Energy for Sustainable Development 23 (2014) 228–236

Contents lists available at ScienceDirect

Energy for Sustainable Development

Community Charging Stations in rural sub-Saharan Africa: Commercial success, positive externalities, and growing supply chains

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ARTICLE INFO

Article history:
Received 19 April 2014
Revised 28 July 2014
Accepted 18 September 2014
Available online xxxx

Keywords:
Sierra Leone
Development
Solar power
Energy kiosks
Community Charging Stations

ABSTRACT

Over the past two decades there has been a proliferation of energy kiosks across Africa and other parts of the developing world. Typically drawing on solar power, these enterprises provide services such as mobile phone and lantern recharging to (largely) rural communities with limited or no other access to electricity. This article develops a broad analytical framework for evaluating the outcomes of energy kiosks, taking into consideration long-term commercial viability, positive community impacts, the dissemination of improved lighting products, and the provision of credit. Using three energy kiosks as case studies, this article applies the developed framework to critically evaluate a NGO's energy kiosk programme in Sierra Leone, West Africa.

Introduction

Extending grid-electrification into rural areas has proved to be a 'wicked problem' in much of sub-Saharan Africa (IEA, 2012). Given the region's continued rapid urbanisation and increasing constraints on state spending, governments have been largely forced to focus on the challenges of maintaining and expanding urban grid-based service and, as a result, the still more difficult problem of rural electrification has remained effectively unaddressed (Acker and Kammen, 1996; Bhattacharyya, 2013; Khennas, 2012). Given this situation, it has been argued that for rural electrification to be achieved, energy planners need to look to new approaches outside the traditional model of expanding conventional grids. At the same time, the improving affordability of photovoltaic technologies and other renewable energy options has presented a critical new range of options for bringing electricity to remote (and not so remote) communities (Deichmann et al., 2011; Karekezi, 2002). Moreover, and particularly in the context of rising concerns over anthropogenic climate change, modular renewable energy technologies have gained increasing appeal as 'leap-frog' technologies, holding the promise of bypassing conventional grid based approaches (Collier and Venables, 2012; Murphy, 2001; Shaaban and Petinrin, 2014) and putting Africa on a 'green' energy pathway (Bosetti et al., 2009; Winkler, 2005). Nonetheless, a key question remaining to be addressed is how the dissemination of renewable energy sources can be realised given the realities of Africa's current political and economic trends.

In the context of this challenge, photovoltaic technology is increasingly suggested as the most promising source of potential solutions. Solar power is seen as a good fit for Africa due to the continent's natural endowment of strong sunlight well distributed throughout the year, the inherently modular nature of photovoltaic hardware, and therefore also its associated potential for 'leapfrogging' in a manner akin to the rapid uptake of mobile phones across the continent (Collier and Venables, 2012). Despite these congruencies, as well as an almost fifty year history of attempts to disseminate solar energy in the region (Lorenzo, 1997), its uptake in Africa has been minimal at best, and only South Africa and Kenya have successfully established viable domestic commercial markets in solar technology (Bawakyillenuo, 2009; Hajat et al., 2009). Assessing such failure, observers have primarily argued that solar power dissemination efforts have most often employed flawed technical approaches, inadequately addressed questions of commercial viability and/or been based on a poor understandings of local socio-cultural realities (Gómez García and Montero Bartolomé, 2010; Nygaard, 2009).

Amongst the various solutions to the dissemination issue that have been explored, a particularly important approach has been the creation of solar powered charging stations: small village kiosks electrified with

Abbreviations: CCS, Community Charging Stations; PCS, Privatised Charging Station; EFO, Energy For Opportunity; SHS, Solar Home Systems.

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http://dx.doi.org/10.1016/j.esd.2014.09.005
0973-0826/

photovoltaic modules which act as centres for recharging mobile phones, lanterns and other small electrical items. They offer an operating model that is based on relatively sound economic principles but that is also flexible enough to be adapted to different local contexts. Nonetheless, although such decentralised systems have been trialled for the past three decades, it has only been in the last few years, with increasing global attention to the relationships between poverty reduction and climate change mitigation, that the approach has gained widespread prominence (Schäfer et al., 2011). Therefore, as Schäfer et al. note, "due to the current international relevance of the topic, a window of opportunity seems open that may allow for the enhancing of discussion about adequate methods and instruments for integrating different types of knowledge in this field" (2011, p. 325). They emphasize, however, that in order to move forward, such a discussion must be underpinned by rigorous research that systematically evaluates the lessons learned from the wide variety of field trials in order to draw transferable conclusions (2011, p. 325). As such, there is a need to establish a "charging station research community," that examines the variety of technologies currently in use in very different geographic and cultural contexts across sub-Saharan Africa (Schäfer et al., 2011).

This paper presents an initial step in responding to the appeal made by Schäfer et al. by presenting the experiences of a non-governmental organisation (NGO) Energy For Opportunity (EFO) which has installed over 30 solar-powered charging stations in rural communities across Sierra Leone, West Africa and has many more planned in future. Focusing on three of EFO's charging stations employing different technological designs and located in dissimilar geographical contexts, the paper provides a rich understanding of the impacts of EFO's approach and lessons learned to date.

