Real-time Monitoring, Control and Payment Technology for Mini-grids: Rwanda Field Test Evaluation Report

Introduction

Among the small number of mini-grids currently operational in Rwanda, in early 2016 none were known to make use of smart monitoring, control and payment technologies. Through its contribution to the ESCoBox research project, Practical Action Consulting (PAC) initiated a pilot test of an automated monitoring and control system on a small-scale mini-grid in Rwanda. This report presents some early findings from the first months of the system's operation and recommendations based on the challenges faced during installation and early operation.

Background

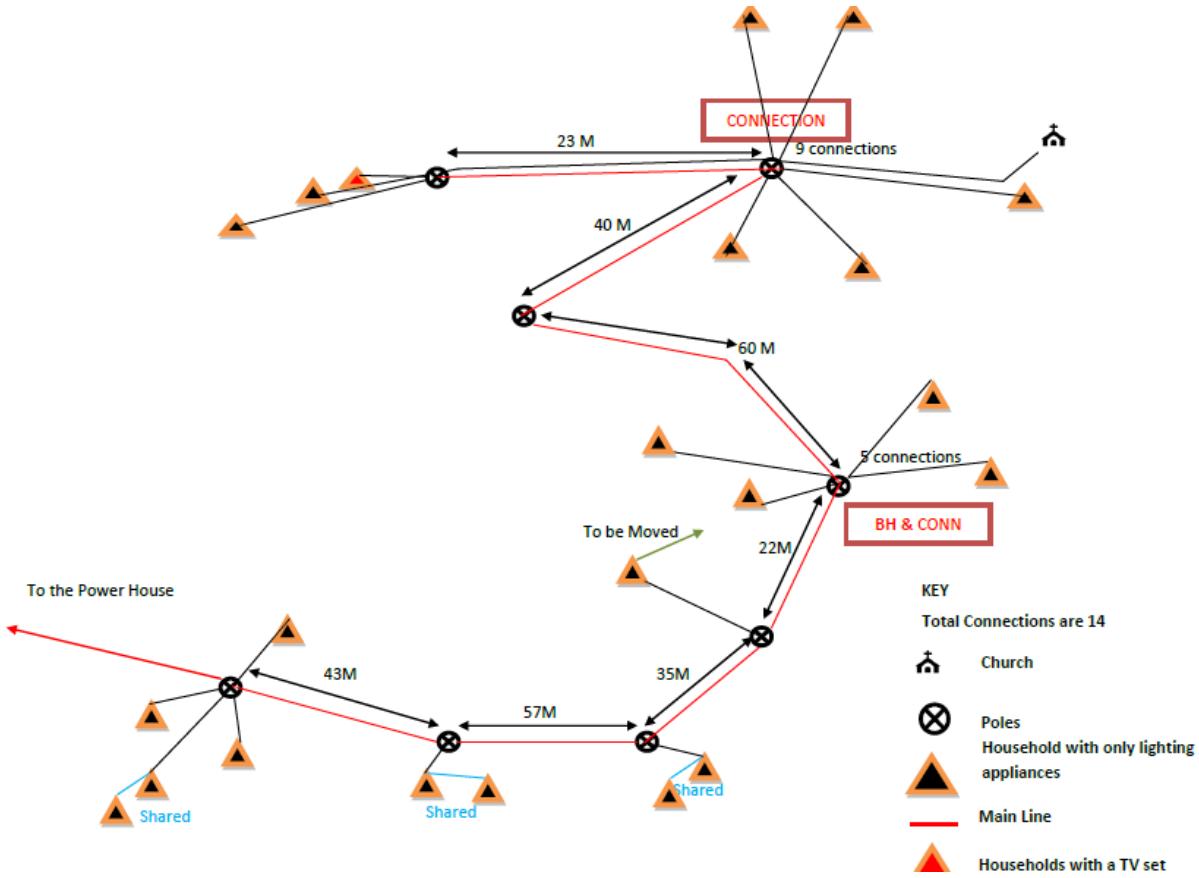
The technology tested was a *BitHarvester* remote data acquisition, payment and control system developed and marketed by SteamaCo.

Field testing of the bitHarvester smart-grid technology took place in Rwanda's western province, in the district called Ngororero, in a village called Nyiramumuhondi. The micro-hydro mini-grid has an installed capacity of 14 kilowatts, and so far 24 households (against a capacity of 50) are connected and supplied with electricity. The grid operator charged a connection fee of RwF 50,000 (US$67), and thereafter a flat monthly fee for continuing power supply. The site was selected because the grid operator expressed interest in the technology, citing challenges with tariff collection due to customer defaults. In addition, the system was prone to frequent equipment failure, and it was anticipated that smart grid technology would enable early fault detection to avoid unnecessary and avoidable system failures. The selection criteria and characteristics of the site were aligned to the ambition of the ESCoBox research project, namely that more mini-grid developers and operators in East Africa and other regions would integrate smart grid technologies into their systems, consequently improving the viability of mini-grid systems and increasing the socio-economic impact for communities. The research objectives tackled by this sub-component were: to test a technology platform for remote monitoring, billing and control of renewable energy-based mini-grids, and to evaluate the poverty impacts of smart monitoring, billing and control systems.

Installation description

Prior to the installation, the grid operator held a general meeting with the community. During this meeting he shared details about the installation plan, including when it would

commence, and sought consensus among members. Afterwards, the system was fitted with a bitHarvester system that comprised of one *THINK* unit and two *CONNECT* units[1]. The new equipment was mounted on poles and connected to 14 houses[2]. The figure below represents the installation layout.



