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Assessing management models for off-grid renewable energy electrification projects using the Human Development approach: Case study in Peru

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ABSTRACT

Electrification systems based on renewable energy have proven suitable for providing electricity autonomously to rural communities, thus reducing poverty. When implementing these systems, a management model is usually designed to maximise technical and financial sustainability. Different evaluations of management models have been made that usually centre on products and final utilities. However, this excessively utilitarian vision of development restricts an analysis of the impact that these projects may have on people's lives. To overcome these limitations, we have used the Human Development approach to evaluate the management model of five electrification projects that use different technologies in Cajamarca (Peru). This approach enables a broader assessment of various key dimensions of development that should be considered in the management model. The results show the weaknesses of the design and implementation process of the management model. Several ideas are proposed to avoid these weaknesses and to maximise the chance of success.

Introduction

Access to electricity is considered to be a key factor in reducing poverty, especially in rural areas, where development indices are usually low (for example, Gomez and Silveira, 2010; Pasternak, 2000; Borges et al., 2007; Kooijman-van Dijk and Clancy, 2010; Valer et al., 2014; Nerini et al., 2014; Shyu, 2014; Groh, 2014). As in most countries (Bhattacharyya, 2012), the Peruvian government's current strategy to increase rural electrification is oriented towards the expansion of the national grid. However, the degree of isolation of non-electrified rural communities represents a significant barrier to access this service due to higher investment costs, limited capacities of operation and maintenance (Palit, 2013) due to a lack of education and access to information (ESMAP, 2001), and low consumption rates (Gouvello, 2002). Isolation is particularly prevalent in Peru because its varied and complicated geography includes a wide mountain range and vast areas of rainforest. (See Fig. 1.)

In such contexts, small stand-alone systems for energy generation, especially renewable energy (RE) based systems, represent a suitable alternative for providing electricity to the rural population (Nguyen, 2007; Breyer et al., 2009; Benecke, 2008; Chaurey et al., 2004; Lhendup, 2008). Studies show that the following are some of the advantages of decentralised models: the use of local resources and the avoidance of costly and inefficient transmission losses (Benecke, 2008), suitability for low-load factor projects (Kaundinya et al., 2009), independence from fuel supply and respect for the environment (Nguyen, 2007), and the provision of energy independence for users (Hiremath et al., 2009; Akorede et al., 2010). In addition, these systems can be managed locally, enabling the generation of local jobs and the participation of local people in decision making (Sánchez, 2006). In particular, ESMAP (2001) states that "*although it is true that all aspects (legal framework, finance, technology, and so forth) are important for improving the rural population's access to electricity, the continuity of the service (that is, the system's sustainability) can only be assured if its management models are functional and efficient*".

In this article, we analyse microenterprise management models focusing on factors that are not usually analysed or that were considered to a lesser extent in previous evaluations. In particular, we use the Human

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Development (HD) approach, which enables us to extend the analysis on various key dimensions of development that should be considered in the process of implementing a management model. Thus, the base of information (Sen, 1999) used to assess the impacts of such projects and improve the planning is enhanced to maximise the chances of future success.

In particular, we focus on an analysis from the HD approach of the microenterprise management model for stand-alone rural electrification systems with RE developed by the Non-Governmental Organisation (NGO) Practical Action (PA) in the northern Peruvian Andes that is specially designed to promote the development of poor rural communities. The analysis has been conducted in the region of Cajamarca, in the northern Peruvian Andes. Five RE electrification projects in isolated rural communities implemented by PA have been studied, whose management model of these projects will be described in detail.

The paper is structured as follows. Section 2 describes how management models have been analysed by other authors and the management model of PA. Section 3 describes the methodology used. Section 4 presents the results obtained. Section 5 discusses the results and makes recommendations based on the HD approach. Finally, Section 6 highlights the conclusions of the investigation.

Management models of isolated rural electrification projects

Literature overview

There are numerous management models of stand-alone electrification systems, among which the most common are those managed privately, cooperatively, or by state or local municipalities or communities. These models have different characteristics in terms of ownership of the systems, level of user participation, responsibility for operation and maintenance of systems, user involvement in infrastructure construction and installation of equipment, management of tariff payments, etc. (ESMAP, 2001).

