Transforming rural communities through mini-grids

AbuBakr Bahaj

Access to energy, especially for rural communities, represents a central pillar of development. For the more than a billion people in the world without reliable access, the provision of electricity will have a huge impact on their livelihoods as it is crucial for human well-being and development.

Without a reliable energy supply it is difficult to escape a subsistence lifestyle and poverty. However, in many developing countries, the upfront investment required to link villages to the electrical distribution network is and will likely remain prohibitively expensive in terms of construction and community affordability. This is the case across most of Sub-Saharan Africa and some areas of South Asia. Previously agreed United Nations development criteria were embedded in the Millennium Development Goals (MDGs)[1], and now energy provision is established as one of the new Sustainable Development Goals[2], which replace the MDGs.

In Africa, renewable energy derived from vast hydropower resources and solar energy potential could satisfy much of the continent's growing need for power. However, power capacity from these sources will have to increase exponentially to provide the necessary access. The United Nations Sustainable Energy for All (SE4All) initiative has responded to the global energy development challenges by setting three linked goals for 2030:

- universal access to modern energy;
- doubling the rate of improvement in energy efficiency globally; and
- doubling the share of renewables in the global energy mix.

To achieve the 2030 target for universal access to electrical power alone, the current global capacity will need to increase by 45 per cent, and this will be in the form of mini-grids[3]. In Sub-Saharan Africa, with 13 per cent of the world's population, only 290

In Africa, renewable energy derived from vast hydropower resources and solar energy potential could satisfy much of the growing need for power million of the 915 million people have access to an electricity network. The estimated cost of universal access is approximately US$ 470 billion for Sub-Saharan Africa alone, compared to US$ 1 trillion globally[4].

These numbers highlight the mammoth task ahead. The challenge for the global community is to address the development and implementation of sustainable energy supply projects in rural communities in Africa and Asia. Solutions should embrace social, technical, economic and environmental aspects, building on cultural understanding and local needs. Such approaches will allow appropriate knowledge generation based on mini-grid projects replicated at scale. In my view, we need to establish joint learning entities or project exemplars between national and international institutions. These will be beacons to show what can be achieved in smart villages, lending much-needed confidence in the scoping and implementation carried out by rural electrification authorities involved in projects of this kind, as well as capturing the valuable knowledge of what has worked and what has not. What follows is a discussion of two exemplary case studies.

Mini-grid case studies

Renewable off-grid energy supply based on mini-grids can be developed and designed to provide essential access to electricity in rural areas. Due to the remoteness of the locations such solutions, using appropriate business models, represent a cheaper option than extending the national grid. Such models will need to have income generation at their core, governed through an energy supply company and supported by a community cooperative or other suitable business venture.

An on-going action-research approach aimed at addressing energy provision in rural communities in East Africa is the grant-funded Energy for Development (e4D) concept. This aims to establish and implement replicable and sustainable off-grid electricity generation to promote development and well-being[5].

The challenge for the global community is to address the development and implementation of sustainable energy supply projects in rural communities

The e4D concept has people at its core, engaging effectively with communities to determine their energy needs and develop appropriate community structures and renewable electrical power supply systems, focusing on long-term project sustainability. A major aim

Figure 1 Community power

A bird's-eye view of the Kitonyoni village trading centre, solar PV canopy and water tank. Two containers underneath the canopy hold the batteries and the system's switch gear and protection. One of the containers is used as the community cooperative office.

of e4D is to invigorate communities and their village centres, providing support for self-governance, finance and entrepreneurship.

Our first intervention in Kenya, in 2012, created a community-based cooperative and a solar photovoltaic (PV)-driven mini-grid providing electricity to the remote Kitonyoni village trading centre, Makueni county, some 130 kilometres from Nairobi. The site was chosen for its remoteness, level of community poverty and grid proximity, with a monitored control village about 30 kilometres from Kitonyoni forming part of the project. The solar project is designed to support around 3,000 very poor inhabitants by providing grid-standard alternating-current power directly to all buildings – shops, cafes, schools, health centres, places of worship and so on, which in turn provide a range of services to customers from the surrounding area. These services include refrigeration and charging of appliances such as light-emitting diode (LED) lanterns and mobile phones. The infrastructure houses the plant equipment and provides office and meeting facilities for the community and its committees, acting as a village focus (Figure 1)[5]. Together, e4D engineers, local contractors and villagers were able to assemble the containerised 13.5 kilowatt-peak (kWp) PV solar plant, battery storage and canopy, and install the locally supplied mini-grid within one week. The premise of the modular project design is to make it easy to replicate and resize to suit villages of various sizes and energy requirements[5].

