or firewood with associated reductions in greenhouse gasses and indoor air pollution, thus avoiding adverse climate and health impacts.
- EPCs shorten the duration of cooking many foods, and do not require supervision, thereby reducing overall time spent in fuel procurement and food preparation. This allows those responsible for cooking, predominantly women, to participate in other household or income generating activities.

Due to the nascency of EPCs as a viable solution for rural households in SSA, there is little documented evidence on the capacity of EPCs to substitution and its impacts. This project is the first of its kind in gathering real-world data on EPC usage in a microgrid context for further study to inform rollout of EPCs on microgrids and other appropriate energy contexts.

How the idea was generated

In their 2018 report on eCook in Tanzania, Batchelor et al. identified that Electric Pressure Cookers (EPCs) are perhaps a best fit off-the-shelf electric cooking solution for the Tanzanian market, due to its energy efficiency, usability, and compatibility with commonly cooked staple meals. Where Tanzanians are paying for biomass cooking fuel, the study concluded that there were *"clear indications…, that households would adopt electricity for cooking – if the price and other conditions were 'right,'"* and *"a move directly to multicookers could be possible."* (page 107)

PowerGen proposed to build on this work by directly testing those conclusions. In advance of this project, PowerGen conducted a feasibility study to determine the fuels and cooking profiles of its customers in Tanzania. The findings below are from a representative excerpt of the survey and data collected from seven PowerGen customers at sites in Western Tanzania.

This data revealed that all PowerGen customers surveyed pay for cooking fuel, with all customers using charcoal and one choosing to stack with LPG. Monthly expenditure ranged from TZS 10,000 per month for the smallest user, up to 64,000 TZS per month for one customer operating a restaurant business. Across those customers, the average cost was 42,000TZS or $18 USD per month.

For the villages surveyed, charcoal was packed in sacks costing about TZS 5,000 per bag, with each bag estimated to contain 30+ kg of charcoal. There has been a gradual increase in the cost (about 500-1000TZS/ $0.22cts- 0.5cts) annually but charcoal still remains affordable and easily available compared to other alternatives such as LPG.

However most customers indicated that they would be willing to transition to more modern cooking services, but their greatest concerns remain:

- Price of microgrid electricity to compete with inexpensive charcoal
- Access to, and awareness of electric cooking appliances

PowerGen initiated this project to address these two challenges concurrently, with the goal of demonstrating rapid uptake of electric cooking in two existing microgrid communities.

3. Implementation

3.1 Project Activities

Preparation

PowerGen partnered with a local distributor of EPCs, TATEDO to supply the technology and consumer training. TATEDO is a partner of the Clean Cooking Alliance that has been working with communities, entrepreneurs and other stakeholders for over 20 years to increase access to sustainable energy technologies and services.

The Nikai Model of EPC was previously tested for quality assurance, product-market fit and mini-grid compatibility and was selected for this project due to its high efficiency and compatibility with the local cooking practices.

Nikai EPC Specifications	
Capacity	6 litres
Operation	Manual
Material composition	Teflon inner pot
Power rating	1000W
Safety Features	Locking mechanism, pressure release valve

Powergen designed a consumer financing product for the EPC that allowed for payment in installments and potentially improved appliance affordability. The payment plan entailed a down payment of TZS 50,000 and monthly instalments of TZS 22,000 for nine months.

Sales, delivery and training

PowerGen staff in Tanzania carried out marketing, sales, and delivery to customers at two active microgrid projects in central Tanzania. The team from PowerGen and TaTEDO together spent 2 full days at each site conducting these activities. The schedule followed for each day is outlined below:

Day 1 Schedule

- Door to door sensitization of women of the community
- Megaphone announcement to rally customers to the meeting place

- Setup and wiring of EPCs, procuring meal ingredients, arranging space for demonstration, etc.
- PowerGen and TaTEDO team member introductions
- TaTEDO-led demonstration of EPCs for local dishes
- Sharing a meal of rice, beans, goat stew, vegetable stew.
- Handout of marketing flyers with the financing offer
- Announcement that anyone who completed the two-day training would receive a TZS 20,000 discount on the initial deposit

Day 2 Schedule

- Megaphone announcement to rally customers to the meeting place
- Setup and wiring of EPCs and arranging space for demonstrations
- TaTEDO-led hands on practical training with the women of the community directly involved in preparing the meals
- Sharing a meal of ugali, chicken stew, vegetable stew, and beans.
- Ceremony for handing out certificates of participation to those who attended both days
- EPC sales and delivery out of the back of the PowerGen vehicle

