Applied Energy xxx (2014) xxx–xxx

Contents lists available at ScienceDirect

Applied Energy

journal homepage: www.elsevier.com/locate/apenergy

Successful technology transfer: What does it take?

P. Klintenberg *, F. Wallin, L.C. Azimoh

Mälardalen University, School of Business, Society and Engineering, Box 883, SE-721 23 Västerås, Sweden

HIGHLIGHTS

- Capacity development of local staff to operate and maintain systems.
- Involvement of users from the start to ensure that the system meets the requirements.
- Implementation of cost reflective tariffs.
- Establish an environment that improves end-users ability to pay for services used.
- Ring fencing of revenue from service provision.

ARTICLE INFO

Article history:
Received 27 October 2013
Received in revised form 13 January 2014
Accepted 25 January 2014
Available online xxxx

Keywords:
Sub-Saharan Africa
Renewable energy
Off-grid rural electrification
Stakeholder involvement

ABSTRACT

Technology transfer from developed to developing countries is often problematic. Insufficient resources for operation and maintenance after project finalization are common challenges. Findings from assessments of two projects in rural Botswana and Namibia where different renewable energy technologies were introduced to improve access to electricity are presented. In Tsumkwe, a Namibian off-grid settlement with about 4000 inhabitants, a large solar–diesel hybrid system has been constructed. A smaller system using photovoltaic and biogas is piloted in the off-grid settlement Sekhutlane in Botswana. In Sekhutlane beneficiaries' ability to pay for services is addressed by supporting local entrepreneurs to establish electricity-based businesses. Functionality of installations was inspected and semi-structured interviews were held with key stakeholders. In Tsumkwe local service providers were unprepared to take charge of operations and maintenance after completion of the project and users have difficulties paying for the services. Too strong focus on technology and insufficient efforts made to involve local institutions and beneficiaries throughout the project are main causes. The promotion of local entrepreneurship in Sekhutlane has resulted in 17 local businesses being established, likely to strengthen the cash economy and improved ability to pay for services, and thereby contributing financial resources towards operation and maintenance of systems.

1. Introduction

Apart from contributing to improved living conditions, rural electrification is a central requirement for development and economic growth [1] and contributes to meeting the Millennium Development Goals [2]. Productive use of electricity, i.e. use of electricity to increase the productivity of institutions and businesses is central to alleviate poverty [1,2]. Bensch et al. [1] concluded that electrification provides a technology impulse that stimulates small-scale businesses to improve their productivity.

Currently only one third of all households in sub-Saharan Africa have access to electricity [2]. Over 70% of the population, mostly in rural areas depend on fuel wood to meet their energy requirements [3]. The demand for energy both in form of wood and electricity is likely to increase due to the rapid development in sub-Saharan Africa ([4] and continued population increase [5].

In remote rural areas the establishment of off-grid renewable energy systems, often using solar and/or biomass to produce electricity, is often seen as a more cost efficient and sustainable alternative than expansion of central power grids. Deichmann et al. [4] showed that, even if a renewable power source has a higher unit production cost than fossil power, it can be economically viable when local costs are compared with cost of extending centralized grids, especially in rural remote areas. According to Matsika et al. [3] the provision of electricity to rural households at affordable (subsidized) rates could provide a viable alternative to fuel wood in areas where these resources are scarce. However, the same study revealed that amongst 264 surveyed households in two villages in Bushbuckridge, Mpumalanga Province in South Africa, connected to the national electricity grid, over 80% still use wood as their main source of energy. The relatively high cost of electricity, both the monthly

* Corresponding author. Tel.: +46 21103195.
E-mail address: patrik.klintenberg@mdh.se (P. Klintenberg).

http://dx.doi.org/10.1016/j.apenergy.2014.01.087
0306-2619/

tariffs and the electrical appliances that have to be purchased, e.g. stove and fridge puts a burden on financially strained households. Wood harvesting on the other hand is cheap and sometimes free, and easily available in comparison to electricity. The households in the study by [3] invest their resources into education, food and clothing rather than electricity. The inability to pay for electricity results in continued pressure on woody resources. This result supports the finding by Geist and Lambin [6] who showed that poverty in Africa is linked to environmental degradation caused by unsustainable use of fuel wood across rural landscapes.

One challenge associated to renewable energy is that the electricity production of most systems varies significantly over daily and annual cycles (e.g. solar, wind and hydro). To provide 24 h access to electricity requires appropriate storage options, and in many cases standby fossil or biofuel power that can cover for the gap [4].

After assessing 232 scientific papers related to renewable energy projects Schillenbeeckx et al. [7] stated that most projects focus on technology and institutions, while viability of the technology and user involvement is often not considered. They concluded that a better understanding of users and more community-involvement is likely to increase long-term sustainability of renewable energy projects, reducing the pressure on, often limited, governmental resources. Loock [8] proposed that strategies for implementation of renewable energy should be based on a business model that not only focus on technology and production but also consider best service delivery, i.e. a model with customer needs as a starting point. This could be achieved through policy formulation, promoting service-oriented business models, education and capacity development related to renewable energy, and support to research and transfer of knowledge related to renewable energy services and best practices [8].