After installation of the hardware, the system was configured with each household's details (location and mobile number). The customer interface software was translated into Kinyarwanda to read as follows:

To buy power: go to the MTN money menu, enter till number: [XXXX], enter the telephone number you registered on, and follow the instructions to top up! You can also pay cash to [XXXX].

"Kugura umuriro: Jya kuri MTN/TIGO Mobayilo mani, Shyiramo nomero ya konteri [XXXX], Andika nomero ya telefoni yawe okoresha nanone ukurikize amabwiriza, Ushobora kandi kwishyura amafaranga kuri [XXXX]. Murakoze"

By following these instructions, the purchaser sends and SMS code to the SteamaCo server, and hence the local bitHarvester is updated with the new credit information.

[1] The *CONNECT* component monitors and controls the power use of a number of consumers, using data about the credit associated with each customer line to switch individual power supplies on and off. The *THINK* component agglomerates and records data from *CONNECT* systems and other sensors, transmitting data to a remote web server via GSM network communications.
[2] The nine households nearest the power house are not connected to the BitHarvester system

Challenges Encountered and Possible Solutions

High capital cost of system: mini-grid and smart system

It was noted that, while most community members wanted to have a power connection, the upfront connection fee was beyond their ability to pay. Subsequently, during the testing period covered by this report, the number of consumers connected to the mini-grid was low compared to the total that in the community and the total capacity of the hydro system. Furthermore, the low number of connections, combined with the relatively low population density of the community, meant that connected customers were widely dispersed. Consequently, not only did this mean that the cost of the power distribution network per user was high, but a lot of data cable had to be used to connect customers to the smart monitoring/control system. The high cost of installation of the wired smart system may mean that wireless connections are a more economic choice in low-density mini-grid contexts.

Non-universal access to mobile phones

Following installation of the bitHarvester hardware, the next step was setting up the SteamaCo software with consumer registration details. In this case, the software is designed such that the main customer identifier is a mobile phone number.

A small number of mini-grid user households (around 4) did not own mobile phones, and so were not able to be registered in the system. GSMA (2016) estimates that only 75 % of Rwandans have mobile phones, so this situation can be expected to be typical in other mini-grid locations. Assuming that such circumstances prevail then it means there is need to remodel smart-grid technologies to identify customers with data other than mobile phone numbers.

Low penetration of mobile money

Initially, it was intended that the pilot would fully test the payment administration and credit-related control functions of the bitHarvester technology in addition to the monitoring and other control capabilities. Ideally, the smart technology would have enabled a switch to a cashless system where the grid operator would receive payments through mobile money, avoiding the cost of direct payment collection and lowering the risk of default. Unfortunately, the challenges of low penetration of mobile money in Rwanda, reflected in the community served by the pilot test mini-grid, meant that a mobile money payment system was not viable. Another consideration is that the operation of a mobile money payment system is not free: it is necessary to factor in the transaction costs that the mobile money company would charge to have the mini-grid operator for collecting money through a mobile number till number (the business identifier).

It was decided that the Nyiramumuhondi system would use the “village” (non-mobile money) model for payment collection whereby customers make cash payments to the grid operator. The operator then sends a coded SMS, causing data to be transmitted to the SteamaCo server and crediting the “account” of the consumer who has made the payment. The automatic disabling of defaulting customers’ supplies is a function that is retained through this system.

Conclusion

Several important lessons can be taken from the experience of installing and operating a new automated monitoring and control system on a small-scale mini-grid in Rwanda. The hardware installation was a smooth process with no problems encountered, although the dispersed layout of the electricity consumers to be connected meant that data cable costs were relatively high. The cost of remote monitoring, payment and control systems adds to the capital cost of mini-grids, which can already be difficult to finance. Although in many contexts they offer good prospects for improving the economic viability of mini-grids (through reducing costs and/or increasing revenue), this is not always the case. To evaluate the cost/revenue impact of systems such as the one piloted in Ngororero, a longer period of data collection is required.

Although in some countries access to mobile money is near-universal, in others (such as Rwanda) mobile money penetration remains too low for cashless energy payment systems to be viable without signification prior investment and community mobilisation. This situation may change in the future as awareness and acceptable spreads and regulations become more favourable. However, project developers must remember that there are still significant numbers of households that do not own mobile phones at all, and so be wary of overreliance on mobile phones and mobile phone numbers for other functions such as customer identification.

All in all, the receptiveness and optimism that both the grid operator and consumer showed towards the integration of an automated remote control system under the Ngororero pilot suggest that there is significant market potential for these systems. As the number of operational mini-grids in Rwanda increases, the demand for smart monitoring, control and payment technologies is likely to follow, and sector players should strive to meet this need with affordable and user-friendly technology.

This document is an output from a project co funded by UK aid from the Department for International Development (DfID), the Engineering & Physical Science Research Group (EPSRC) and the former Department for Energy & Climate Change (DECC) for the benefit of developing countries. The views expressed are not necessarily those of DFID, EPSRC or DECC.

This evaluation report was produced as part of the ESCoBox research project. The authors would like to acknowledge the lead research partner De Montfort University, and partner organisations including Institute for Development Studies and SteamaCo for valuable contributions of thought leadership, insightful studies and collaborative working.

Take Practical Action. Work with us.

This evaluation report was written by Elizabeth Njoki and Louise Waters of Practical Action Consulting.

Drawing on over 40 years of international expertise, Practical Action Consulting (PAC) provides independent and professional consulting services in the use of technology for poverty reduction to governments, NGOs, donors and the private sector.

To find out how we can work together contact us: consulting@practicalaction.org.uk

Website: http://practicalaction.org/consulting

Offices in Peru, Bolivia, Zimbabwe, Malawi, Kenya, Rwanda, Nepal, Bangladesh, India, Senegal, Sri Lanka, UK.