Outcomes:

- Energy consumption ranged between 1 – 1.2 kWh each day of the training across five to six EPCs used in the demonstration
- 65 men and women received certificates of participation in the training
- 25 EPCs were successfully deployed to PowerGen customers

Cooking demos were delivered by TaTEDO to train customers on the optimal EPC usage/operation, energy-saving best practices, suggested menus for cooking local staple foods, and demonstrate the impact of modern energy cooking services. 60 people attended the demos between the two sites. Out of the attendees, 25 purchased an EPC. Four customers later purchased the appliance after

witnessing the benefits and ease of use from their neighbors. Energy consumption ranged between 1 – 1.2 kWh per day of training across the five to six EPCs that were used in demonstration.

Data collection and monitoring

Monitoring and evaluation included leveraging remote monitoring data to gauge usage, and conducting direct follow-up with EPC customers to understand their experience and impressions of the service. These included

- Initial baseline SMS customer survey was carried the last week of October; see appendix
- In-person EPC customer survey carried out in the first week of December, 3rd-9th and was conducted in two parts; the customers first answered the initial baseline SMS questions, see appendix A and put then a post usage survey; see appendix B
- Household level smart meter data was extracted for the first 25 EPC purchasers, and included their energy consumption through the end of January

3.2 Project Findings

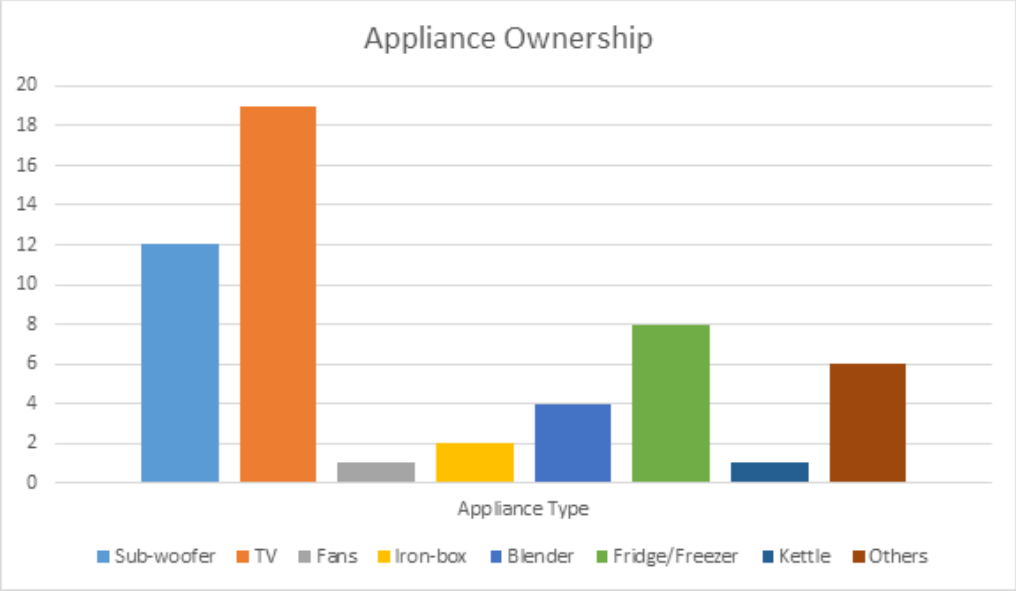
Demographics

Household size: ranged from 3 - 9 people. Average household size was 5 people.

Age of users/buyers: ranged between 28- 58 years; with about 36% of the users above 50 years.

Economic Activities: included hotel/restaurant businesses, shops, entertainment centers, butcheries, agriculture and mining.

Appliance Ownership: 19 of 22 homes own 2+ appliances.



*Others include power mixers, printers, video decks and driers.

40% (9 out of 22) interviewees had refrigerators/freezers and a majority were used for commercial purposes; hotels and shops. Refrigerator penetration in Africa currently stands at 17% (SOGAM Report 2019, p. 9).

Appliance ownership amongst the customers is progressive; generally customers purchase one appliance at a time and complete repayment before making the decision to buy another appliance.

High rates of appliance ownership can be partly attributed to PowerGen's business model, which includes provision of appliances on loan, as tested in this study.