Charging Stations in Africa—an evaluation rubric

Whilst there are numerous different approaches to developing and operating solar powered charging stations, a survey of the literature that has emerged on the topic thus far indicates four major criteria for success: 1) commercial viability; 2) positive community impacts; 3) dissemination of improved lighting; and 4) the provision of credit.

1) *Commercial viability* is conceptually straightforward but frequently complex to achieve in practice. As noted earlier, many solar power projects in Africa have failed due to the lack of financial mechanisms to facilitate their long-term maintenance (Nygaard, 2009). Thus, it is important for charging stations to be based on sound business principles to ensure that they raise enough revenue—not just to cover day-to-day operational expenses, but also to finance the replacement of key parts of the system (e.g., batteries, controllers) should they breakdown. In short, the charging station needs to be able to operate completely independent of any external funding.
2) *Positive community impacts* is a more amorphous category. 'Positive impacts' could simply be construed as the provision of the charging station in itself; however, a charging station that demonstrates a greater degree of 'community ownership' and facilitates broader positive developmental impacts in the community can be judged as having greater success. As LeMaire (2011) notes, this could include improved education outcomes, increased business opportunities, and the raising of community revenue.
3) *Dissemination of improved lighting* is directly linked to the charging station's potential to replace kerosene lamps and other 'inefficient' lighting technologies with higher quality lighting sources (Adkins et al., 2010). Key amongst these are LED lanterns (high lumen, low energy lamps) and Solar Home Systems (SHS)—small residential kits that usually include a small solar module, controller, battery and lights, as well as a plug for recharging mobile phones in some cases. The charging station's ability to provide a 'self-sustaining model' for the dissemination of such technologies therefore can be taken as a key measure of its success (Chaurey et al., 2012; Pode, 2013). Whilst this measure may evidently overlap with the previous category of 'community benefits' it is primarily focused on residence-level improvements in quality of life and is often quite an overt focus of charging station projects.
4) *Provision of credit* links directly to improved lighting. LED lamps currently cost around $US15, whilst SHSs are upward of US$100—prices generally beyond the immediate disposable income of many rural households in Africa. Nonetheless, due to reduced household costs for kerosene and battery purchases these lighting options are actually more cost-effective than traditional lighting sources in the long-term. The challenge, therefore, is to develop funding mechanisms so that households can overcome the purchase cost barrier to 'transition' over to these improved lighting products. Given that such mechanisms frequently entail purchasing on credit, a One-Stop-Shop model in which the same entity that disseminates improved lighting products also provides options for credit is of great advantage because it consolidates operations under a single organisation (Pode, 2013).

Drawing upon these four criteria we have developed an evaluation rubric, seen in Table 1, which can be used to assess the impacts of a charging station. Importantly, the rubric is not concerned solely with a station's commercial dimensions, but rather more broadly with its ability to spread positive impacts throughout the community in which it is situated. Each of the rubric criteria has four levels that, taken together, can provide a qualitative evaluation of the charging station's progress. In addition, we wish to emphasize that this rubric is not presented as a perfected finished product, but rather as a first step towards more standardised and transferrable charging station evaluation and a means of focusing broader debates on disseminating improved lighting products throughout West Africa on certain key matters of concern.

It is evident that a charging station which fulfils all of the above criteria has the potential to be a very powerful transformative force at the village level. Figs. 1 and 2 below provide a conceptualisation of what this transformation might look like. First, the pre-charging station village (Fig. 1) uses low lumen lighting (i.e., kerosene, battery operated torches) that presents significant household hazards. Second, money paid to recharge mobile phones at generator-powered telecentres and to refill lamps with kerosene or torches with batteries represent a significant leakage of hard-won household income.[1] Third, profits from these sales largely flow out of the village, and even the country, as generator fuel, kerosene, and batteries are usually imported commodities with attendant issues of foreign exchange expenditures at the national level and vulnerability to supply disruption for all users. In contrast, the post-charging station village (Fig. 2) is able to trap most of this revenue: as operational costs for the kiosks are minimal, previously leaked funds can be redirected to community projects. Furthermore, if the dissemination of 'improved lighting' products is achieved, the charging station will also assist in improving overall household lighting in the village whilst simultaneously reducing a number of considerable domestic health and safety hazards.

In sub-Saharan Africa one of the major barriers to realising the transformation from Fig. 1 to Fig. 2 has been the large initial capital costs of solar power installations (unlike generator systems which have relatively lower initial capital cost but much higher operating costs). Other issues include a lack of available photovoltaic equipment and a lack of skilled installers in country. All three issues are slowly being addressed by the growing international market as the price of photovoltaic systems has dropped dramatically whilst photovoltaic installers are becoming increasingly common across Africa, but nevertheless the ability to realise the installation of these systems tends to be beyond the financial and logistical capabilities of most rural villages.

[1] Pode (2013) estimates that rural households spend around 10–15% of their income on lighting needs.