ENERGY FOR DEVELOPMENT: REPLICATION OF RURAL DECENTRALISED OFF-GRID ELECTRICITY GENERATION THROUGH TECHNOLOGY AND BUSINESS INNOVATIONS

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Access to energy, especially for rural communities, represents a central pillar for development. The work presented here, describes on-going action-research programmes addressing the UN Millennium Development Goals (MDG) through community led off-grid electrification projects. The aim of the programmes is to invigorate rural communities and enhance their livelihood through the provision of replicable and sustainable electrical power supply systems within villages in sub-Sahara Africa. To address this aim we have been studying rural communities in Kenya, Cameroon, Mozambique and Uganda. This paper address the projects in Kenya in which we assessed whether an off-grid renewable energy scheme based on solar photovoltaic (PV) can be both sustainable (in terms of cost recovery); provide measurable social and health benefits and be replicated in other rural communities in sub-Saharan Africa.

Keywords: Rural electrification, mini-grids, PV energy supply, rural development, PV systems

INTRODUCTION

To date it is estimated that around 1.3 billion people around the world have no access to reliable electricity [1]. The provision of electricity is vitally important for development, alleviation of poverty and for fulfilling the Millennium Development Goals (MDG) which currently have a target date of 2015 [2].

In many developing countries the upfront cost of connecting rural villages to the nearest electrical distribution network is and will remain prohibitively expensive. This is the case in sub-Saharan Africa, which is the target of our energy for development (E4D) programme [3]. A reliable electrical supply is however vital for development in key areas including health, education and small business. This project addresses fundamental scientific, engineering, social and policy research issues in rural power generation and distribution, transferring knowledge between participating countries and building research capacity both in the UK and in other collaborating nations. The project is based around three core components:

- *People:* how to engage effectively with communities to determine their energy needs and design appropriate systems for long term sustainability.
- *Product*: technology configurations appropriate and robust to rural sites delivering and meeting requirements of power, and self-sufficiency.
- *Process*: business models that give a sense of ownership to the rural communities, providing incentives to people to maintain and ultimately replicate the electrification scheme.

Current projects within the E4D programme address rural communities in Kenya, Cameroon, Mozambique and Uganda. This paper will address work undertaken over the last 3 years and will mainly focus on the first project implemented in Kenya in 2012.

The aim of the programmes is to enhance rural communities' livelihood as well as invigorating their society through the provision of replicable sustainable electrical power supply systems to villages in sub-Sahara Africa. The paper addresses the work carried in Kenya in which we assessed whether an off-grid renewable energy scheme based on solar photovoltaic (PV) can be both sustainable (in terms of cost recovery); provide measurable social and health benefits and be replicated in other rural communities in sub-Saharan Africa.

E4D PROGRAMME APPROACH

The programme was structured to address the salient issues related to energy for development including aspects of baseline knowledge on country and communities. Such issues as well as the stated components of the project mentioned under the introduction were investigated through interconnected workpages which for brevity are given in Fig.1. As can be seen from the figure the work encompasses technical, social and economic investigations and the development of the needed tools to support evidence based project interventions which is gear to support project sustainability and replication. Full details of the E4D

programme can be found at the project website given in [4].

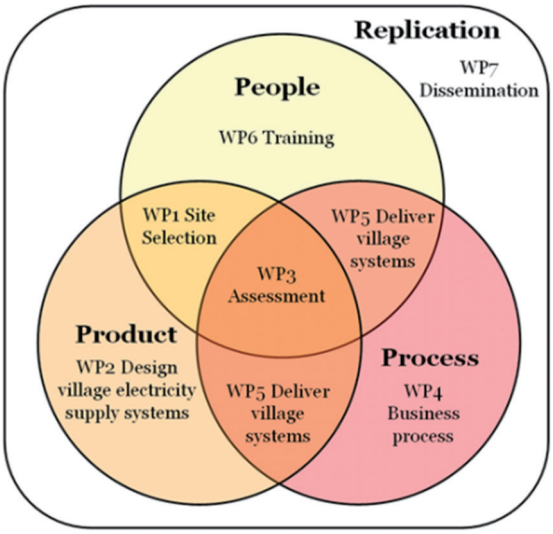

Figure 1. E4D project interconnected workpackages.

In order for the project to progress, we have undertaken major studies of Kenya. These include:

- A GIS (Geographical Information Systems) database of Kenya has been developed containing the necessary data and parameters for informing the programme decision making process.
- High-level pre-selection criteria was developed to identify suitable sub-locations using GIS database.
- Initial reconnaissance visit to assess sub-locations for suitability.
- Needs assessment carried out through field work in two selected sub-locations (deployment and control)
- Designed Household questionnaires based on Needs Assessment
- Assessment of energy demands of model villages taking into account provisions to trading centres, health centres and schools
- Technology implementation designs considered and evaluated that take into account the aims of the programme.
- Pilot and full baseline household survey undertaken.

On-going research outputs to support the above studies will be provided periodically and will be disseminated as the project progresses. In addition to these outputs, the project has also developed a network with full details given in [4].

PROJECT IMPLEMENTATION

Design of both the physical infrastructure (foundations, canopy, containers, container conversion systems, PV panels and frames, lanterns, rain harvesting system, etc.) and the overall PV system (size and number of panels, inverters, charge controllers, system protection, control gear, system redundancy, monitoring etc.) was carried by the team with most of the appropriate items sourced and procured within the UK. All systems components and equipment likely to be needed in the field were packed into two containers and shipped from the UK to Mombasa, Kenya with on land transport arranged to site. The two containers were converted appropriately, on site and are currently being utilised as (a) housing for all the switch gear, batteries etc. and (b) as the office for the cooperative and its manager.