Purchasing Decision

- Although 16 out of 22 households identified the man as the leader in the home, the decision to purchase the EPC was made by the women in the majority of households, 17 of 22.
- Four men decided to purchase the EPC in order to ease the cooking process for their wives.
- One man made the purchase in order to empower himself to be able to cook on his own and not depend on his wife.

Impact of Cooking Demos:

The demos were highly recommended and deemed instrumental in catalyzing purchasing decisions. Customers who participated reported that the training:

1. Made them aware of the advantages of EPCs
2. Allayed some fears/concerns about cooking with electricity
3. Built confidence by allowing them to practice cooking directly with EPCs
4. Encouraged men to become more independent of their wives in cooking activities
5. Conferred the sense that EPC knowledge is considered a valued skill

Impact of the Loan Facility:

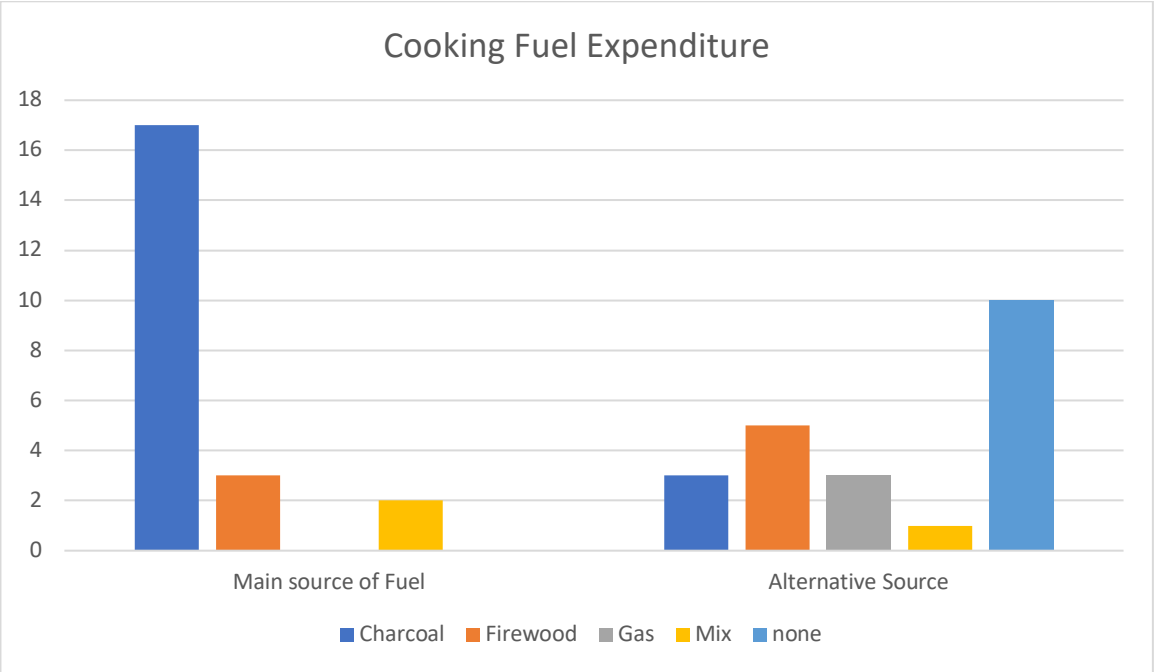
19 out of 22 customers interviewed reported they could not have afforded the EPC without the loan facility.

Fuel Sources Prior to EPC adoption:

