SunGate

VHSS Village Help for South Sudan

Electric cooking in the world's youngest country

Summary report on mini-grid electric cooking in South Sudan

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Partners

A variety of unique partners collaborated on the project as highlighted in Table 1 below.

Table 1: Project Coalition

Name	Description	Role in Project
Village Help for South Sudan **Village Help for South Sudan**	Village Help for South Sudan is a non-profit delivering education and economic opportunity to remote areas of South Sudan.	Implementing organization for the electric cooking project providing project management and oversight for the cooking project.
SunGate **SunGate Solar**	SunGate Solar is a professional solar design, installation, and service company in South Sudan. Since its founding in 2013, SunGate has installed a wide range of Off-Grid solar power systems for individuals and private and public institutions. These include the University of Juba, Rumbek University of Science and Technology, and mobile money operator M-Gurush. With three offices, a team of 40 employees, and 9-years operating in the country, the company is well-positioned to lead a consortium of implementers working to increase energy access in South Sudan.	Mini-grid operator for the Wanyjok mini-grid project and on-the-ground delivery partner supporting the electric cooking experiments and pilot project.
CREATING HOPE IN CONFLICT: A HUMANITARIAN GRAND CHALLENGE **Humanitarian Grand Challenge (HGC)**	Creating Hope in Conflict: A Humanitarian Grand Challenge is a partnership of the U.S. Agency for International Development, the UK Foreign, Commonwealth & Development Office (FCDO), the Ministry of Foreign Affairs of the Netherlands, and Global Affairs Canada, with support from Grand Challenges Canada. HGC's goal is to find and accelerate life-saving or life-improving innovations to help the most vulnerable and hardest-to-reach people impacted by humanitarian crises caused by conflict.	Primary grant financing for part of the Wanyjok mini-grid project (SunGate equity / investment matched funding) as well as the full electric cooking pilot (VHSS).

 Dunn Family Charitable Foundation	Dunn Family Charitable Foundation was formed by Kelly and Ray Dunn in order to share from their financial abundance with persons and communities in need. The goals of the Foundation reflect the values and interests of the founders and their children. The Foundation is primarily focused on poverty alleviation and social justice.	Social impact investor and strategic oversight for SunGate Solar and the Wanyjok mini-grid project.
 PowerGen Renewables	Founded in 2011, PowerGen Renewable Energy is one of the leading solar electricity mini-grid developers active in East Africa. PowerGen aims to make clean, renewable energy accessible to more people in Africa and is currently serving over 10,000 customers across Kenya and Tanzania with 24/7, AC power through 90+ sites. The company employs over 120 full time staff and has 4 offices/warehouses across these 2 countries.	Engineering, Procurement, and Construction firm and mini-grid developer leading overall design, procurement, construction, installation, and commissioning of the Wanyjok mini-grid
 EarthSpark International	EarthSpark International is a non-profit focused on building business models to end energy poverty. EarthSpark currently operates 2 solar mini-grids in Haiti through their Haitian social enterprise Enèji Pwòp with plans to expand to an additional 20+ mini-grids over the next five years.	Technical advisors for mini-grid design, business model, and electric cooking research.

Executive Summary

In 2020 there were an estimated 2.4 billion people without access to clean cooking solutions and without accelerated action an estimated 2.1 billion people will still lack access to clean cooking in 2030. In South Sudan, over 99% of the population utilizes charcoal and firewood for cooking, often in dark, cramped, unventilated spaces.

These fuels are burdensome and expensive and can lead to significant negative impacts for the environment and the well-being of communities, particularly women. Cooking fuels, especially charcoal, are also very expensive and costs are increasing continuously with some households spending over 20% of their monthly income on cooking fuels. On top of all of this, traditional cooking fuels like charcoal and woodfuels are seen as a substantial driver of deforestation in South Sudan.

More broadly, South Sudan is one of the least electrified countries in the world with an estimated 7% of the population with access to electricity leaving over 10.4 million people unelectrified.

In Fall 2021, the Humanitarian Grand Challenges program funded two parallel projects in South Sudan to address energy poverty with Village Help for South Sudan (VHSS) and SunGate Solar as well as their partners Dunn Family Charitable Foundation, EarthSpark International, and PowerGen.

The first project with SunGate Solar developed South Sudan's first solar mini-grid in September 2022 in the rural market town of Wanyjok combining a solar array (55 kWp), battery storage (84 kWh/36kVA), and a diesel genset (66 kVA) to deliver reliable electricity to an initial 73 customers.

In parallel, the second project is an electric cooking pilot project powered by that SunGate solar mini-grid in Wanyjok which conducted controlled cooking experiments adapting South Sudanese cooking to electric pressure cookers and then deployed electric pressure cookers for 25 participants in Wanyjok as well as for SunGate's own operations and some of their other solar customers.

This initial electric cooking pilot has highlighted a number of key opportunities, needs, successes, and challenges for electric cooking including:

- **High compatibility of foods** – Most SS cuisine can be cooked in the EPC except kisra (flatbread) and fried foods like Mondasi (doughnuts)
- **Potential time and cost savings** – 15-50% cost savings (at a high $0.60/kWh) and 25-85% time savings for EPCs compared to charcoal for initial sampled meals
- **Need for bigger devices** – Most participants did not end up utilizing the EPC very consistently (<75% of days) and had very low consumption (<0.7 kWh/day of cooking). Most of these users highlighted that they liked the EPC and would use it more if it was bigger or fit their needs better
- **Pathways for high consumption users** – There were 6 participants who utilized the EPCs consistently (>75% of days) and had strong electricity consumption (>1.36 kWh/day of cooking). These users still highlighted similar challenges with the EPC,

but were able to find consistent use cases (e.g., utilizing the EPCs to cook specific meals when cooking for fewer people)

- **Successful integration with the mini-grid and potential for substantial load** - Even with the challenges and only a few "High Users", EPC load still represented about 10% of the total mini-grid consumption. Consumption was particularly significant early in the morning accounting for 33% of load in the 6:00 AM hour, 54% of load in the 7 AM hour, and 31% of load in the 8 AM hour
- **EPC benefits** – All of the participants highlighted that they liked how fast the EPC cooked especially compared to charcoal and woodfuels. 32% of the customers also highlighted that the EPC had "no stress" when cooking and an additional 16% of customers highlighted the benefit of no smoke when cooking
- **EPC challenges** – Every participant also noted that the biggest challenge for the EPC (and why they didn't use it more) was that the EPC was too small. An additional challenge that was noted by about 26% of participants was that the EPC couldn't cook specific dishes, particularly kisra, bread, and fried foods
- **Opportunity to target stand-alone solar customers** – One unexpected and unplanned success of the project was the integration of EPC cooking into SunGate and Water for South Sudan operations. Both entities now effectively utilize EPCs everyday to cook for their staff and are actively promoting the value of the EPCs. These initial deployments have showcased the key opportunity to couple electric cooking with SunGate's rapidly growing home, office, and commercial solar business making EPCs an important value add for the stand-alone solar customers
- **Need for innovative financing** – While costs savings are significant at US$0.60, the current cost-recovery tariff for the mini-grid is US$1.00. Notwithstanding the many benefits of eCooking over charcoal cooking, widespread adoption of eCooking will not occur on the mini-grid unless eCooking is cost competitive with charcoal cooking. There is a key need for innovative financing mechanisms like results-based financing (SDG7, gender, health, carbon, etc.), and consumer financing to reduce the costs and accelerate deployment of electric cooking solutions as well as the mini-grid and solar systems that power them

Overall, despite the challenges, the pilot electric cooking project demonstrated significant potential to multi-solve for electricity access and clean cooking by designing clean cooking solutions in parallel with new electricity access solutions, particularly mini-grids in South Sudan.

Introduction

This interim report provides an overview of Village Help for South Sudan (VHSS) SunGate Solar's pilot electric cooking project conducted with SunGate Solar on their mini-grid in Wanyjok, South Sudan. The report has six primary sections:

- **Overview of Global Electric Cooking** – Background information on the global clean cooking deficit and current electric cooking research and how this project broadly contributes to the literature
- **South Sudan Context** – Framing and background for the clean cooking sector in South Sudan including the existing challenges of baseline cooking fuels
- **VHSS / SunGate EPC Pilot Project in Wanyjok** – Detailed write-up for the VHSS / SunGate electric pressure cooker (EPC) pilot in Wanyjok including an overview of the project structure, methodology, results from cooking experiments and mini-grid pilot, as well as some key limitations of the project
- **Key Challenges and Lessons Learned** – Detailed rendering of key challenges and lessons learned highlighted by the EPC pilot project
- **Discussion** – Provides an elevated discussion of the results and potential next steps for scaling clean electric cooking in South Sudan
- **Conclusion –** A summary of the report and next steps

Overview of Global Electric Cooking

The SDG 7 tracking report highlights that in 2020 there were an estimated 2.4 billion people without access to clean cooking solutions. Despite some progress and a lot more focus at the country level on clean cooking (more than 65 countries have already included household energy or clean cooking related goals in their Nationally Determined Contributions (NDCs), population growth outpaced these improvements, particularly in Sub-Saharan Africa where the access deficit for clean cooking has nearly doubled since 1990 reaching an estimated total of 923 million people in 2020. Without accelerated action an estimated 2.1 billion people will still lack access to clean cooking in 2030. [1]

[1] ESMAP SDG 7 Tracking Report (2022); Available at: https://trackingsdg7.esmap.org/data/files/download-documents/sdg7-report2022-full_report.pdf

Baseline charcoal stoves in Wanyjok, South Sudan

At the same time, an estimated 733 million people lacked access to electricity in 2020, and for the first time in a decade, this number is set to rise by nearly 20 million in 2022. Among people without access to electricity, 77 percent—about 568 million people—lived in Sub-Saharan Africa in 2020. In order to meet 2030 electrification targets, globally new connections need to rise to 100 million a year. [2]

Globally, an estimated 3 million people received access to electricity via a mini-grid solution between 2010-2019, and IEA's electrification scenarios estimates that a minimum of 31 percent of the unelectrified population in Sub-Saharan Africa will gain access to electricity via a mini-grid or off-grid solar solution. [3] Previous estimates suggest that mini-grids will be the cheapest option for electricity access for 490 million of the 1.2 billion to be electrified by 2030.[4]

All of this highlights a need and key opportunity to multi-solve for electricity access and clean cooking by designing clean cooking solutions that can be deployed in parallel to new electricity access solutions, particularly mini-grids.