Technology and knowledge transfer has the potential to bridge the gap between developed and developing countries [9], and is central to off-grid rural electrification solutions as most systems originate from developed high-tech countries, while the need for the technology is high in developing countries where the demand for electricity is increasing rapidly. According to Shujing [10] there are two kinds of technology transfer; vertical technology transfer, i.e. when technologies are transferred from the research and development stage to commercial implementation; and horizontal technology transfer from one geographic location to another. There is always some degree of vertical transfer, even when a fully commercialized technology is transferred from one geographic location to another, especially if transferred from a developed to a developing country and/or to a different climatic zone. Successful technology transfer also requires transfer of skills and knowhow for operation and maintenance of the technology, resulting in improved capacities in the recipient country [10]. According to Pueyo [11] a number of enabling factors have to be in place at the national level to allow successful technology transfer: (1) foreign equipment and knowledge must be allowed to enter into the country with a low transaction cost, (2) local actors must have the required abilities and technological infrastructure allowing efficient operation and maintenance of the technology, and (3) there must be a demand for the technology being transferred. Based on case studied in Chile, Pueyo [11] showed that increasing energy prices of non-renewable fuel, e.g. fossil fuel, is often enough to create a sufficient large demand for implementation of renewable energy technologies. The ultimate goal of technology transfer, according to Liu and Liang [9] is not only to transfer technology to developing countries but also to enhance their internal capabilities, enabling local development and innovation of the introduced technologies. To achieve this Liu and Liang [9] suggest a four-pronged approach to successfully transfer renewable energy technology, involving physical transfer of technologies, enabling financial mechanisms, capacity development in the receiving country, and monitoring systems. Technology transfer from developed to developing countries is often challenging, which was shown by Costa-Junior et al. [12] that after analysing 75 Clean Development Mechanism (CDM) projects for technology transfer concluded that only 28% of the projects benefited the intended recipients and as few as 21% of the projects led to the implementation of cleaner technology. According to Costa-Junior et al. [12] main reasons for project failure are insufficient capacity development and incentives, and transfer of off-the-shelf out-dated technology mainly gaining the developed countries to extend their markets.

The overall objective of this study is to assess the outcomes of two initiatives transferring renewable energy technology from developed countries to developing countries in southern Africa. The specific objectives are to:

- Investigate how the introduction of renewable energy technology has influenced the energy situation at the two sites.
- Investigate how provision of electricity has influenced the inhabitants and local institutions.
- Investigate what measures that have been taken to ensure local ownership and sustainable operations and maintenance of the introduced technology.

2. Material and methods

2.1. Data collection

The results presented are based on separate assessments of the renewable energy systems in Tsumkwe village in Namibia and Sekhutlane village in Botswana, and their impacts on the target settlements. Four independent assessments were conducted in Tsumkwe [13–16]. In Tsumkwe surveys were made between 2008 and 2012, and in Sekhutlane in 2012. Interviews were also held with the project manager after the end of the project. In Sekhutlane, two researchers engaged in establishing the renewable energy technology at the site, collected the information [17]. Semi-structured interviews were held with key informants and local inhabitants of the two villages. Different questionnaires were used in Tsumkwe and Sekhutlane as the assessments were conducted independently, but addressing similar issues. This does not allow direct comparison of individual answers given by respondents at the two sites but results allows a comparison of causes and effects leading to the outcomes of the two projects at the time of data collection.

2.2. Study area

2.2.1. Tsumkwe settlement, Otjozondjupa Region, Namibia

The settlement of Tsumkwe is situated about 300 km east of Grootfontein, the closest town, in Otjozondjupa Region (Fig. 1). According to the Namibian population census of 2001 there is an estimated population of 9000 in the Tsumkwe constituency, and about 3800 living in Tsumkwe [18]. In total there is about 250 permanent households in the settlement. Tsumkwe is a central part of Tsumkwe Constituency and a strategic place for commercial business, serving as a supply centre and provider of basic services as medical care and law enforcement for as many as 37 surrounding settlements. None of these settlements are connected to the national electricity grid, and are not likely to get connected within the next 20 years. Economically, the inhabitants' livelihoods are based on tourism, animal farming, and small-scale crop farming. Several ethnic groups live there, mainly San, Kavango, Herero, Damara/Nama, Owambo and Caprivians. A majority of the inhabitants belong to the San ethnic group, which is considered to be the most marginalized and vulnerable group in Namibia [19].

Please cite this article in press as: Klintenberg P et al. Successful technology transfer: What does it take? Appl Energy (2014), http://dx.doi.org/10.1016/j.apenergy.2014.01.087