Creating Resilient Sustainable Micro-grids through Hybrid Renewable Energy Systems Report (EPSRC)

A Report

Prepared by CREEC

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Introduction

The project aimed at developing and experimentally validating a holistic design platform for micro-grids (MG) with hybrid renewable energy systems that enabled an end-user-driven, resilient and sustainable electrification of rural communities in the low- and middle-income countries (LMICs) of Tanzania, Uganda and Republic of Congo.

Activities

1. Socio-economic survey

Socio-economic survey was conducted in three countries and the raw data submitted to the University of Leeds. CREEC in Uganda conducted a socioeconomic survey in three different settings: an Island which has a mini-grid installed for its electricity suppl; an urban and peri-urban set up connected to the national grid; and an inland unstructured rural village that is off grid. The areas selected in Uganda were in the central region. Similar surveys were conducted by our partners in Tanzania and Congo Brazzaville. The survey was structured around three attributes: electricity and energy consumption; fuel and biomass; and household characteristics. The report describes the locations of the survey, sample selection criteria, insights into cooking practices, energy markets and challenges faced during the survey.

a. Location of the survey

In Uganda the survey was conducted by CREEC in these districts within the central region; Mukono, Kampala, Wakiso districts, Kalangala district (Bugala Island) and Kiboga districts.
In Tanzania the survey was conducted by Dar-es-salaam Institute of Technology (DIT) in the areas of Luxmanda is in Babati district in Manyara region and Kibindu Village is in Chalinze District in pwani region. In Congo it was conducted in three different districts.

b. Sample Selection

In Uganda, 604 households were interviewed in kalangala and Kiboga districts we using semi-structured and random sampling methods, 401 households were interviewed in Kampala, Wakiso and Mukono districts combined. In Tanzania for both Luxmanda and Kibindu villages, a total 353 households were interviewed. Interviewed households were carefully selected to ensure they represent household characteristics of the households in the two study villages. In Congo Brazzaville, a total of 434 households were interviewed for the three different districts.

c. Sources of energy in the study areas

In Tanzania, mini-grids are the source of electricity supply to the two villages of Kibindu and Luxmanda. The mini-grid type installed at Luxmanda village is a hybrid combining solar PV and wind with a total installed capacity of 25 kW. The capacity of the solar PV is 19 kW and 6 kW from the 2 wind turbines of 3 kW each. At Luxmanda village, only the secondary school, village government office, and dispensary are powered by the village mini-grid. There are no households connected to the mini-grid. The Connected units use less than 3% of the electricity generated by the mini-grid, 97% of the electricity generated was not in use at the time of the survey.

Figure 1. Solar PV at Luxmanda Village

The mini-grid installed at Kibindu Village, is a solar PV system and gasifier system which work separately. The installed capacity of the two units is 44 kW. The solar unit has 24 kW capacity while the gasifier has 20 kW.

In Uganda, Kalangala District is an off grid area. This district is mostly dependant on the mini-grid managed by the Kalangala Infrastructure Services (KIS) for its electricity supply. There are however some homes with installed solar systems. The power station is located in Bukuzindu village, on Bugala Island which is the largest island in Ssese islands.

Figure 2. Bukuzindu Hybrid Solar and Thermal Power

The station is a 1.6MW hybrid solar and diesel fuel fired thermal power plant. The hybrid power station has 0.6 MW solar energy component and a 1.0 MW diesel fuel fired thermal component.

Figure 3. Enumerator administering Choice cards during the survey in Kalangala

In the urban and peri-urban areas of Kampala, Mukono and Wakiso district which are connected with national grid, all the households interviewed were connected with national grid and some also have solar home systems as backup systems. Some of the business owners have backup generators. In Kiboga district, which is an unstructured rural area totally off-grid, households use lanterns, solar home systems and torches for lighting.

Figure 4. Keresone Tadoba and battery torch used for lighting in Kiboga

d. Cooking fuel.

The cooking technologies and fuels used by the participating households include LPG, firewood, charcoal, electricity, briquettes, kerosen and agricultural residues.

Firewood and charcoal are the main sources of energy used for cooking in the study villages and districts in Uganda, Congo and Tanzania. Only a few households use liquefied petroleum gas (LPG) for cooking occasionally.

Figure 5. Charcoal business in one of the study areas.