[2] ESMAP SDG 7 Tracking Report (2022); Available at: https://trackingsdg7.esmap.org/data/files/download-documents/sdg7-report2022-full_report.pdf
[3] ESMAP SDG 7 Tracking Report (2022); Available at: https://trackingsdg7.esmap.org/data/files/download-documents/sdg7-report2022-full_report.pdf
[4] Sustainable Energy For All. (2020). 2020 Tracking SDG7 Report; Available at: https://trackingsdg7.esmap.org/downloads

South Sudanese woman using an electric pressure cooker (EPC)

A novel solution, but one that has rapidly growing traction in the global clean cooking sector is electric cooking, especially electric pressure cooking. There is a growing body of evidence and initiatives that highlight the immense potential for electric cooking solutions to deliver reliable, affordable access to clean cooking, particularly when coupled with mini-grids and other electrification efforts. An overview of a few key landscaping studies for the electric cooking space can be seen below[5]:

- **ESMAP Cooking with Electricity**[6] – The report explored five case studies for a range of electric cooking solutions in different contexts. Overall, the report highlighted that electric cooking on national grids or mini-/micro-hydropower is already cost effective for many people today and that by 2025, the costs of cooking with AC appliances connected to solar hybrid mini-grids ($8–$25/month) and with DC appliances powered by solar home systems ($11–$24/month) become fully competitive if they aren't already. Overall, EPCs are expected to be cost competitive currently in areas with low-cost grid connections (electricity tariffs below USD 0.35/kWh) and high charcoal cost (above USD 0.40/kg). Finally, the report found that "the uptake of electric cooking will depend substantially on the willingness of solar companies, mini-grid operators and utilities to adopt cooking as part of the suite of services it offers its customers."

[5] EarthSpark International Electric Cooking Memo; Available at: https://www.earthsparkinternational.org/clean-cooking-memo.html
[6] ESMAP. (2020). Cooking with Electricity: A Cost Perspective. Washington DC: World Bank. Retrieved from https://openknowledge.worldbank.org/handle/10986/34566

- **Hivos Beyond Fire Report**[7] – Due to significant decreases in both batteries and PV modules (76% and 82%, respectively since 2010) as well as expanding demonstrations for customer preference and functionality, electric cooking is rapidly becoming a viable solution for clean cooking deployment, particularly in mini-grid systems. The study specifically found that electric slow cookers and pressure cookers can enable household cooking costs between EUR 3.56 – 9.53/month for mini-grids (4.19 – 11.21 USD) indicating that electric cooking is well within the range of cost-competitiveness of other alternatives.
- **MECS Solar Mini-grid Cooking Assessment**[8] –The study highlighted cost-competitiveness for electric cooking particularly for community service applications on a fully-renewable solar mini-grid. Specifically, the study found a range of Levelised Cost for Cooking a Meal (LCCM) for electric cooking ranging between 0.16 and 0.70 USD/kWh (depending on assumptions for device penetration and fuel stacking) which was comparable to all other cooking options for the area.
- **Efficiency for Access/CLASP EPC Brief**[9] – This brief systematically explored the market, potential, and barriers for expansion of EPC cooking. The brief echoed other studies highlighting the potential for cost-effective electric cooking and further showed that advances in EPC technology and increased availability of these products in key national markets have the potential to accelerate EPC adoption and competitiveness. The brief also highlighted new innovative strategies for supporting long-term adoption of EPCs including KPLC's Pika na Power campaign and EnerGrow's asset-based financing program both of which have been successful in driving uptake (and repayment of over 90%) of EPC devices. Among other recommendations, the brief highlighted the need to integrate cooking into electrification planning and renewable energy investments to accelerate SDG 7 goals for rural communities.
- **MECS EPC Consumer Insight Report**[10] – Through interviews with 718 EPC customers in Kenya, the report explored a number of elements of consumer acceptance and consumer feedback for EPC models and utilization. Among other findings, the report revealed that 90% of EPC users had no prior exposure to EPCs before making their purchase and that 24% of consumers were also served by solar home systems and mini-grids. The high percentage of first-time consumers demonstrates that EPCs are viable replacements for diverse households and have potential for growth in sales among off- and non-grid connected communities. The report also highlighted the importance of developing consumer-based financing tailored to individual communities and households.

[7] Couture, T. D., & Jacobs, D. (2019). Beyond Fire: How to Achieve Electric Cooking. Hivos; World Future Council. Retrieved from https://greeninclusiveenergy.org/assets/2019/05/Beyondfire_How-to-achieve-electric-cooking-1.pdf
[8] MECS. (2020). Accelerating uptake of electric cooking on AC mini-grids through business and delivery model innovations. Retrieved from https://mecs.org.uk/wpcontent/uploads/2020/06/MECS-TRIID-PowerGen-Project-Report.pdf
[9] Efficiency for Access / CLASP (2021). Electric Pressure Cookers Solar Appliance Technology Brief; Available at: https://www.clasp.ngo/wp-content/uploads/2021/05/EforA_Solar_Appliance_Technology_Brief_EPCs_July-2021.pdf
[10] MECS Electric Pressure Cooker Usability Testing Buyer's Guide; Available at: https://storage.googleapis.com/e4a-website-assets/Electric-Pressure-Cooker-Usability-Testing-Buyers-Guide_final.pdf

South Sudan Context

Cooking and food are core to culture in South Sudan. It's what brings families and communities together. However over 99% of the country utilizes charcoal and firewood for cooking, often in dark, cramped, unventilated spaces.[11]

Baseline charcoal stoves in Wanyjok, South Sudan

These fuels are burdensome and expensive and can lead to significant negative impacts for the environment and the well-being of communities, particularly women. In fact, it is estimated that over 10,000 people in South Sudan die annually from conditions attributable to household air pollution from cooking (e.g., ischaemic heart disease, respiratory infections, COPD, lung cancer, etc.).[12]

Further, cooking can be a significant time burden for women with some meals taking 4-5 hours of their time per day. Cooking fuels, especially charcoal, are also very expensive and costs are increasing continuously with some households spending over 20% of their monthly income on cooking fuels. On top of all of this, traditional cooking fuels like charcoal and woodfuels are seen

[11] SDG7 Tracking Report; Available at: https://trackingsdg7.esmap.org/country/south-sudan
[12] WHO Household Air Pollution; Available at: https://www.who.int/news-room/fact-sheets/detail/household-air-pollution-and-health

as a substantial driver of deforestation in South Sudan (deforestation rate is currently estimated at 1.5%-2%).[13]

The clean cooking sector in South Sudan, is unfortunately quite limited. There have been some small clean cooking projects implemented in the country including an assessment of ethanol cooking in White Nile State (UNHCR 2019)[14], a small ICS manufacturing pilot in Northern Bahr el Ghazal state (FAO SAFER)[15], ICS and briquette cooking in Jur River County (CORDAID / HARD)[16], and a biogas initiative in Malakal (IOM[17]). This VHSS / SunGate project marks the first electric cooking pilot project in the country.

More broadly, South Sudan is one of the least electrified countries in the world with an estimated 7% of the population with access to electricity leaving over 10.4 million people unelectrified.[18] Even in electrified areas like Juba, the capital, electricity supply is unreliable with constant outages and disruptions.

In the absence of reliable electricity households and businesses must remain without power or rely on diesel generators which are very expensive to operate given the high cost of diesel fuel and complicated logistics in South Sudan.

This energy poverty critically limits South Sudan's potential economic development and exacerbates the challenges for its people.

In the face of all of this, the government has set a number of targets to expand electrification and clean cooking in South Sudan, but progress has been slow.[19][20] There are a number of private sector led initiatives, however, that have demonstrated success in driving energy access in South Sudan.

SunGate Solar, for example, has developed over 180 projects deploying over 2 MW of stand-alone solar+storage projects for a variety of customers in South Sudan including households, NGO / international partners (e.g., Water for South Sudan, UNHCR), institutions (hospitals and universities), and businesses (hotels / guest houses, restaurants, etc.).

In September 2022, SunGate launched South Sudan's first solar mini-grid in the town of Wanyjok located 40 minutes northeast of Aweil in Northern Bahr el Ghazal state. Wanyjok is a rural market town home to about 20,000 people, and while some businesses utilize expensive diesel generators for some limited electricity, most people in Wanyjok currently have no access to reliable electricity.

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[13] Black Gold Report (2021); https://globalinitiative.net/wp-content/uploads/2021/03/Black-Gold-The-charcoal-grey-market-in-Kenya-Uganda-and-South-Sudan.pdf-GITOC.pdf
[14] UNHCR Refugees in Sudan Reap Benefits of Clean Cooking Energy; Available at: https://www.unhcr.org/news/stories/2021/2/6038cc6b4/refugees-sudan-reap-benefits-clean-cooking-energy.html
[15] FAO/USAID SAFER; Available at: https://www.fao.org/south-sudan/news/detail-events/zh/c/1368051/
[16] Cordaid Partners for Resilience Cookstove Project; Available at: https://www.cordaid.org/en/news/clean-cookstoves-a-simple-way-to-strengthen-resilience/
[17] IOM Green Energy Initiatives in WASH - Biogas
[18] SDG7 Tracking Report; Available at: https://trackingsdg7.esmap.org/country/south-sudan
[19] South Sudan's Second National Communication on Climate Change; Available at: https://www.undp.org/sites/g/files/zskgke326/files/migration/ss/South-Sudans-Second-Nationally-Determined-Contribution.pdf
[20] AfDB South Sudan Energy Plan; Available at: https://www.afdb.org/fileadmin/uploads/afdb/Documents/Generic-Documents/South%20Sudan%20Infrastructure%20Action%20Plan%20-%20%20A%20Program%20for%20Sustained%20Strong%20Economic%20Growth%20-%20Chapter%208%20-%20Provision%20of%20Electricity%20and%20Rural%20Energy.pdf

Pilot Project in Wanyjok

Overview

In Fall 2021, the Humanitarian Grand Challenges program funded two parallel projects in South Sudan with Village Help for South Sudan (VHSS) and SunGate Solar as well as their partners Dunn Family Charitable Foundation, EarthSpark International, and PowerGen.

The first project with SunGate Solar developed South Sudan's first solar mini-grid combining a solar array (55 kWp), battery storage (84 kWh/36kVA), and a diesel genset (66 kVA) to deliver reliable electricity to an initial 73 customers. The majority of these customers are small business and institutional customers including pharmacies, health clinics agrovets, computer/printing centers, retail stores, and restaurants.

SunGate and PowerGen teams launching the Wanyjok mini-grid

In parallel, the second project is VHSS's electric cooking pilot project powered by that SunGate solar mini-grid in Wanyjok. The HGC electric cooking pilot had three key components which are explored individually in detail below:

- **Controlled Cooking Experiments** – Initial controlled experiments testing EPCs and South Sudanese cuisine in the SunGate offices in Juba.
- **SunGate Operations and C+I Customers** – Deployment of EPCs for SunGate operations and C+I customers

- **Mini-grid Pilot** – Pilot EPC study with 25 participants in the Wanyjok mini-grid

Each of these components have yielded key insights for the viability of electric cooking in South Sudan.

Methodology

Selection of EPCs

VHSS / SunGate ultimately selected two EPC models to test through the cooking experiments for deployment for participants. The first was the REBUNE 8L electric pressure cooker and the second was the Nutricook 8L electric pressure cooker. These EPCs were selected based on availability and price in the markets in Nairobi and Khartoum.