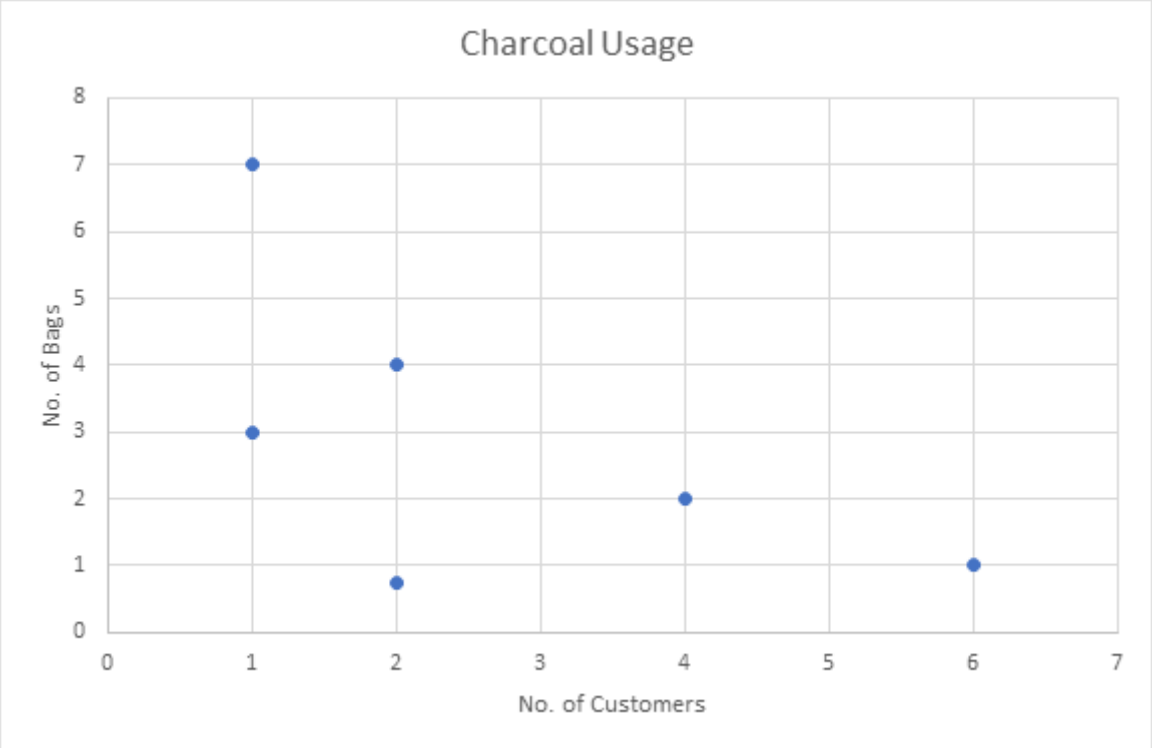
The majority of users cooked entirely on charcoal before purchasing the EPC. Households, on average, use one to two bags (30-50 kg/bag) of charcoal per month while the hotel businesses used between three to eight bags. The average price of a bag is about TZS 8,000 (about $3 USD) therefore the average expenditure on fuel ranged between $10-32 USD.

Firewood was preferred for fast cooking, whereas gas was used for light cooking, e.g. evening meals. Two out of the three customers who use charcoal as an alternative to firewood use less than a bag every month. It was noted that changes in seasons affect both availability (decrease) and cost (increase), to about TZS 10,000 ($5 USD).

Average Monthly Household Fuel Expenditure (USD)



Average Monthly Consumption of Charcoal



EPC Use Case

The overwhelming majority of EPCs are being used in the home. Four customers had hotel businesses but only one used the EPC within the business. Types of foods cooked included: rice, maize and beans, beans, bananas, porridge, tea, meat etc. The consumers confirmed that they cooked at least one meal everyday on the EPC; either breakfast or dinner, meals that are susceptible to time constraints.

Design Wins

1. Compact, portable and robust design. The customers are happy that the appliance is not fragile and that it is not too large; it is possible to pack and carry the EPC during travels.
2. Sufficient safety features
3. Moderate consumption
4. Ease of use: the EPC is very easy to operate.
5. Sleek/attractive design.

Newly Realized Advantages

Time Savings: All the users confirmed that the EPC created more time for them to spend in their businesses, farms and other activities. The EPC freed up nearly two hours per household. This has been made possible for the following reasons:

a. Unlike open fires and jikos which require constant attention, the EPC requires no supervision
b. EPC operation is quite straightforward and as a result, consumers can carry out multiple tasks simultaneously.
c. EPCs require very little preparation to carry out cooking
d. Heavy foods cook much faster.

> "The best thing about this [EPC] is having more time. I used to sit inside for two or three hours to prepare each meal (lunch and dinner), but now I can put the food inside the cooker and just leave. I go to my farm and can work there all day. It is especially helpful during the harvest season when we have so much to do. Now I come home and the food is ready."

One customer said that with this additional time, she is able to spend more time on her farm, finishing tasks such as weeding in time for the planting season. Another recommended it as 'the go-to appliance for the empowered woman.'

Cost Savings: the customers enjoy using the EPC for precooking/boiling activities; previously, pre cooking foods such as beans would take about three hours and consume a huge amount of wood or charcoal. The EPC had halved this time and by extension cut down on the firewood/charcoal that would have otherwise been bought. A deeper CBA could be done later once the customers have used the EPC for a longer time

No Negative Health Impact: health issues that would arise from the smoke are no longer a problem. Common ailments such as chest and eye problems are no longer a problem as well as accidents such as burns and spills.

