Energy Research & Social Science xxx (2015) xxx–xxx

Contents lists available at ScienceDirect

Energy Research & Social Science

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

Small-scale hydropower in Africa: Socio-technical designs for renewable energy in Tanzanian villages

Helene Ahlborg[a,*], Martin Sjöstedt[b]

[a] Department of Energy and Environment, Chalmers University of Technology, 412 96 Göteborg, Sweden
[b] Department of Political Science, University of Gothenburg, Box 711, 405 30 Göteborg, Sweden

ARTICLE INFO

Article history:
Received 25 June 2014
Received in revised form
12 December 2014
Accepted 18 December 2014
Available online xxx

Keywords:
Rural electrification
Renewable energy
Sociotechnical systems
Africa

ABSTRACT

In this article, we explore the process of economic change following the NGO-led implementation of a small-scale off-grid hydropower system in Tanzania. We examine how the implementing actor deals with economic challenges and local ownership in order to achieve sustainable electricity supply. The qualitative case study shows that the NGO, ACRA-CCS, has overcome a number of constraints, which are sometimes associated with donor funding. This has been achieved by having multiple donors, an integrated approach and a longer presence. The 'logic' of implementation included active enhancement of productive electricity use, community services and benefits. As a result of these actions, the customer base grew quickly, rather than it taking many years to develop. The case illustrates the process whereby an off-grid system becomes economically viable. Local ownership has led to the project becoming an arena for community collaboration and problem solving, and creating values such as effective load management and protection of infrastructure. We suggest that attention should be given to possible public private community partnerships (PPCPs) – involving communities as crucial partners. The choice of a socio-technical system perspective was fruitful and provided crucial insights into how different factors manifested, interacted and played out in practice.

1. Introduction

In this article, we are concerned with access to electricity for poor people in East Africa and specifically study a case of rural electrification using off-grid mini-hydropower in Tanzania. The hydropower system of 300 kilowatts (kW) was built by an Italian non-governmental organization (NGO) in partnership with the local church and funded by international and national donors. Since 2010, the system has been supplying electricity to customers. The aim of the project was to provide access to electricity and thereby contribute to social and economic development of the area.

Electricity is a powerful resource that has the potential to catalyze societal change by providing opportunities for a new range of activities and services. However, previous research shows that such positive outcomes – such as social and economic development resulting in improved quality of life and improved livelihoods for rural populations – do not always result. In fact, many rural electrification initiatives do not produce the sought-for development outcomes and even fail to deliver electricity services over the expected system lifetime [1,2]. This is commonly attributed to the way in which the electrification initiatives interplay with existing local conditions and especially how developers and implementers handle the challenges associated with implementing reforms in agrarian, seasonal economies where people generally have low incomes.

We focus our discussion on a few aspects that previous research highlight as prerequisites for sustainable small-scale energy systems in poor rural areas: achieving economic viability, a high degree of local participation and development of local expertise [2–6]. The most important overall factors that make these goals hard to achieve are rural poverty and poorly developed rural economies and markets. These factors result in low demand for electricity services, slow development of economically productive electricity use and a weak customer base [7–10]. For private and commercial entities, economic viability includes recovering investment costs, and making a profit. For donor-funded, non-commercial initiatives, cost recovery is not necessary, and economic viability is defined as covering the costs of operation, maintenance and, in this case, future reinvestments. However, development aid – in many areas, not only electricity – has been criticized for not resulting in economically viable installations or

* Corresponding author. Tel.: +46 31 7723105.
E-mail addresses: helene.ahlborg@chalmers.se (H. Ahlborg), martin.sjostedt@pol.gu.se (M. Sjöstedt).

http://dx.doi.org/10.1016/j.erss.2014.12.017

self-sustaining organizations. According to this critique, development aid maintains structures of economic and organizational dependence on external actors [11].

In contrast, NGOs are often considered champions of local participation and empowerment. The NGO that is the focus of this article is no exception; the project has been ambitious in involving local communities and building local competences. The project has also included complementary investments and cross-sector coordination, other features identified by scholars as important for success [12]. Therefore, the case we study here displays what literature has identified as both negative determining factors – donor dependency and working in a poor area – and positive determining factors – a strong emphasis on local ownership, capacity building and complementary investments. What will this mean for the sustainability of the project and its impact on the local economy?

Our aim is to explore the process whereby a donor-funded off-grid electrification project using renewable energy, implemented by an international NGO, translates into an organizationally and economically viable local utility, and a growing local economy. The case is of general interest because it provides insights for the development of mini-grids based on hydropower or other renewable energy sources in poor rural areas all over Africa, the subject of this Special Issue, as well as for other parts of the world with similar energy needs (see also Eder, Mutsaerts and Sriwannawit [13], and Hancock in this special issue [14]). It is also of wider interest as decentralized electrification in African countries is often carried out by non-governmental entities [6,15] and non-profit entities and community-based organizations are likely to play an important role in future development of renewable energy systems – sometimes in partnership with commercial actors or as social entrepreneurs.