The e4D team worked closely with villagers to determine their needs, aspirations and goals with respect to electrification. We established an economically sustainable approach

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whereby the community contributes to the project and is responsible for the operation and maintenance of the plant. Through the energy supply company ESCO, income for the cooperative is generated via membership fees, local sales of electricity and share ownership. Such income covers all the running and replacement costs of project components and management, provides micro-financing for the community and contributes to the recovery of the capital cost of the project.

The school, health centre, churches and more than 40 businesses in Kitonyoni have a 24-hour, stable and reliable source of electricity, allowing them to extend their working hours and to provide additional services to 3,000 local people; services include information technology training, tailoring and hair-dressing, as well as the electrical charging facilities mentioned earlier. Moreover, the solar canopy of the PV system was designed to serve as a rain collector feeding tanks with capacity for 20,000 litres, enabling water to be stored and sold by the cooperative to the community throughout the year.

The transformation of the trading centre is very clear – land prices have more than doubled, benefiting the local community through land sales. At least 10 new buildings have been completed since the project's inception, new businesses have started, business income has more than doubled in most cases and, importantly, a newly donated maternity ward has been electrified and is now operational. Over the 24 months of operation, the e4D project has transformed the trading centre and the lives of the villagers, providing electrical services more reliably than the national grid. The project has given the research team data on system performance, energy demand at the trading centre, and comparative developmental analysis with the control village. It has also allowed the Kenyan Rural Electrification Authority (REA) to learn from the experience, developing capacity that has now expanded, with three additional solar PV projects based on the e4D concept.

The e4D concept was applied to another project developed and installed by the team, this time in a small community in Bambouti, rural Cameroon. This project was designed to test the growth and expansion of the concept of implementing a PV power plant – only this time it was initially without a mini-grid. It has a 6 kWp PV array and battery storage system that supplies the local dispensary with electricity and provides power to a community-based charging station for batteries and other appliances. The health centre is clearly improving and, according to the community 2014 annual report, the child mortality rate has fallen. Entrepreneurial activities such as a tool-sharpening business and a barber's shop have mushroomed since the arrival of electricity from the plant. The purpose is to enable the community to expand the project by their own means; currently the income from electricity sales and membership fees contributes to the establishment of a micro-grid to supply power to buildings at the centre of the village[5].

Conclusions

The scope for implementing the technologies needed to deliver access to electricity in rural communities is complex. I have highlighted some possible ways forward in delivering these services at scale through optimised modular designs, community structures, and partnerships between communities and energy authorities, creating projects that generate income and pay back the capital cost over an appropriate period of time. However, the challenge is now to reduce capital costs and embed the concepts and models in replication projects. This is currently being undertaken in four further partnership projects in Kenya and Uganda. In addition, strong and growing interest in adopting the e4D approach has emerged among governments and the private sector as well as international funding agencies, pointing to substantial funding to support the concept at scale.

Access to electrical power is fundamental to development and there are many global activities endeavouring to achieve this goal. However, there is huge inertia in the establishment of projects such as electrical mini-grids to support the development of rural communities[6]. Some of the reasons could be attributed to:

- failure to understand the technological and economic issues surrounding mini-grids;
- regional contexts of project implementation;
- lack of capacity in the delivery institutions;
- insufficient understanding of affordability (ability to pay) and the value of electricity from mini-grids compared to an unreliable utility grid; and
- lack of proper dissemination of the results of previous mini-grid projects, resulting in lessons not being learned for the future.

International initiatives will need to take these issues into account so that sustainable projects can be delivered to rural and poor communities at scale.

SMART VILLAGES

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Author

Professor AbuBakr Bahaj is the Principal Investigator of the e4D programme and leads the 45-strong Energy and Climate Change Division at the University of Southampton, where he progressed from a researcher to a Personal Chair in Sustainable Energy. a.s.bahaj@soton.ac.uk