> "The [EPC] is so easy to use, I even let my children cook in it. Now that they can cook, I have more time and know that they are safe. Coal and fire can be dangerous, but the [EPC] is easy and safe."

Impact on Household Energy Consumption

Smart Meter Data Analysis for first 25 EPC Customers				
	Date Range - Before	Unit	Date Range - After	Unit
Number of Days	84	days	84	days
Date To	11/7/19		1/31/20	
Date From	8/15/19		11/8/19	
Total Consumption	914	kWh	1092	kWh
Average Consumption Per User	13.6	kWh / user month	16.2	kWh / month
Change	**+2.6**	kWh / user month	**19.50%**	change

3.3 Limitations of the Approach

Time

We were only able to extract data for 84 days of customer consumption. More time is needed to account for the impact of seasonality on customer income, charcoal prices, etc. The short timeframe of the project also limited the depth of analysis we could conduct on the data.

Small Geographic/Cultural Sample

Only two communities were studied, and they were in close proximity to each other. A broader sample is needed to understand if the results are representative of other parts of East Africa.

Metering

Ideally, the EPC would be metered separately from the rest of the household to disaggregate its usage from other appliances. Without an extremely detailed analysis of instantaneous power vs.

energy consumption at the household meter level, we cannot yet claim the EPCs as causation of the consumption increase.

4. Next steps

4.1 Recommendations for Follow-Up Studies

We recommend a follow-up analysis of these EPC customers is completed after 6 -12 months, to give time for customers to get used to the EPCs, pay off their loans, and to try to smooth out any seasonal fluctuations in income and charcoal prices.

Deeper analysis is recommended to confirm to what degree EPCs were the source of the increase in consumption during the study period. It would also be valuable to study what times of day customers used the EPCs, and compare across usage patterns for customers without EPCs at the two study sites.

To broaden the sector's understanding even further, follow-up studies with separately-metered EPCs should be done by:

1. Offering EPCs across a broader variety of microgrid customers to confirm product-market fit
2. Testing different kWh price points to more deeply understand willingness to pay
3. Studying the longer term impacts of EPCs on customer consumption and ARPU
4. Studying the longer term impacts of EPCs on microgrid economics technical performance

4.2 Dissemination Plan

CLASP will support the dissemination of this report following Efficiency for Access protocols. The dissemination plan will include the following:

- Published report on Efficiency for Access publication library
- 1-pager highlighting key insights from the report
- Short research analysis published on CLASP publication library, linked to report
- Publicity through the CLASP, Efficiency for Access, and partner newsletters
- Social media toolkit to be shared on CLASP and Efficiency for Access twitter and LinkedIn pages

4.3 PowerGen's Plan

PowerGen has already partnered with Access to Energy Institute (A2EI) to scale up to 100 EPC customers across different geographic clusters in Tanzania. These EPCs will be metered separately to disaggregate their consumption from the other appliances in the household. Different prices per kWh will be tested to determine willingness-to-pay.

PowerGen will be seeking $100,000-200,000 USD in grant funding to further scale up these activities across Tanzania, and to conduct commercial feasibility studies in West African countries where it operates, such as Sierra Leone and Nigeria. EEP Africa has been identified as a potential channel for this funding.

5. Conclusion

While still early days, It is exciting to see off-the-shelf EPCs strongly compatible with microgrids and their customers. This would mean a clear and immediate path to scale for MECS alongside the fast-growing microgrid sector, with a chance to impact the lives of millions of beneficiaries and potentially huge tracts of forest slated for charcoal production in the coming years.

This study has demonstrated that with relatively straightforward and inexpensive interventions by a microgrid developer, microgrid customers have the capacity to leap-frog up the energy ladder - from 3 stone fires and charcoal stoves to one of the cleanest, most efficient methods available in the modern world.

A key lesson for any developer implementing such an intervention is that both financing facility and in-person training are crucial to uptake and retention. The training engagement should be a core component of any program design to deploy electric cooking appliances for first-time users.

Even in this small sample, the numbers are encouraging. Since receiving EPCs, households in the study consumed an additional **2.6 kWh per month** through the end of January. This represents an increase of 19.5% in consumption compared to the prior 3 months, demonstrating a clear appetite for consuming more power among microgrid customers.