Supply of local infrastructure for the project such as was the foundations, mini grid components (pole, cables, switch gear, terminators at business properties etc.), internal wiring as well as for the storage batteries was arranged with local firms. The local supply chain and a programme of training to facilitate the utilisation of local labour were put in place.

Prior to the project's team arrival in Kenya, preliminary work has been done on site. This included excavation of the holes in which the grid poles were to be positioned as well as pouring the concrete foundation for the PV canopy. Local partners, (now developed as project supply chain) undertook the construction of the mini grid, including the connection of the businesses to the grid.

To support the project locally, two local engineers were recruited and trained to work on the PV installation and the electrical power network. One of these was recruited by the cooperative to provide support when needed for the installation.

The overall installation began on the 10th September 2012 and within 7 days all systems were installed and working. After 2 days commissioning, power was supplied to the businesses on the 9th day of the installation period.

Project parameters and outputs are logged and monitored both locally and remotely. Full project data and operational parameters can be found on the E4D web portal www.energyfordevelopment.net/?page_id=432.

In addition to the community benefits achieved through the electrification of the Kitonyoni village trading centre, another important outcome of the activities is the creation of local partnerships to form the supply chain for replication of this project in the future in East Africa.

KITONYONI, KENYA

Kitonyoni is an off-grid rural market village in Makueni County, Kenya. The Energy for Development Network [4] worked closely with the residents to determine their needs with respect to electricity supply and business development. Following an extensive baseline survey, a 13.5 kWp solar photovoltaic system with rain water harvesting facilities was installed allowing local businesses in the village trading centre to have access to reliable, renewable electricity (Fig.2). The project is managed and maintained by the local co-operative and has been supported by the local and national government in Kenya.

INITIAL RESULTS

As indicated earlier, within this project we have carried out community needs and baseline surveys and created a national geographical information system (GIS) to cover all Kenya. This has provided the programme and the research team a proficient capability that allowed accurate resource (energy) mapping, settlement locations, health centres, school locations etc, as well as grid proximity to these to be established. As a result of this work, a powerful national tool was created that is currently being promoted to the government in Kenya.

Figure 2. Photograph showing solar PV installation and local businesses in Kitonyoni, Kenya.

More than 16 location where surveyed through social lenses that allowed understanding of the communities and their needs. From the point of view of this paper, we have established that in the areas surveyed solar photovoltaics (PV) is the appropriate power generations system needed for the regions studied. The work confirmed that PV is the most appropriate route for the provision of electricity in many rural regions in Kenya.

In addition, since the first installation in Kitonyoni, there have been clear indicators that the trading centre of the village has been transformed with land prices increasing, new buildings being constructed, new businesses opening and existing businesses reporting significant increases in revenue. There have also been clear improvements in healthcare provisions with a newly donated, fully electrified maternity ward now in operation. These improvements, their effects and the relationship to energy provision will be discussed further research outputs.

Furthermore and in addition to these qualitative results, initial data analysis shows that there has been a 22% overall increase in electricity use since the installation (Fig.3). This demonstrates a growing demand for electrical service even in one of the poorest areas in Kenya.

Changes in health, education, income and business activity are being measured against baseline surveys in order to enable rigorous assessment of the impact of the specific intervention scheme. Initial analysis indicates that villagers' livelihood has been enhance through the provisions of power directly to businesses within the village centre and through chargeable LED for lighting to outlying villagers' homes.

The commercial activities within the village centre of Kitonyoni have increased by at least a factor of three with new businesses opening within the first year of the project. Additional benefits which we will report on are education, health and ICT activities established for the first time in the community.

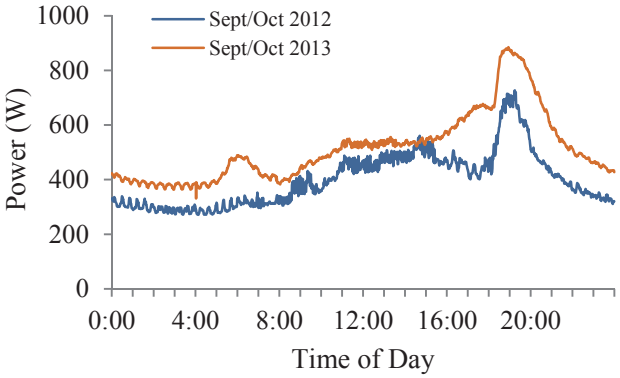

Figure 3. Over one year over 20% increase in electricity usage in Kitonyoni, Kenya.

CONCLUSIONS

This work has established and implement easy to replicate and sustainable off-grid electricity generation projects which promotes development and improves wellbeing in rural communities in East Africa.

The initial data analysis for the first year of operation has shown that the provision of a stable electricity supply has had a positive impact on the local community of Kitonyoni businesses, health centre, education, places of worship and the village surrounding areas.

The subsequent stages of the analysis in this project will be aimed at looking at households in the surrounding areas of the village and how the provision of LED lighting and other electrical charging facilities have impacted on their development. These studies are underway through the project endline survey which covers over 500 household. A comparison will then be made through such endline survey on the impact of energy on both the control village and the intervention village (Kitonyoni).

Other projects within the E4D programme have benefitted from the templates developed for the Kitonyoni project. These were applied in a small scale project in Cameroon. A new cost-share project with the Rural Electrification Authority in Kenya is currently underway.

This progress gives the team confidence that the objective of the E4D is starting to bear fruit and that replication at large scale through joint actions with local governments and international institutions is about to

commence.

Since replicability is fundamental to making a widespread impact on rural electrification, a crucial output of this study is the development of a set of concise templates which provide all the relevant and necessary details for (a) co-operative set up, (b) its management, (c) technical design, (d) implementation procedures and (e) social impact monitoring. Such tools are being applied in Uganda, Tanzania and Mozambique.

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