Given the importance of management models in stand-alone rural electrification projects with RE, various studies have analysed them, including that designed by PA. ESMAP (2001) analysed management types based on whether the system is owned by the state, municipality, the community, or cooperative or private interests in 12 communities in Peru, evaluating the service quality and economic aspects of each system. Yadoo and Cruickshank (2010) analysed cooperatives as a management model in USA, Bangladesh, and Nepal, focusing on their technical and economic feasibility and sustainability while also considering the effect of public participation and the promotion of equity and empowerment that such a model can create.

Regarding PA's management model, Sánchez et al. (2006) performed a comparison between governmental, municipal, private, and community management models in Peru. He focused on technical and economic sustainability, concluding that the most successful is the microenterprise model implemented by PA. Ferrer-Martí et al. (2012) studied three projects in the Peruvian Andes using the microenterprise management model employed by PA, taking into account the benefits of the projects in terms of new resources or services, as well as the technical and economic sustainability of the systems, and concluded that the management model is generally satisfactory in the three communities. Yadoo and Cruickshank (2012) analysed three projects in Peru, Nepal, and Kenya with different management models. The organisational dimension, capacity strengthening, client relationships, and stakeholder participation were evaluated. In this analysis, the project implemented by PA was the highest rated in the social and institutional dimensions.

However, there might be limitations on the different management models analysed that have escaped the attention of the authors of previous studies due to the use of an approach excessively centred on technical and economic aspects, without addressing in depth the impact these projects have on people's lives beyond the provision of material and economic resources. As we will highlight further, by using the HD approach, it is possible to identify, analyse, and propose strategies to substantially improve the impact of this type of intervention regarding development promotion.

Description of the Practical Action management model

The analysed management model was designed and promoted by PA, which is an international technical cooperation NGO that has been operating in Latin America since 1985. PA has developed a management model (Ferrer-Martí et al., 2010, 2012) whose main objective is the efficient financial and technical long-term operation of small isolated power systems. In this management model, the owners of the systems (generally the district municipality) give responsibility for operation, maintenance, and administration to a private local microenterprise (managed locally by the members of the community) on a medium or long-term contract.

The management model is composed of different actors, including the microenterprise, users, and the municipality (Ferrer-Martí et al., 2012) (See Fig. 1).

- Users and control unit: Each user is required to pay a monthly tariff that covers the maintenance of the equipment and has the right to attend monthly financial review assemblies. Furthermore, the community periodically evaluates the performance of the microenterprise and either re-elects the current operator–administrator or appoints a new person to run it. Moreover, a control unit elected by the assembly and composed of local people, mainly authorities, is responsible for overseeing the administration of the microenterprise (use of tariffs, non-paying clients, quality of service, etc.) to ensure compliance of user obligations and address their complaints or suggestions.
- Microenterprise: The microenterprise is composed of one or more of

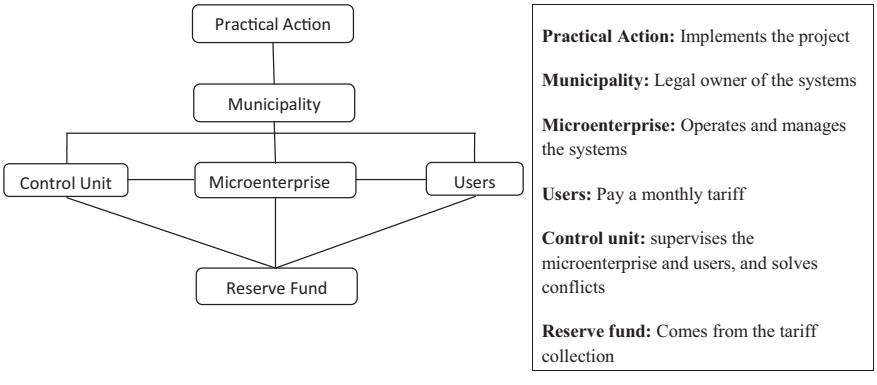

Fig. 1. General scheme of the Practical Action management model. Adapted from Ferrer-Martí et al., 2010.