Cooking Experiments

SunGate, with oversight from VHSS and EarthSpark International, conducted a number of EPC cooking experiments in the early stages of the project to test EPCs, build capacity, and gather initial cooking data. To do this a "lab" setting was created in the SunGate offices in Juba to track electricity consumption and other variables for meals cooked in the EPCs.

Selection of Mini-Grid Pilot Participants

Initially the pilot project was supposed to focus on residential customers only, but this needed to be adjusted to include other types of participants (see mini-grid pilot section below). Ultimately, participants were selected based on a number of factors:

- Alignment with mini-grid footprint
- Whether or not they were regular customers of the mini-grid
- Average number of meals cooked per day
- Type of cooking customer (household, clinic, shop, small vendor, restaurant)
- Interest in, willingness, and capacity for participating in the electric cooking study

EPC training in Aweil

Mini-grid Pilot Setup

For the mini-grid pilot, selected participants received an EPC for free (sometimes two EPCs for the larger demand customers). The pilot planned to give the electricity for free as well for up to 3 months so that participants could learn and get used to utilizing the EPC for cooking. After the 3 months the electricity cost would be set at the prevailing mini-grid tariff of $1.00 / kWh. This interim report focuses on the first three months of electric cooking observations from the mini-grid EPC pilot from October 2022 to December 2022, so only focuses on the "free period" and does not track any cost comparisons for the participants though indicative cost comparisons were developed as part of the initial cooking experiments.

Participant Training

Each participant received direct training from SunGate staff for the use of the EPC both in the form of community demonstration events whereby SunGate staff demonstrated cooking a specific meal in the EPC for a group of participants as well as one on one training in the participant's home or place of business when the EPCs were installed. SunGate staff also provided additional "re-training" and customer support for questions once the EPCs were online.

Mini-grid Installations

The electric pressure cookers were connected to a 60A smart meter with circuit protection via a 25A circuit breaker which in turn was connected to a breaker box and then to a 60A smart meter for the overall household (Figure 1). A third 60A smart meter was also installed in parallel with the EPC meter for monitoring of all customer consumption not specific to electric cooking.

This setup was chosen to allow for individual measurement of each cooking device as well as the overall "non-cooking" electricity consumption. This helped to avoid the need for specific load

disaggregation which has been a challenge for other studies. Additionally, when EPC and non-cooking tariffs eventually align and no longer require disaggregated monitoring, this configuration allows for the most seamless transition to a standard installation.

Installation of devices followed best practices, in the context of rural South Sudan and, more generally, for East Africa as defined by the overseeing project Engineering, Procurement & Construction firm (PowerGen) at the time of installation. Efforts were taken to source adequate cabling for the pilot to allow for placement of the electric pressure cookers at the most appropriate location within the residence, considering both customer cooking preferences and security of the of the equipment. Materials specific to electric cooking were sourced in Juba, due to the interest in first testing in the SunGate Juba office to best ensure all project objectives being met.

Any instance necessitating alternative methods were described to the customer during training, to allow for ensured safe operation of the system. Future installations will work to return to normal installation practices.

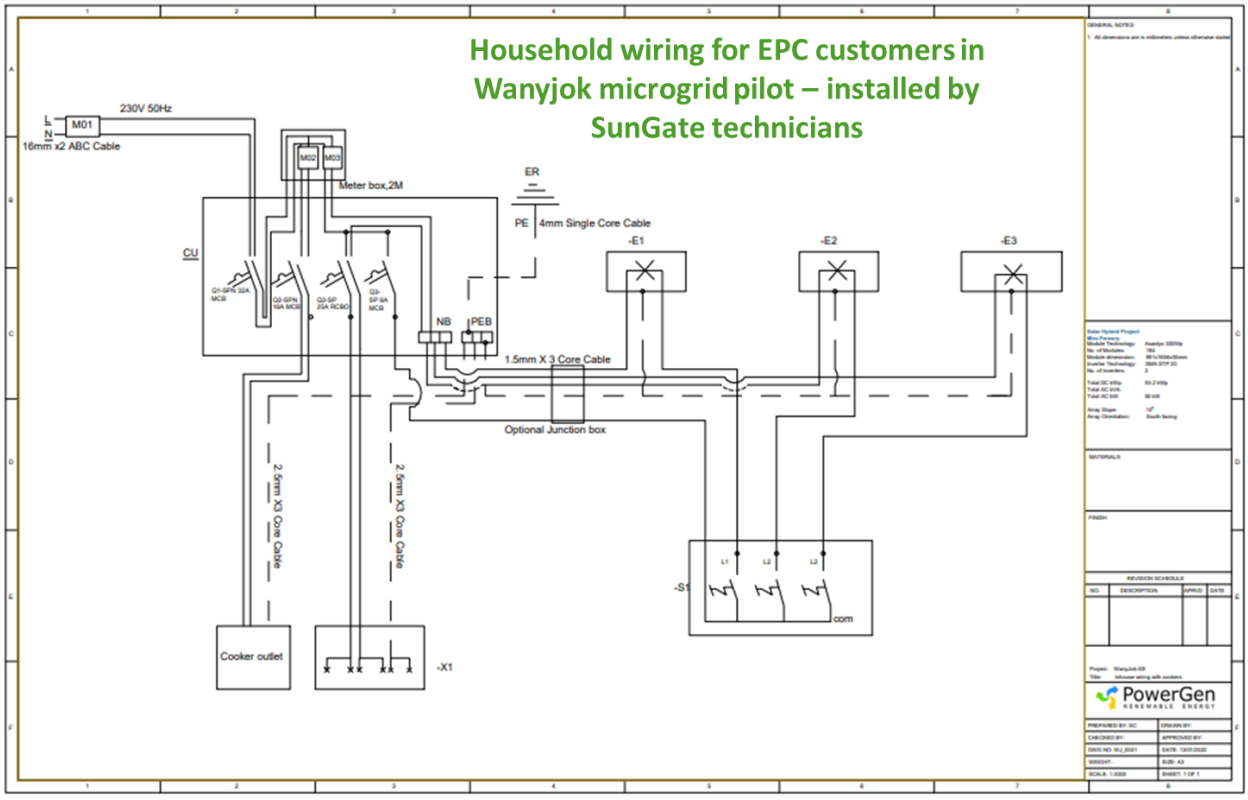


Figure 1: Line Diagram for EPC Mini-Grid Installation

One concern leading into this study was the potential for tampering of the system, risking the integrity of the electric cooking pilot. The provision of free electricity, even for a relatively short period of time, alongside paid for electricity ($1.00/kWh for non-cooking energy uses) in a region with high existing competency with building electrical wiring provided a temptation that the project team hoped to mitigate as best as possible. If a customer or adjacent resident were to connect to the installation intended for electric cooking, it would artificially increase the consumption witnessed within the pilot study, compromising the results.

Efforts taken to mitigate this risk of tampering included:

- Placing a "totalizer" meter on the adjacent utility pole
- Placing customer load meters (both electric cooking and non-cooking consumption) elevated and on the external surface of the customer structure
- For electric cooking, using armored cable from the point of the electric cooking meter to the electric cooking receptacle
- Selecting breaker and receptacle enclosures with the capability to lock by SunGate staff
- Leaving the electric cooking outlet locked within the receptacle enclosure, allowing the only access point to be the specialized terminal designed specifically for the electric cooking in use
- Monitoring of customer energy consumption for any signs of use inconsistent with an electric pressure cooker or other potential warning signs

As of the writing of this report, there have been no clear indications of tampering or inappropriate consumption from those included within the study, which bodes well to the approach taken to mitigating the risk.

Data Sources and Analysis

The project collected a variety of quantitative and qualitative data streams utilizing a variety of different methods including:

- **Surveys** – Customer surveying was done in person by SunGate field staff and surveys were conducted utilizing KoboCollect and tablets. This included baseline surveys as well as follow-up customer satisfaction surveys
- **Electricity Consumption** – Electricity consumption was measured by SparkMeter smart meters connected specifically for the EPC devices
- **Cooking Diaries** – SunGate field staff recorded daily "diaries" in a Google Form for participants focused on four questions: 1) what meals were cooked; 2) what fuel was used; 3) if EPC was used how did things turn out; 4) were there any specific challenges?
- **Cooking Experiments** – Data was recorded in a Google Form

All data analysis was done in Excel.

Initial Cooking Experiments

At the start of the project, the project team conducted a series of cooking experiments with electric pressure cookers in SunGate's offices in Juba. These experiments were designed to accomplish a number of goals including:

- Test different models of electric pressure cookers in order to determine which model would work best for the pilot mini-grid deployment
- Build SunGate staff's capacity and familiarity with the electric pressure cookers
- Test compatibility of different South Sudanese cuisine with the electric pressure cookers
- Estimate preliminary time, energy and cost implications of cooking using electricity in South Sudan and develop initial comparisons to baseline charcoal and firewood fuels

Over a two-month period SunGate cooked over 60 EPC meals across a variety of cuisine types ultimately highlighting:

- High compatibility of foods – most SS cuisine can be cooked in the EPC except kisra (flatbread) and fried foods like Mondasi (doughnuts)
- 15-50% cost savings (at a high $0.60/kWh) and 25-85% time savings for EPCs compared to charcoal for initial sampled meals.

A summary of the cooking experiments can be seen in Table 2 below.

Table 2: Summary of Controlled Electric Cooking Experiments

Meal	Times Cooked	Avg. EPC Total Cooking Time (minutes)[21]	Avg. Cooking Time (minutes) (Charcoal/Firewood)	Avg. Electricity Consumption (kWh)	Electricity Cost (SSP)	Charcoal/Firewood Cost (SSP)	Savings (SSP)	Savings (Minutes)
White Beans	4	57.5	173.3	0.7	175.0	316.7	141.7	115.8
Rice	23	20.3	35.7	0.3	63.3	78.3	15.0	15.3
Green Beans	10	62.9	173.3	0.7	156.6	316.7	160.1	110.4
Adas	6	9.0	67.5	0.3	67.0	112.5	45.5	58.5
Beef	6	28.7	127.1	0.6	141.9	182.9	41.0	98.5
Chicken	4	45.0	150.0	0.6	141.9	375.0	233.1	105.0
Asida	5	23.6	31.6	0.4	105.2	90.4	-14.9	8.0
Red Beans	1	74.0	173.3	0.6	149.0	316.7	167.7	99.3
Fish	2	19.0	120.4	0.5	108.8	155.6	46.8	101.4

[21] Includes time to pressure, cook time, and pressure release

SunGate Operations, and C+I Customers

Following the success of the initial experiments, SunGate outfitted its offices in Juba, Wau, and Wanyjok with EPCs to support staff meal prep. In total, SunGate has now trained 20+ staff to cook with the EPCs and eight do so regularly for SunGate meals. At least 1 staff member has also purchased an EPC for their own household with multiple additional staff inquiring about the potential.