A sack of Charcoal in Uganda goes for 120,000 ugx and in Tanzania 10,000 Tzs on average.

Figure 6. This a lorena stove (improved stove used by many households in Congo, Tanzania, Kalangala and kiboga

Figure 7. Enumerator interviewing a lady making briquettes for cooking in Kampala

e. Benefits of the installed standalone solar PV and mini-grids

The key informant interviews and discussions carried out with various groups in the off-grid study areas highlighted a number of benefits the communities enjoy due to increased availability and access to mini-grids electricity and standalone solar PV systems for households, business enterprises, public and private entities. These benefits include:

- Increased employment opportunities such as operating small enterprises like hair salons, phone charging, juice and ice cream making kiosks.
- Improvement of the learning environment for children with more reading time and new avenues of learning including television, tablets/smartphones. General cleanliness also improved.
- Increased access to local and international news. With electricity, households are making use of electrical appliances and equipment including mobile telephones, televisions. This has improved internal and external communication which will most likely lead to socio-economic and cultural transformations in the long term.
- In schools, learning and teaching environment improved . Printing of study materials and operation of school laboratories have been improved.
- Health aspects.The use of kerosene and candles have reduced and therefore exposure to smoke and related health risks also reduced although firewood and charcoal still remain a challenge.


Figure 8: Standalone solar PV connected businesses which charge mobile phones and show various types of sports, movies and news.

Figure 9. Kiosk for charging cell phones.

f. Challenges faced during the survey

No significant challenges encountered during the survey as the village officials we worked with throughout the survey were so cooperative and excellent in introducing the team to the respondents. Only few challenges were observed which did not hinder the work.

- Language barrier, some enumerators needed translators

- It was not possible to estimate amount of feed for livestock as they are free ranged
- Some respondents were more interested in food and water issues and not energy

2. Partnerships with local companies in Uganda

CREEC and the Leeds team visited differences places to benchmark and do a situational analysis. The local partners involved include; watoto children's home, Entebbe botanical garden, Nature Palace Foundation (NPF), Public Private People Partnership and Kalangala Infrastructure Services(KIS).

a. Watoto children's Home

Watoto Suubi village is one of the Christian founded orphanages set up by Watoto Child Care Ministries in Uganda. Suubi village is located in a rural area with an intermittent supply of electric power from the main grid. The energy needs of the village are substantial however, more than 60% of the village is not connected to the national grid. This has resulted in the heavy usage of diesel generators to power critical loads, a solution that is costly and unsustainable.

The team assessed 10 Households at watoto children's home which are connected with stand-alone solar systems. The solar system comprised of 1250 Wp panel, 50 A MPPT charge controller, 53 W tubes and 39W LED tubes, 1 AGM 200 Ah battery, 110 A single pole circuit breaker.

Figure 10. The battery box, inverter and controller of the SHS in one of the households at Watoto village

b. Entebbe Botanic garden.

This study trip aimed at identifying 1) Tree species that bear fruits with oily seeds 2) The tree species should be capable of facilitating agricultural activities such as intercropping. This was in line with the proposed establishment of an energy garden as part of the sustainability plans under the on-going research programs. The botanical gardens together with the National Gene bank located in the same place are considered as the Plant Genetic Resources Centre of the National Agricultural Research Organization. The garden was set up to ensure the conservation, management and sustainable use of Uganda's plant genetic resources for food and agriculture while optimizing their full potential in contributing to national development goals. The garden is home to over 400 plant species ranging from little known indigenous fruit trees to medicinal plants.

Figure 11. These are some of the tree species in the garden

There are lot more varieties of scenic views enriched by the great diversity of plant and animal life and out into the open wood and grasslands exposed to a wide range of plants including ornamentals. To a large extent the garden was not a host of some of the tree species of *Cordia Africana* Mukebu, *Maesopsis eminii musizi, Canarium Schweinfurthii purple canary tree African canarium, Ficus natalensis, Croton megalocarpus and Accasitan Podocarpus.* This necessitated the team to travel to another Botanical garden called Nature Palace Foundation.

c. Nature Palace Foundation (NPF)

The garden is a multi-purpose energy garden where tree establishments are meant to provide energy and other livelihood benefits to the households sustainably. They are based on cultivation of Ficus natalensis commonly known as 'Mutuba' tree in an agro-forestry system. The fast growing Ficus natalensis trees provide firewood from sustainably harvested branches that can be used in the energy-saving stoves. The tree bark, on the other hand is sustainably harvested annually to provide bark-cloth that currently has national, regional and global markets. Bark-cloth was recognized by UNESCO as 'a masterpiece of the world's intangible heritage' and as 'a unique indigenous textile production craft' which present an opportunity for small-holder farmers to an additional income.