Followup analysis and surveying of this cohort is advised to confirm impacts observed here. Broader studies of EPC usage at different kWh price points and in geographically disparate communities will be valuable to continue mapping willingness to pay and product-market fit.

6. Appendix

Appendix A - Initial Survey Questions

Metric	**Disaggregation**
Village	
Household size	
Head of household	M/F
Age	
Primary source of income	
Who made the decision to purchase the EPC	
Ulitumia vifaa vipi, katika hivi vifuatavyo? (Which appliances amongst these do you use)	kompyuta pasi, subufa, televisheni, tochi, feni
Ulitumia vifaa vipi, katika hivi vifuatavyo? (Which appliances amongst these do you use)	Blenda, Friji/friza, birika la umeme, rice kuka, machine ya kusiaga
Je, unapika chakula cha idadi ya watu wangapi nyumbani kwako kwa siku? Ambie namba. (How many people do youu cook for on average in your home?)	
Je, unapika chakula kwa ajili ya biashara? (Do you have a cooking business)	Ndio, Hapana
Je, kwa kawaida, unapika milo mingapi kwa siku? (How many meals do you cook in a day)	
Ni njia gani kuu unayotumia kupika? (What is you main mode/source of fuel for/of cooking)	la makaa, la kuni, la gesi, la mafiga matatu, la umeme, la mafuta taa

Kwa mwezi, unatumia kiasi gani ya pesa kwa matumizi yako ya kupika? Chagua mojawapo kati ya hivi (How much do you spend monthly on the above mode?)	Situmii pesa. Nakusanya, 2. 0 - 2,000 TZS, 3. 2,000 – 5,000 TZS, 4. 5,000 – 10,000 TZS 5. 10,000 – 20,000 TZS, 6. More than 20,000 TZS
Ni njia gani nyingine unayoitumia kupikia zaidi ukiachilia njia ya awali? (Which other mode/source of fuel do you use in your cooking?)	la makaa, la kuni, la gesi, la mafiga matatu, la umeme, la mafuta taa
Kwa mwezi, unatumia kiasi gani ya pesa kwa matumizi yako ya kupika? Chagua mojawapo kati ya hivi (How much do you spend monthly on the above mode?)	Situmii pesa. Nakusanya, 2. 0 - 2,000 TZS, 3. 2,000 – 5,000 TZS, 4. 5,000 – 10,000 TZS 5. 10,000 – 20,000 TZS, 6. More than 20,000 TZS
Unapika vyakula kipi zaidi, na unatumia njia vipi kuvipika? (Which foods do you cook regularly and what mode do you use to cook them?)	

Appendix B - Post-Usage Survey Questions

Metric Number	**Metric**	**Translation**
Output 1: User Acceptance		
1.1	What impact had the EPC had on your quality of life; comparison to initial fuel	Ni mabadiliko gani jiko lenye presha limeleta kwenye ubora wa maisha yako, kulinganisha na njia ya awali?
1.2	What are the newly realized advatages?	Ni faida gani mpya umeziona baada ya matumizi ya jiko lenye presha?
1.3	What are some of the challenges that you have experienced?	Ni changamoto umeziona?
1.4	What are some of the concerns that you had at the start and maybe still have?	Ulikua na wasiwasi gani kabla na labda mpaka sasa unao?
1.5	Will you continue to use/recommend to others?	Utaendelea kutumia au kupendekeza kwa wenzako?

Output 2: EPC Design Features		
2.1	Comments on performance, time, and quality of food.	Maoni juu ya ufanisi, muda na ubora wa chakula?
2.2	What are some of your favorite features	Ni vitu gani kuhusu stovu unavyovipenda wewe?
2.3	Are there any features you do not like/understand?	Kuna vitu ambavyo huvipendi/ huvielewi?
2.4	What additional features would you recommend	Vitu gani ungependa viongezwe?
Output 4: Economics		
3.1	Was the loan facility extended by the company helpful? Would you purchase another EPC without the loan facility?	Je, mkopo uliopewa na kampuni umesaidia? Utanunua Jiko lenye Presha bila mkopo?
3.3	Were the cooking demos helpful?	Je, mafunzo ya mapishi na matumizi yalikuwa na msaada wowote?
3.4	what are some of the foods that were cooked on the epc	unapika vyakula vipi katika stovu yako
3.5	If business, is it being used in the business?	Je unatumia EPC katika biashara yako
3.6	frequency of usage// product stacking//time saving	