"My first encounter with the electric pressure cooker was a bit worrying because I had never used one before. However, it is very easy to learn and use. I am now even training other SunGate staff. The best thing about the EPC is that it does not take much time at all. Food gets ready fast and is always cooked well. Insha Allah, if I open my own restaurant, I will purchase an EPC. I would also want to get one for my children in Kampala. I cannot wait to stop using charcoal in my home."

Asha Jabber, SunGate Solar Cook

Through this, SunGate has also demonstrated the EPCs for some of their stand-alone solar customers as well. For example, Water for South Sudan is a large NGO with operations and offices across South Sudan. SunGate had previously installed a stand-alone solar system for their compound in Wau. SunGate did an EPC demonstration event for the Water for South Sudan staff which led to Water for South Sudan purchasing an initial 5 EPCs from SunGate as part of a trial for their operations. SunGate then supported them with on-site trainings and EPC setup. Water for South Sudan is now promoting their EPC cooking and interested in further partnership with SunGate. This initial partnership with Water for South Sudan illustrates a key potential avenue for scaling electric cooking in South Sudan.

While both the SunGate office deployment and the Water for South Sudan deployments were not part of the VHSS electric cooking project, they happened because of the initial successful experiments from VHSS / SunGate.

Wanyjok Mini-grid Pilot

Participants and Meals Cooked

In total, 25 participants were selected for the mini-grid EPC pilot:

- 3 households (cooking for self-consumption)
- 4 health clinics (cooking for staff)
- 8 shops (cooking for shop owner)
- 5 small vendors (cooking small portions of beans, rice, and stew to sell)
- 5 restaurants (cooking larger meals for sale to customers)

15 of the participants (the households, clinics, and shops) were all utilizing the EPCs to cook for their families/staff (e.g., for self-consumption), while the 10 small food vendors and restaurants were making food to sell to others. In general, each participant was given one electric pressure cooker each with the exception of the restaurants and one of the larger clinics which were given two to handle the higher cooking demand (Figure 2).

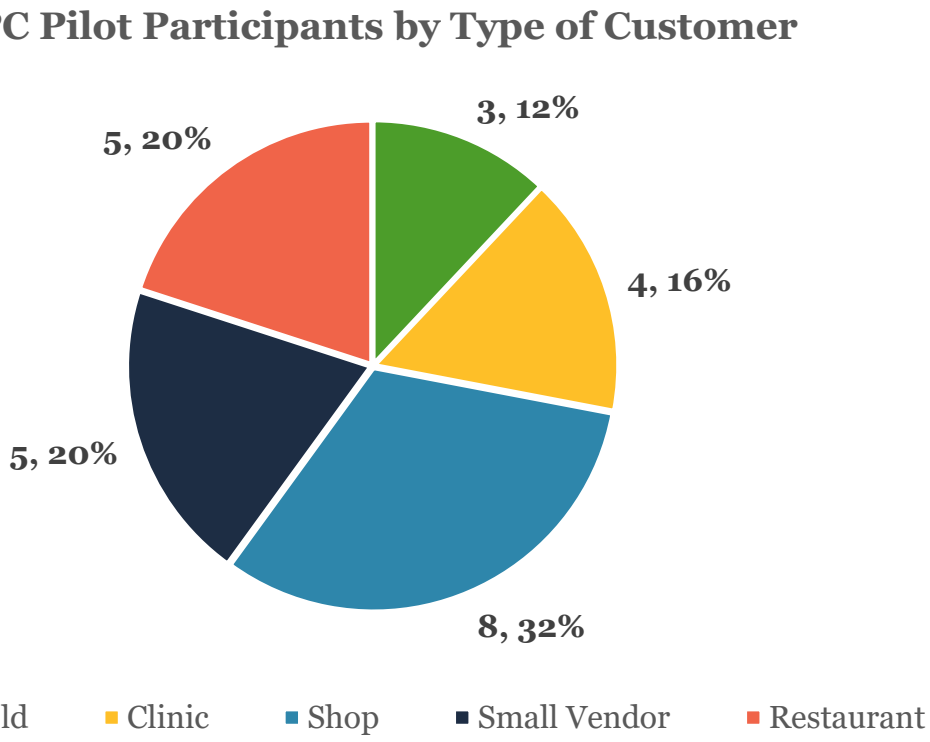


Figure 2: EPC Pilot Participants by Type of Customer

The pilot participants have been able to utilize the EPC to cook a variety of South Sudanese meals. The most commonly cooked foods were beef, beans, chicken, rice, and adas (Figure 3).

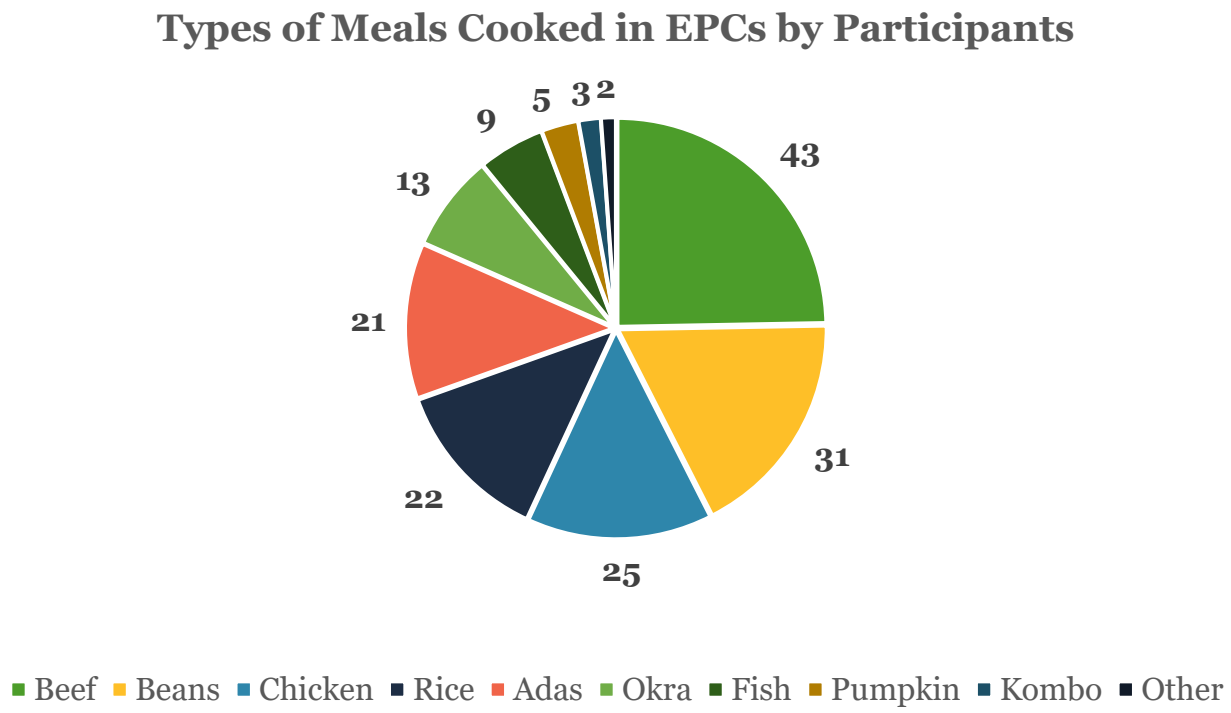


Figure 3: Types of Meals Cooked in EPCs by Participants

Electricity Consumption

Overall, the pilot had mixed success across all participants due to some challenges with the sizing of the EPCs, capacity of users, etc. (see customer satisfaction and challenges sections below). Ultimately the initial pilot has highlighted two distinct groups of users.

The first group are the "low users" who did not end up utilizing the EPCs very consistently (<75% of days) and had very low consumption (<0.49 kWh/day of cooking). The majority of participants fell into this category (19 participants total). Most of these users highlighted that they liked the EPC and would use it more if it was bigger or fit their needs better (see customer satisfaction and challenges sections below). This suggests that electric cooking could work for these users if different devices were procured.

That being said there were also some very high use participants who utilized the EPCs consistently (>75% of days) and had strong electricity consumption (>1.36 kWh/day of cooking). These users still highlighted similar challenges with the EPC, but were able to find consistent use cases. For example, utilizing the EPCs to cook specific meals when cooking for less people (e.g., lunch for households) or parts of meals that were better suited for the EPCs (e.g., chicken, rice, beans) and leaving other larger elements like stews, asida, etc. to be cooked with traditional stoves and fuels (Figure 4).

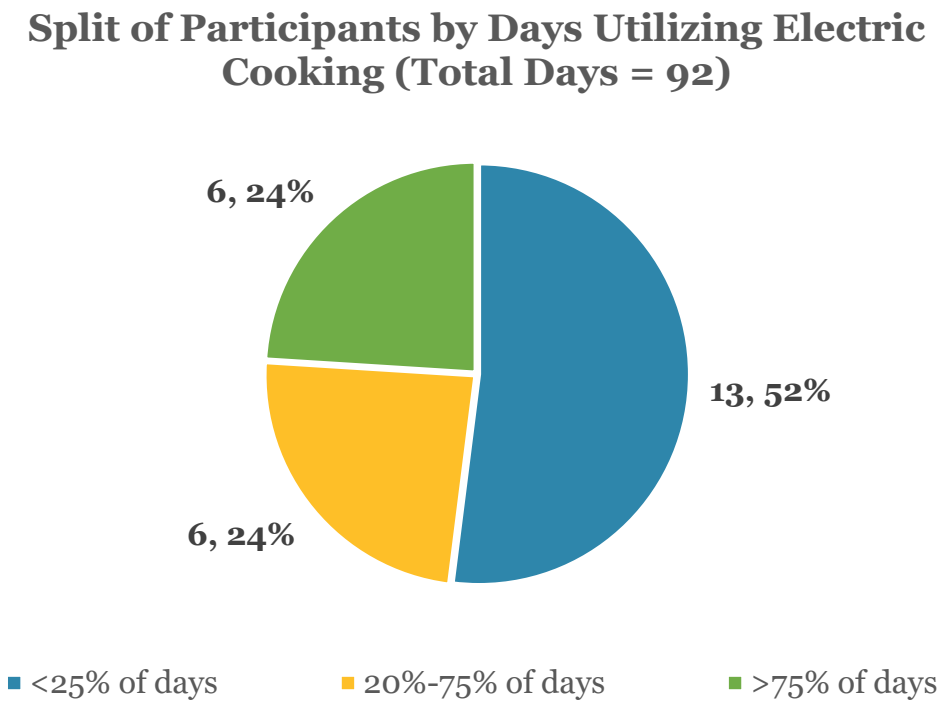


Figure 4: High User vs. Low User Participants

There weren't any conclusive rationales for why a participant was a high user or not, but a few important variables were highlighted:

- **Size of Cooking Need** – Users with smaller cooking demand overall or at least smaller cooking demand for particular meals (e.g., households) were also more likely to utilize the EPC as the size challenge became less of a concern for the smaller meals
- **Previous Experience with EPCs –** Some of the participants had previous exposure to EPCs when they lived in Khartoum, Sudan

In total, the high users accounted for 84% (795.5 kWh) of the total EPC consumption in the period (Figure 5). Average daily consumption when cooking and overall average daily consumption for high users were 1.36 kWh and 1.25 kWh, respectively compared to 0.49 kWh and 0.17 kWh for low users and 0.70 kWh and 0.43 kWh for the total participant sample (Figure 6).