The setup of this garden is mainly farm based with most of the trees planted in the community's gardens which was ideal for what we intended to do, however there was need to look for more species that can be planted across the whole region since the mutuba species is mainly in the central region.

Figure 12. Inter cropping with Mutuba tree

Figure 13. Harvesting the back

Figure 14. Finished backcloth

d. Public Private People Partnership

The purpose of our engagement with this entity was to discuss the energy conversion opportunities available for the waste generated after the extraction of the crude oil from the palm seeds. Public-Private Partnerships are now one of the innovative options introduced by the Government of Uganda to enable public sector procure infrastructure and offer opportunities to improve service delivery and assure better value for money.

e. Kalangala Infrastructure services (KIS)

The team visited KIS (mini-grid plant) in Kalangala, Bugala Island

Figure 15. Operations manager explaining to the team on how the mini-grid operates

3. Dissemination

a. A panel Discussion highlighting innovative UK-Africa partnerships implementing low carbon energy access –COP26.

This panel discussion provided a platform for representatives from Africa to share experiences and views on climate justice and energy, while showcasing innovations implemented through collaboration with UK Universities and partners in Malawi and Uganda in order to achieve clean energy access. CREEC shared a video recorded presentation showcasing bioenergy technologies in Uganda and the different pathways the Centre has chosen in sharing renewable energy based information to wider audiences.

CREEC with her partner on dissemination, Atonga media, produced a DVD with one short video shot in HD with full usage rights for music. The fully produced clips was in 1080p (HD) resolution shared with project partners, national audience including government institutions, CSOs, local stakeholders, local communities as well as the international audience.

b. The radio drama series ‘Ojuk” on clean energy access for communities

A Radio drama is a dramatized audio performance broadcast on radio or published on audio media, such as CD with no visual component. A radio drama depends on dialogue, music, and ambient sound to help the listener imagine the characters and the story. The ‘Ojuk” radio drama was scripted and produced for the following specific objectives; to provide listeners with an opportunity to learn more about alternative clean energy solutions and engage them in prevention and control of practices like deforestation within their social context; to provide listeners with information on service locations to access clean energy, that is, energy saving stoves, cooking fuels such as briquettes, community mini-grids for productive use powered by solar other renewable energy technologies; to provide the target audience with additional opportunities for further interaction with key sector players for instance in capacity building, opportunities for financing and entrepreneurship in renewable energy; to edutain the listeners using humor as a tool to increase awareness of clean energy solutions;to reach a special group of people in the society, like the blind; to cover larger audiences as most of the people in Africa live in rural areas and have access to radio cassettes.

The format of ‘Ojuk’

The show is as series of 40 episodes pre-recorded during studio sessions, cleaned, mastered, and produced in a supported format recommended by local radio stations and the BBC. 7 different languages were considered for translation starting with the first 9 episodes in English, other languages are Ateso, Luo, Runyankole, Luganda, Kiswahili and French to cover all the regions of the partner countries and the Globe.

The Elements

Introduction: this is the first part of the radio drama that sets the pace for the rest of the story for the audience to follow.

Characters: the main character, 'Ojuk', is sensational but very informed character challenging the status quo and inspiring the audience to take decisions on their energy patterns
Setting: the setting of the drama will be a typical African community that the audience can relate with easily.

Problem/Solution: the story a problem, something common to the community; and creates its solutions hinging on clean energy use.

Besides the above-mentioned aspects, other key elements to enrich the story would include the ambient sound and music to support dialogue among the characters.

The message

The message that the ‘'Ojuk'” radio drama carries is crucial in influencing the populace and relevant entities to make decisions and take the necessary actions towards increasing access to clean and affordable energy solutions that are friendly to the environment while improving livelihoods. This is the motivation for the production of the drama and its translation to various languages.

4. Conclusion

This report gives a summary of the CREEC activities on the project while the raw data generated through the socio economic surveys, interviews and field work were submitted to the heads of the work packages at Leeds for integration into the final project reports. The details of this data have not been reported here.