Scientifically, we contribute to existing knowledge by providing a rich description of how and why various factors come to matter. A theoretical and empirical contribution of the article lies in its investigation and analysis of system dynamics. Electrification processes are unique and play out differently in each place, but the system understanding guides us to what is likely to be important, what to look for and what questions to ask. The study fits well into the ambition of *Energy Research & Social Science* to investigate the social system surrounding energy technology and hardware. It engages with some of the research questions and areas highlighted in the first issue of this new journal, in the articles by Sovacool [16], Stern [17] and Stirling [18]: it applies human-centered research methods and field work in an exploratory study of human–energy interactions. The electrification process is viewed from the perspective of multiple actors, including citizens in their roles as users, customers, and members of the local utility.

The article is organized as follows. In Section 2, we explain the theoretical perspective and the focus of the case study, and summarize key points from earlier research. Section 3 gives a brief description of the project and of the area and the economy in which the project was implemented. Based on this, the aim of this paper is specified into concrete research questions directing the analysis (Section 4). A method section follows (Section 5), before the case study results are presented and discussed (Section 6). Finally we sum up the findings and relate them to theory and earlier research (Section 7).

2. Theoretical perspective and previous research

2.1. A socio-technical approach to electrification

This paper argues that our understanding of system dynamics in rural electrification is greatly enhanced by taking the literature on socio-technical systems seriously. This literature contributes a perspective that sees technological and societal change as interrelated [19]. Socio-technical approaches highlight co-evolution of technology and society, the multi-dimensionality and complexity of technological change, and multi-actor processes [20]. Researchers have applied socio-technical approaches in analyses of large-scale infrastructure development and the development of new renewable energy technologies, mainly within industrialized countries [20–22]. As yet, few studies apply this perspective to small-scale energy systems in East Africa ([23,24], see also Ulsrud, Winther, Palit and Rohracher in this special issue [25]).

We theorize electrification as a dynamic process of formation of a new socio-technical system, which brings people, technology, institutions and resources into specific relationships (see Fig. 1 for the theoretical conceptualization). In small-scale hydropower systems, actors, institutions and networks form around the concrete system of energy production and distribution. Networks connect local actors to one another as well as to district, national and international stakeholders, thereby providing important support. The system is shaped by and shapes its environment, with dynamic and emerging outcomes. As the system develops over time, the relationships produce outcomes that transform the dynamics as well as the system design in itself.

Scholars in the field of socio-technical systems pay close attention to the role of technology [26] and how technical systems come with specific demands, possibilities and restrictions, that condition development. They acknowledge the importance of actors and human perceptions as well as relations of power – although the consideration of power relations is still an emerging issue in the field [20]. In our analysis, we focus mainly on the implementing NGO, the local utility, and local users. The implementing actor plays a key role and works according to a certain 'logic', namely: (1) the NGO's ethics and objectives, (2) its choice of system design and mode of operation, and (3) the strategies for implementation and system sustainability. Our focus is on how the NGO handles the economic challenges (related to rural poverty and the need for economic viability) and the challenges of building from scratch a local organization to independently own and manage the system, after the NGO exits. We analyze how the relationships develop over time between the NGO, the local utility and people in the communities.

2.2. Existing critique of NGO-led development

To enhance our understanding of the implications of the 'logic' by which electricity is introduced, this article also departs from the scholarly discussion on NGO-led development and the vices and virtues of the aid industry in general [27–29]. NGOs have often been conceptualized as a grassroots alternative to supposedly corrupt and inefficient government agencies, and their involvement has been held to safeguard a participatory, bottom-up approach to development and social improvement [30,31]. Yet although initially welcomed by policy-makers and academics alike, NGO-led development has in more recent times come under closer and more critical scrutiny [32,33].

One important critique directed toward NGO-led development in recent years is related to NGOs' dependency on donors. The literature argues that this dependence risks placing NGOs in a patron–client relationship with donors, where the activities and interventions are more or less donor driven. Scholars also raise serious questions about whether the NGOs are primarily accountable to the donors or to the targeted communities [34]. It is also argued that this might divert resources into tangible and visible projects undertaken to please potential contributors, at the expense of more complex and long-term processes with potentially higher, but less easily measured, impacts [35–37]. According to this logic,

Please cite this article in press as: Ahlborg H, Sjöstedt M. Small-scale hydropower in Africa: Socio-technical designs for renewable energy in Tanzanian villages. Energy Res Soc Sci (2015), http://dx.doi.org/10.1016/j.erss.2014.12.017