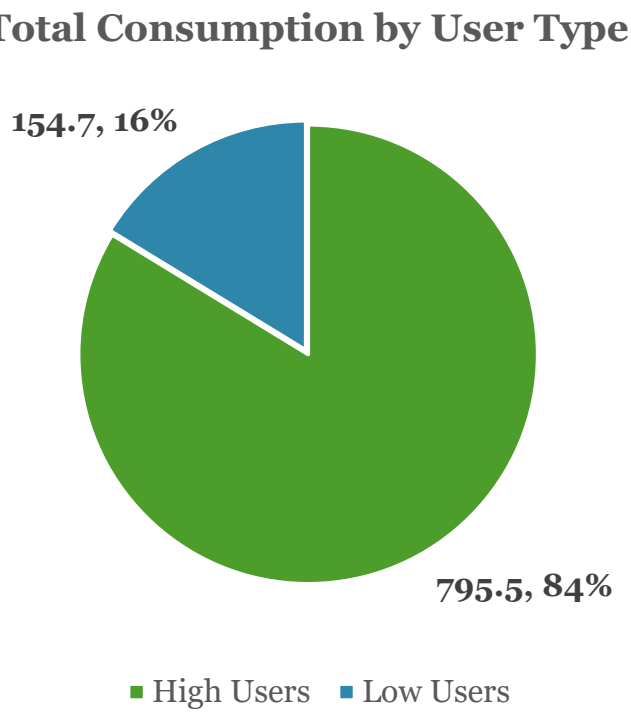


Figure 5: Total Consumption by User Type

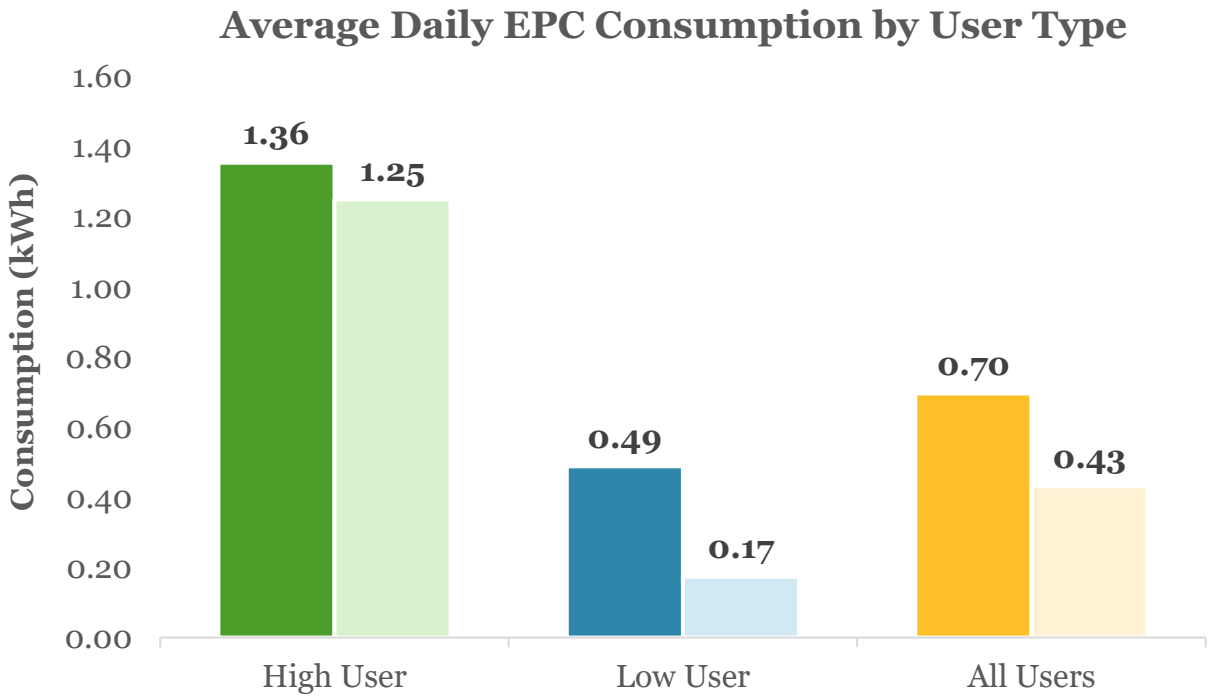


Figure 6: Average Daily Consumption by User Type (dark bars = average on days with cooking; light bars = overall average)

Electricity consumption also varied significantly across participant types. In general, households and restaurants averaged higher daily average consumption values both on cooking days and

overall. While sample sizes are too small to be conclusive, both households and small vendors had higher proportion of "High Users". As above, the use case for these participants aligned better with the EPCs with both households and restaurant participants reporting that they were able to allocate a particular meal (e.g., lunch) or a particular part of a meal (e.g., chicken) to the EPC. In total, of the six "High Users", one was a restaurant, two were households, two were small vendors, and one was a clinic.[22] This highlights the potential feasibility of electric cooking for a variety of customer types if challenges can be overcome (Table 3).

Table 3: Average Consumption by Participant Type

Participant Type	Count of Participants	Average Daily Total (kWh)	Average Daily when Cooking (kWh)	Proportion High Users
Household	2	1.67	1.87	100%
Clinic	4	0.30	0.57	25%
Shop	9	0.01	0.21	0%
Small Vendor	5	0.45	0.71	40%
Restaurant	5	0.78	1.20	20%
Total	25	0.43	0.70	24%

Mini-grid Integration

Overall consumption was lower than what was initially expected during the mini-grid design phase, but other than that the integration of EPCs into the mini-grid shows strong promise.

Even with the challenges and only a few "High Users", EPC load still represented about 10% of the total mini-grid consumption during the observed period. The EPC load was particularly significant early in the morning accounting for 33% of load in the 6:00 AM hour, 54% of load in the 7 AM hour, and 31% of load in the 8 AM hour (Figure 7). This aligned with average high consumption / cooking times for EPC users (Figure 8).

[22] It should be noted that several restaurants classified as "Low Users" cooked with the EPC about 60% of days – several may also have been closed during the holiday season (December 2022) which may have lowered total cook days.

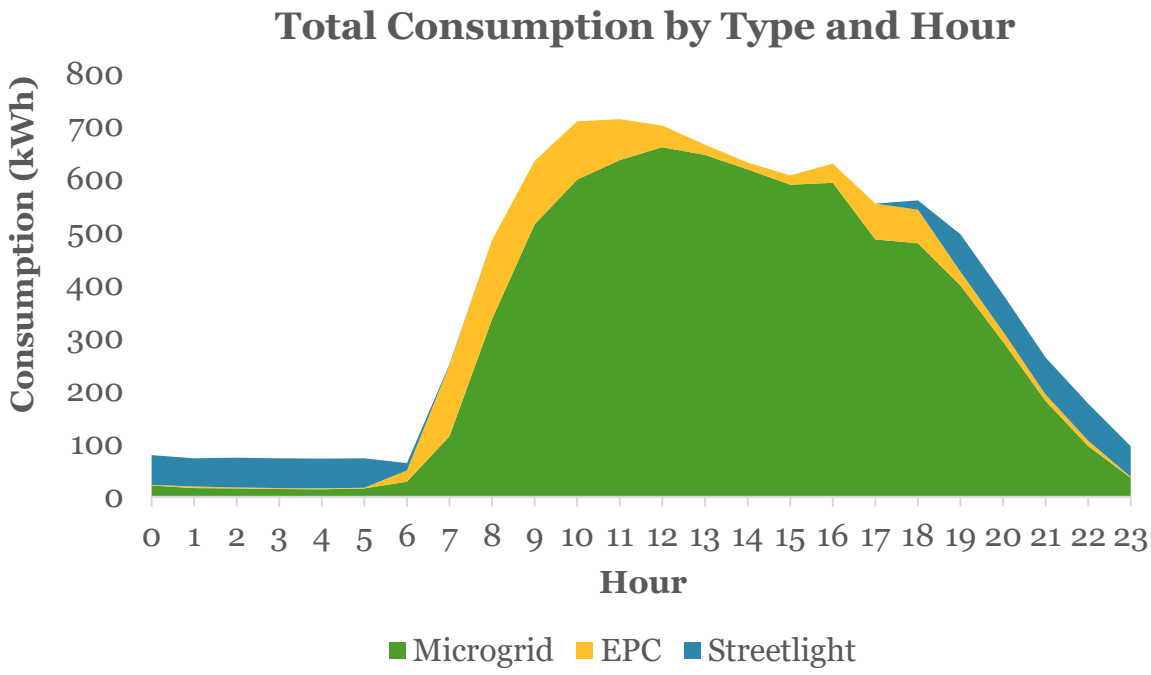


Figure 7: Total Mini-grid Consumption by Customer Type and Hour

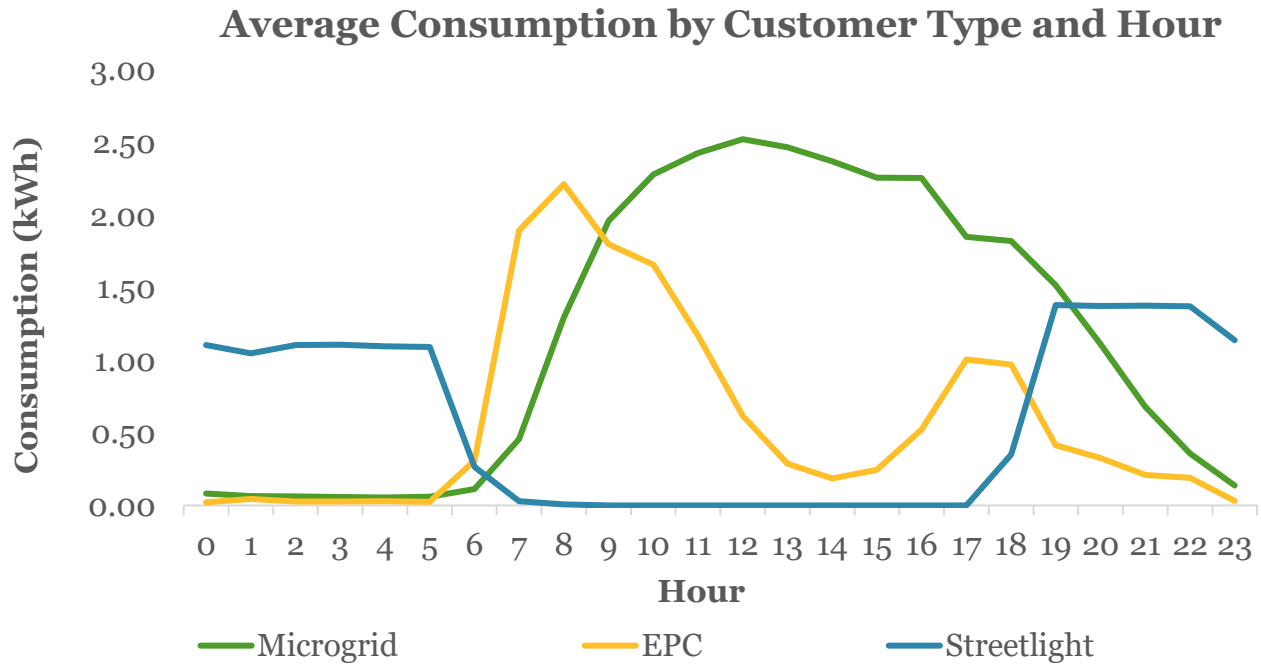


Figure 8: Average Consumption by Customer Type and Hour

Customer Surveys

At the end of the three-month period participants were surveyed about electric cooking and the EPCs themselves. In total 19 of the participants were surveyed (others were out of town or

otherwise unable to be surveyed). Every participant highlighted that they did appreciate the EPC and thought that it was a "very good device." Specifically, 100% of participants highlighted that they liked how fast the EPC cooked especially compared to charcoal and woodfuels. 32% of the customers also highlighted that the EPC had "no stress" when cooking and an additional 16% of customers highlighted the benefit of no smoke when cooking (Figure 9).

"Cooking with electricity is enjoyable, it cooks fast and clean food. Before, cooking was difficult for me because I cannot leave the food on fire and go do other things, it might cause a fire outbreak within the market or the food might burn…And now with the EPC you can set time then go and do whatever you want to do without fear because when the time is over, it just goes off alone and keeps your food warm."

Aluet Bol Atem, Small Food Vendor

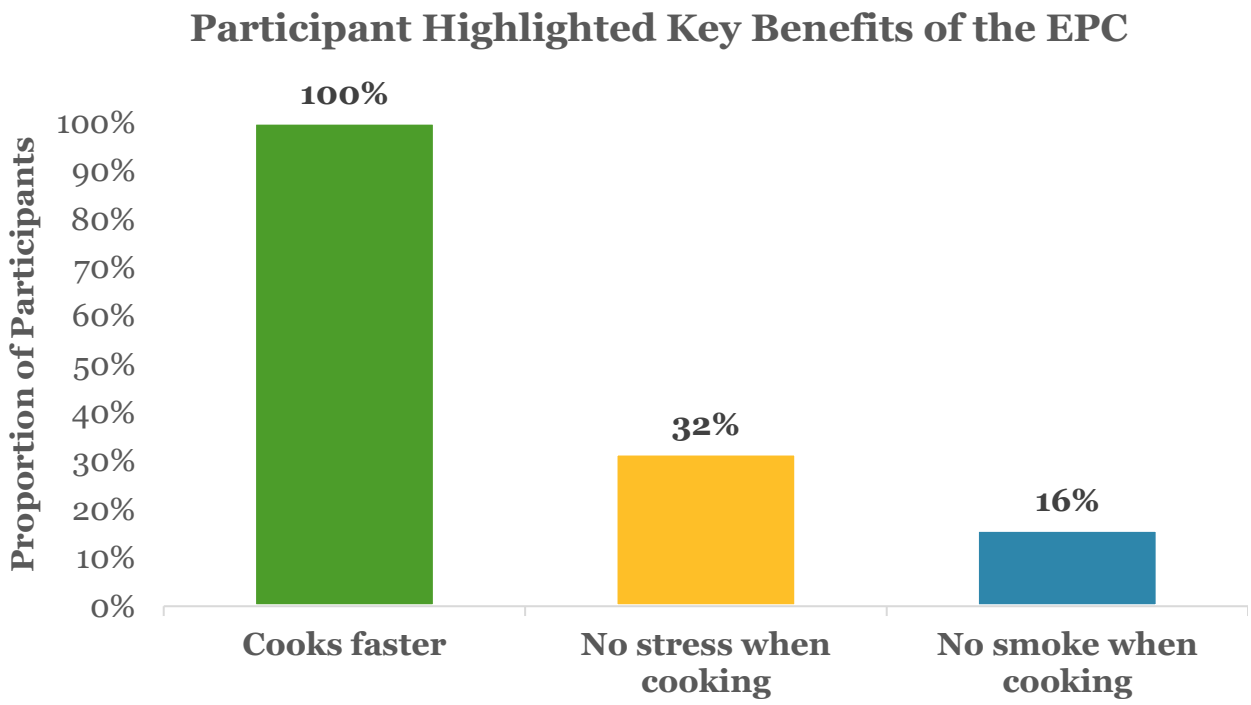


Figure 9: Participant Highlighted Key Benefits of the EPC

Despite this, every participant also noted that the biggest challenge for the EPC (and why they didn't use it more) was that the EPC was too small. An additional challenge that was noted by about 26% of participants was that the EPC couldn't cook specific dishes, particularly kisra, bread, and fried foods.

Challenges and Lessons Learned

The different EPC pilot components above have highlighted a number of key challenges and lessons learned for electric cooking and electric pressure cookers in South Sudan.

Baseline costs / needs and data collection

Collection of baseline charcoal costs for participants was challenging for a number of reasons. First many people bring home food from the market / jobs which makes it difficult to fully track

Charcoal bag at the market in Wanyjok

meals cooked in a given household. Further, firewood is used as a backstop to fill shortfall in charcoal purchasing which makes the true costs per meal / week difficult to fully capture. Prices themselves are actually quite volatile particularly in more rural locations (fluctuating shop to shop), so there is a need to establish price lines in more fixed or systematic ways outside of the main urban areas where prices are more consistent.

It was also difficult to train field staff to collect charcoal and baseline costs reliably and accurately and there was very limited ability to do QA / QC for reported numbers making the baseline cost data not too reliable for this study. Similarly, it was also difficult to establish baseline cooking needs for participants (times per day cooked, for how many people cooked, charcoal used, etc.). There is potential to screen for high-capacity beneficiaries/participants and leverage their responses to develop proxies for other customers which would help to address some of the costing outlier issues.

For other data, particularly the daily meal diaries from participants, collection processes were time consuming for field staff. Initially the setup was a questionnaire form that field staff would enter following conversations with participants. This was good for facilitating data entry and limiting data errors; however, it was still time consuming for field staff to engage with customers and record responses.

EPC Functionality and Cooking

By far the most commonly observed challenge was the need for bigger capacity EPCs. The pilot study utilized 8-quart EPCs as those could be somewhat readily sourced in the Nairobi and Khartoum markets. However, these proved to be too small for many of the participants due to a combination of large cooking demand (e.g., high number of people per meal for both households and other participant types) and some of the South Sudanese foods being cooked (e.g., Asida for example takes a large volume of space and water to cook).

There are certainly higher capacity EPCs being manufactured (e.g., 10, 12, and even 20-quart models), but they are currently less readily available, especially for South Sudan. However, studies like this that highlight the big market opportunity / need can hopefully help to develop pathways for larger fit-for-purpose devices to enter the market.

The electric cooking experiments highlighted significant challenges with the initial EPC selection from REBUNE as it had very limited flexibility for setting timers (could only do intervals of five minutes and had to use preset buttons which made it very confusing for

operators). The cooker was initially selected because it had an Arabic faceplate which would have been very helpful for participants, but ultimately it wasn't deployed because of the timer challenges.

The Nutricook system that was ultimately utilized for the pilot project had different challenges. The EPC comes with almost 20 preset buttons on the EPC which, while may be nice for more advanced users, these preset buttons, especially when they are in English only serve to confuse new users. In the end, sourcing and/or working with manufacturers and groups like MECS to develop more tailored EPC solutions would be beneficial for greatest rates of adoption.

South Sudanese woman making kisra over a traditional charcoal flattop stove

The early cooking experiments also highlighted that there were a few key South Sudanese dishes that could not be cooked effectively in the EPC, particularly "kisra" a South Sudanese flatbread (requires high temperature and larger flattop surface) and some of the fried foods like mondasi, a breakfast doughnut. This underscores a key need to prove out the model for other appliances for frying (e.g., air fryer) and kisra (e.g., flat top griddle; injera/crepe maker).

Participant Training

There were some participants who grasped concepts quite quickly, but in general participants struggled early on to understand and confidently utilize the EPCs for cooking by themselves which caused SunGate staff to need to provide substantial "retraining" and continued support for participants. A lot of this is to be expected given the new technology which is dramatically different from what the participants are used to, however there likely is room to improve the

training procedures. Further there is a need to develop more pictographic leave behind materials for customers.

For the initial pilot, project staff quickly grasped concepts (times, quantities, procedures, safety, etc.), but actually demonstrating and teaching participants was much harder. More practice for delivering trainings would likely be helpful.

EPC training for participants in Wanyjok

Participant Selection

Another challenge was related to participant selection. Initially the pilot project planned to target solely households as their cooking needs were expected to align better with the EPCs. However, due to the ultimate design of the mini-grid system, this had to be adjusted as there were not enough households within the initial grid footprint. Further a number of households and small vendors had informal setups and lacked permanent secure locations that would enable both an electricity connection and the deployment of an EPC.

Procurement and Costs of EPCs

Since there is no established electric cooking market in South Sudan, and procurement to the country is generally challenging the EPC unit costs were very high. The Base Cost per unit from individual suppliers in Kenya / Sudan was $130, but the landed cost per unit for VHSS / SunGate at the Wanyjok mini-grid ended up being $255. For this pilot, participants received the EPCs for free as the costs of the were covered by grant capital (to prioritize generating actionable research data from the pilot), but this price point is likely way too high for most customers outside of maybe NGO partners (e.g., Water for South Sudan) and some larger stand-alone solar customers.

Nutricook EPC with goat stew ingredients

There were a number of factors that contributed to the high unit costs for EPCs including, but not limited to:

- Procurement was done through individual, single sellers from markets in Nairobi and Khartoum. Opportunity to work directly with larger distributors or manufacturers to lower costs
- Ultimately, the pilot had a small procurement volume (10-20 units / seller), but there may be potential to get better pricing for buying in bulk

- Procurement for EPCs was uncoordinated / uncoupled from other mini-grid equipment which raised the overall cost, but highlights an opportunity to coordinate with existing procurement streams
- There are no existing electric cooking suppliers in South Sudan and there was substantial hesitation from external suppliers to service South Sudan. For example, South Sudan had early conversations with BURN manufacturing to directly supply their EPCs for the pilot, but BURN quickly indicated that South Sudan was not a target market at this time.
- Initially, VHSS / SunGate had unclear specifications for the EPC features, functionality, design, etc. needed for South Sudan
- Unfavorable import conditions and tariffs elevated landed costs. High taxes, particularly from Khartoum forced 1 by 1 procurement processes. Foreign exchange control policies in Sudan forced procurement process to exchange for USD twice in order to get receipts in USD

The initial pilot project highlighted a few key actions to take to help mitigate the costs of future EPC procurement for VHSS / SunGate and its customers:

- **Connect directly to suppliers / manufacturers** – Leverage MECS and other partners along with initial pilot results to build relationships directly with suppliers and manufacturers. This will help to lower procurement costs, cut down on middlemen costs, and support pathways for buying more in bulk. Further as highlighted above, this can also potentially help to tailor EPCs for the South Sudan context.
- **Bulk procurement** – Buying in bulk (especially directly from suppliers) can drop the per unit cost substantially at point of purchase, but also downstream by allowing for more easily coordinated procurement.
- **Coordinate / couple procurement streams** – SunGate has significant existing procurement streams and operations from its stand-alone solar work, there is a key opportunity to integrate electric pressure cookers into this framework to save on procurement costs for EPCs.

Some other potential opportunities to mitigate end-customer costs that VHSS / SunGate could explore include:

- **Results based financing** – Results-based financing is emerging as a key financing stream for clean cooking solutions globally. RBF streams for key impacts (carbon, cooking access, meals, health, gender, etc.) could help to mitigate upfront costs for customers and VHSS / SunGate, but these are not existent or accessible to VHSS / SunGate in South Sudan currently.
- **Consumer financing** – Potential to engage money exchange and banks to extend existing customer financing and loan products to include EPCs.
- **Partnerships with government / development partners** – Potential for additional support financing to buy down cost of EPCs, particularly if they align with ongoing programmatic/policy goals (e.g., food/nutritional security, enabling energy access, etc.).
- **Differentiated pricing models** – VHSS / SunGate could potentially develop different pricing models for local customers compared to NGOs and international partners effectively creating a cross-subsidy to drop the price point for lower WTP / ATP customers.

Mini-grid Integration and Delays

The electric cooking project experienced significant delays due to delays in the overall development of the mini-grid in Wanyjok. Initially the project was targeting a Spring 2022 launch but was ultimately delayed to Fall 2022. This functionally reduced the observational window for the electric cooking pilot before this interim report.

Key delays arose from the following:

- Supply chain shortages for power electronics and other related materials specific to generation procurement
- Unusual backup in production following Chinese New Year holiday for affiliated manufacturing plants
- Manufacturing hold placed across Chinese manufacturing zones from an extended COVID lockdown
- Re-directing of materials shipped through alternative routes, due to proposed seaport backups and delays
- Construction commencing during regional rainy season due to previously mentioned procurement delays, leading to longer construction timelines
- Political challenges to overcome during construction, such as additional regulatory obstacles not known prior to arrival of materials

SunGate team installing the mini-grid array in Wanyjok

Although delays ensued from challenges that were difficult to predict during the project planning phase, the implementation was ultimately quite successful and offered important learning opportunities for future installations. These lessons learned and the preceding challenges are further discussed as part of SunGate's mini-grid report to HGC.

Other Limitations of the Study

The report / study had a number of other limitations including:

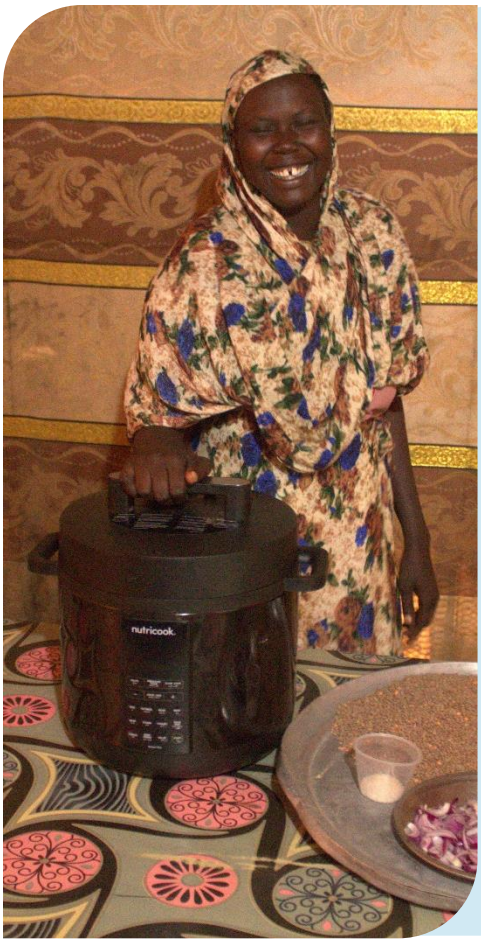
- Limited sample size (n=25) makes it difficult to draw broad sweeping conclusions for electric cooking in South Sudan.
- As highlighted above, for the interim report electricity was free to the users so the study has yet to analyze key variables like willingness to pay for electric cooking which is key for developing a business model. However, with the high and growing costs of charcoal, and savings at electricity tariffs of $0.60 / kWh in the initial experiments, there does seem to be a significant opening for willingness to pay for electric cooking. Likewise, the willingness to pay for the EPCs themselves has not been tested in this study, however partnerships like Water for South Sudan do highlight some potential willingness to pay especially if EPC costs can be reduced as discussed above.

Discussion

Potential for Electric Cooking in South Sudan

Despite the project's challenges, overall, it demonstrated substantial potential for electric cooking solutions in South Sudan, particularly if larger EPCs can be sourced.

The cooking experiments and participant feedback highlighted a high degree of compatibility of South Sudanese cuisine and electric pressure cookers. Not only can most types of foods be cooked effectively in the EPC, there is a large proportion of long-boil foods like stews, meats, beans, and rice all of which have substantial potential cost and time-savings compared to baseline charcoal and woodfuels if the right technologies and price points can be delivered.



"EPCs make cooking easy and no more stress. I cook all types of South Sudanese dishes using the EPC."

Atap Mout Deng, Household

Participants across the board have highlighted how the EPCs allow them to cook faster and easier than before without the smoke and heat of an open fire. The major obstacle has been the size of the EPCs. Most of the "low users" in the study were the result of the small capacity devices rather than a fundamental issue with electric cooking itself.

Critically, the study was able to show "high users" across most participant types (plus significant high users in SunGate and Water for South Sudan, discussed below), demonstrating the potential viability of the solution if the other challenges can be addressed.

Beyond EPCs the research has identified a key need to explore other electric cooking devices, particularly air fryers and / or electric griddles or injera makers to target the few foods that were not effective in the EPCs.

VHSS / SunGate has already leveraged the initial cooking work to establish a research partnership with the Modern Energy Cooking Services (MECS) initiative, a multi-year program based in Loughborough University and funded by UK DFID. This partnership is focused initially on developing an "eCookbook" for South Sudan (part of MECS series of country-focused eCookbooks) which will highlight the opportunity of electric cooking in South Sudan through a series of cooking profiles and recipes and direct comparisons to baseline fuels. On top of the eCookbook, SunGate / MECS will also be conducting a detailed market assessment for clean cooking in South Sudan. Both of these will help to support advocacy and market development for clean cooking, particularly electric cooking.

Opportunity to Target Stand-Alone Solar Customers

One unexpected and unplanned success of the project was the integration of EPC cooking into SunGate and Water for South Sudan operations. While not technically activities under the HGC grant, the opportunities developed based on the initial success of the electric cooking experiments and demonstration events from the pilot.

Both entities now effectively utilize EPCs everyday to cook for their staff and are actively promoting the value of the EPCs. This has illustrated the potential for other organizations in South Sudan who are now contacting SunGate about partnership, procurement, and training. Moreover, these initial deployments have showcased the key opportunity to couple electric cooking with SunGate's rapidly growing home, office, and commercial solar business making EPCs an important value add for the stand-alone solar customers.

SunGate has over a decade of experience developing stand-alone solar+storage projects for a variety of customers in South Sudan including households, NGO / international partners (e.g., Water for South Sudan, UNHCR), institutions (hospitals and universities), and businesses (hotels / guest houses, restaurants, etc.).

Currently SunGate has around 180 customers in its stand-alone solar portfolio (with 50+ customers on the waiting list for systems) and saw over 2.5x growth in customers over the last 18 months. This portfolio is expected to grow dramatically over the next two years, particularly as SunGate builds visibility through the launch of the Wanyjok mini-grid and the discussions around the regional metro-grids.

"I did not know you can use electricity to cook many things, especially South Sudanese food…. And with the experience that I got from the SunGate team; I can cook everything with electricity making cooking easy for me."

Ayuel Ngong Makuei, Wanyjok Restaurant Owner

With that, VHSS / SunGate has the important opportunity to develop the electric cooking business model to support the existing / new home, office, commercial and institutional stand-alone solar customers. This includes both designing future stand-alone solar solutions to include electric cooking as well as integrating electric cooking into the existing stand-alone solar portfolio.

This approach has several key advantages that will reduce costs for VHSS / SunGate and help rapidly develop the electric cooking market in South Sudan, including, but not limited to:

- Many of the stand-alone solar customers are organizations with multiple offices / areas of operation and/or large cooking needs which creates a single point of sale for multiple EPCs thereby reducing transaction costs for VHSS / SunGate down the line
- SunGate has an established, trusted brand and decade of experience with stand-alone solar along with existing capacity and systems for sales, marketing, procurement, finance, after-sales service, etc.
- Stand-alone solar deployments tend to be much higher visibility as they can support key community organizations and companies. This can lay the groundwork for future market development.
- The stand-alone solar customers will also realize immediate savings on fuel costs as they will be essentially producing their own electricity from their solar systems.

- Provides a rapidly growing and easy customer pipeline for EPCs without the need for significant marketing and customer discovery costs
- Stand-alone solar customers tend to be higher capacity customers which may make EPC adoption and utilization easier compared to the general population.
- The EPCs will have built in follow-ups and check-in as part of solar system performance
- The stand-alone solar customers have a high likelihood of becoming net-promoters (especially NGOs and International partners) potentially significantly reducing the costs for marketing and customer discovery

The sales and marketing strategy for these customers is also easier to scope:

- Leverage pilot mini-grid collateral (e.g., eCookbook, user stories, media, etc.) to promote concept to new customers
- Identify key community "influencers" to do direct engagement with (e.g., restaurants, churches, high-profile individuals, clinics, school etc.)
- EPCs couple with solar electricity to target "full spectrum of baseline energy costs"
- SunGate is already a trusted provider for solar and electricity solutions (trust + name recognition)
- Immediate savings on fuel costs for stand-alone solar customers as they will be producing their own electricity
- Alignment with program/policy goals (especially for NGOs / development partners)

Need for Innovative Financing

As highlighted above, a critical step to enable expanded electric cooking in South Sudan is unlocking more innovative financing to grow the market and specifically to support electricity grid developers, operators, and end users by reducing the upfront costs of the EPCs and reducing the cost of fuel (electricity) for appliance users while maintaining cost recovery for grid operators. More broadly there is also a need for expanded support for deploying the energy access solutions (e.g., mini-grids, stand-alone solar, etc.) themselves.

There are a number of solutions being developed in other energy access, clean cooking, and electric cooking initiatives that should be explored for the South Sudan context including:

- Asset based financing for the electric cooking devices (i.e., the Energrow or KPLC models in Uganda and Kenya, respectively)
- Results based financing for outcomes related to energy access (SDG7), health (SDG 3), gender (SDG 5)
- Carbon financing from avoided emissions as a result of electric cooking and deployment of electrification solutions utilizing a methodology like the one developed by the UK-funded Modern Energy Cooking Services Program (MECS) [23] and/or Gold Standard, Verra, and the Clean Development Mechanism.

[23] MECS Electric Cooking Carbon Methodology; Available at: https://www.climatecare.org/resources/news/press-release-new-electric-cooking-methodology-mecs-climatecare/

- Grant and innovation financing to refine business models for electric cooking and energy access including piloting and iteration (i.e., USAID DIV, AFD FID, Rockefeller Foundation, etc.)
- Technology partnerships and research/development funding to support manufacturers and distributors in the electric cooking space to make electric cooking products more accessible, more affordable, and more fit for purpose (e.g., larger sizes of EPCs; simplified, pictographic faceplates; and on-board verifiable usage tracking) to better support this new universe of customers and financiers

Need to Further Integrate Gender-Lens

By working to develop and deploy electric clean cooking solutions in a region where cooking is largely done by women, the project is inherently directly working to address some of these burdens by eliminating harmful smoke and air pollution, significantly reducing cooking time, and making cooking more convenient (e.g., set the electric pressure cooker and walk away). VHSS / SunGate are also leveraging the project deployments to specifically target and support restaurant owners and small food/drink vendors in Wanyjok (the vast majority of which are women).

By equipping small-scale entrepreneurs with electric pressure cookers, VHSS / SunGate worked to help improve their enterprises by saving them time and money and showcasing their enterprise for the community. While the majority of the participants and EPC users are female (addressing the heavy existing burden for cooking described above), VHSS / SunGate have

EPC training for small shop participants in Wanyjok

worked to also include men in the pilot (about 40% of EPC users) and have deliberately trained men in their staff to utilize and demonstrate the EPCs. Both of these represent a small, but hopefully meaningfully visible step towards addressing the gender bias in cooking.

For future electric cooking efforts, VHSS / SunGate need to be closely identifying and integrating the differentiated needs and interests in electric cooking devices between men and women into their marketing and deployment strategies. For example, the male participants in the pilot highlighted aspects like "interesting new technology", "modern way of cooking", and "cost savings" when talking about the benefits of the EPCs whereas the women participants more often highlighted time savings and ease / convenience of cooking with the new devices.

"Before the staff used to eat at the restaurant which was costly to the clinic but with the new modern way of cooking, I hired a cook to prepare food at the clinic which reduced the expenses."

Hassan Ajak Deng, Health Clinic Owner

Pathways and Partnerships for Scale

The initial success of the stand-alone solar and mini-grid projects has led to discussions with government stakeholders to both expand mini-grids to other communities as well as to develop larger regional electricity grids known as "metro-grids" for some state capitals in South Sudan. SunGate recently even signed new Memorandums of Understanding with the state governments in Western Equatoria and Northern Bahr el Ghazal. In total, SunGate currently operates in 6 of the 10 states in South Sudan and this is expected to grow with the potential pipeline of stand-alone solar projects highlighted above (Figure 10).

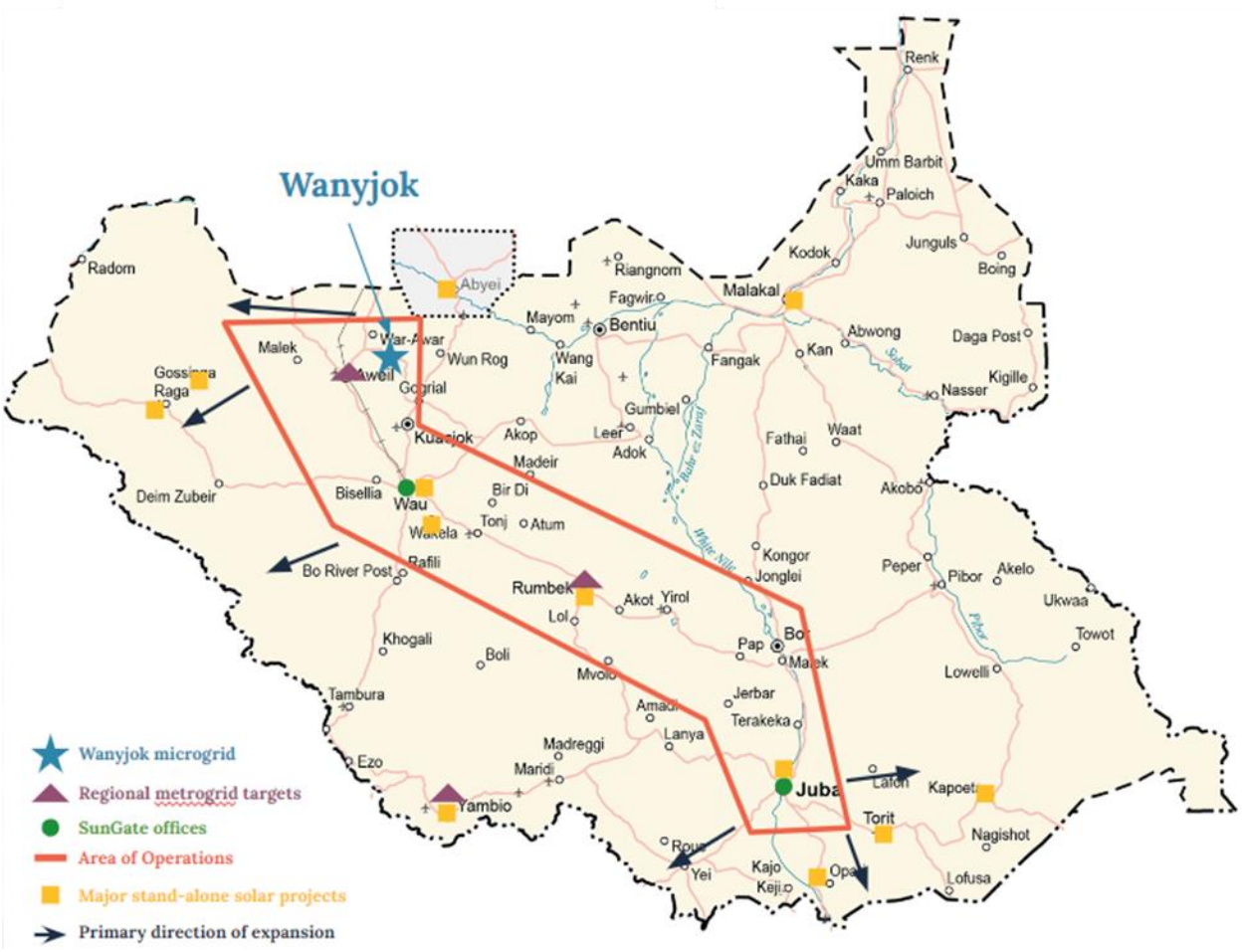


Figure 10: Map of SunGate Activities

This creates a significant foundation for VHSS to support SunGate in refining and expanding business models for electric cooking, but to do so VHSS / SunGate will need to develop key partnerships with a variety of stakeholders including:

- **Investment and Other Financing Partners** – VHSS / SunGate will need to identify and secure additional financing partners to help expand both electric cooking as well as the variety of solar solutions that power it (e.g., stand-alone solar, mini-grids, metrogrids, etc.). This will necessarily need to include equity/debt providers and additional innovation/grant capital especially for results-based financing as highlighted above. This financing, particularly the results-based financing, needs to be targeted to support both the cooking solutions themselves as well as the power systems (e.g., mini-grids)
- **Clean cooking research organizations** – As above, VHSS / SunGate and their partner EarthSpark International have been able to connect directly with MECS to launch a research partnership centered around developing an eCookbook for South Sudan as well as a national market assessment for clean cooking. SunGate also was able to submit an application for the MECS challenge fund based on this initial research. MECS will be critical funding and research partners for scaling and enhancing the electric cooking solutions and business model in South Sudan and it will be important to

build off this initial collaboration and identify additional research partners in the space to share innovation and learnings with.

- **Regional governments in South Sudan** – SunGate has engaged a number of regional governments (e.g., Northern Bahr el Ghazal state and Western Equatoria state) in conversations about the mini-grid and electric cooking work. It will be critical for future scale-up to be growing these partnerships and particularly communicating key successes and progress for the mini-grid and electric cooking work. This will help to bolster support and open up new opportunities for scaling the mini-grid and electric cooking solutions to additional communities in South Sudan.
- **Other development partners** – VHSS / SunGate have also been able to have meetings and initial electric cooking demonstrations for other development partners and organizations including UNHCR and World Food Programme. These partners, like Water for South Sudan will be key for amplifying VHSS / SunGate's research success and hopefully for building specific collaborations and future initiatives to expand electricity access and clean cooking in South Sudan.
- **Electric cooking manufacturers and distributors** – As highlighted above it will be critical for VHSS / SunGate to work directly with manufacturers and suppliers to formalize procurement channels and lower costs of EPCs, but also to identify better fit for purpose devices. SunGate has had initial conversations with BURN and other suppliers at the Kigali Sustainable Energy for All Forum, but the initial scale of VHSS / SunGate's electric cooking work prohibited any collaboration. All of these providers will be an important part of SunGate planning for scaling its electric cooking solutions.

Conclusion

Sustainable Development Goal 7 promises 'modern energy for all', but the division of cooking energy from electricity service has left many with suboptimal solutions or with lightbulbs and open-fire kitchens. There is much work to be done in unifying the planning for SDG 7. This project, though small, aimed to begin to bridge that gap.

VHSS / SunGate's electric cooking project illustrated that South Sudanese cuisine was highly compatible with EPCs and there was potential for substantial time and cost savings for users compared to the status quo, especially if challenges related to the size of the EPCs and the need to find solutions for specific South Sudanese foods like kisra and mondasi can be addressed. Further, the project proved how electric cooking solutions can be effectively integrated into both mini-grid and stand-alone solar systems laying the foundation for business models to expand clean cooking and energy access going forward.

Overall, despite the challenges, the pilot electric cooking project demonstrated significant potential to multi-solve for electricity access and clean cooking by designing clean cooking solutions that can be deployed in parallel to new electricity access solutions, particularly mini-grids and stand-alone solar in South Sudan. To do this effectively, there is a critical need for new innovative financing and partnerships to accelerate and support both deployment of electric cooking solutions as well as the mini-grid and solar systems that power them.

The hope is that this project lays a strong foundation for future business models for integrated planning and delivery of clean cooking and access to reliable electricity in South Sudan. By demonstrating the high potential for electric cooking solutions and creating actionable evidence

to refine the enabling environment, business models, and ultimate deployment of solutions the project has uncovered clear next steps to address energy poverty in South Sudan.