Renewable and Sustainable Energy Reviews 20 (2013) 1–7

Contents lists available at SciVerse ScienceDirect

Renewable and Sustainable Energy Reviews

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

Operational costs of A 13,000 solar home systems rural electrification programme

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ARTICLE INFO

Article history:
Received 4 July 2012
Received in revised form
21 November 2012
Accepted 26 November 2012
Available online 20 December 2012

Keywords:
Photovoltaic
Rural electrification
Decentralized
Costs
Operation and maintenance

ABSTRACT

This paper presents an assessment and evaluation of the costs of operation and maintenance (O&M) in a real PV rural electrification (PVRE) programme, with the aim of characterizing its costs structure. Based on the extracted data of the 5-years operational costs of a private operator, the programme has been analyzed to take out the most relevant costs involved in the O&M phase as well as the comparative appraisal between the 3 main activities: installation, O&M and management. Through this study we try to answer to the new challenge of decentralized rural electrification based on larger programmes (with tens of thousands of SHSs) and longer maintenance and operation periods (at least 10 years).

Contents

1. Introduction

Most PV rural electrification projects based on solar home systems (SHSs) and *fee for service* concept [1,2] have failed because real operation and maintenance (O&M) costs are larger than initially expected [3–5]. Fees lower than real cost produces serious financial imbalances, making O&M unfeasible and leading to the desertion of SHSs by the local operator.

In fact, despite many programmes and subsequent evaluations has been carried out since 1970s [6–14], real O&M costs are scarcely reported at the available literature [15], making difficult the task of designing new SHSs programmes.

This paper reports on the *fee for service* programme (*Programme d'Electrification Rural Global*, PERG) awarded to the energy service company (ESCO) Isofoton in Morocco [16,17]. The programme has been developed in a region consisting of 12 provinces, covering around 200,000 km^2, and having more than 13,000 installed SHSs at the end of 2010. A previous paper [18] gave statistically meaningful data on the reliability of SHS components, mainly in terms of failure rates and mean time to failure (MTTF). Now, we present the distribution of real costs

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http://dx.doi.org/10.1016/j.rser.2012.11.073

(installation, O&M and management) from the operational data of the ESCO Isofoton during 5 years, and we discuss the influence of some key aspects as battery and geographical dispersion.

2. PERG programme features

In the operative frame, the ESCO was responsible to sell the SHSs directly to the final users through a *fee for service* mechanism, as well as its furniture and installation within the 3 first years of the programme (from 2006 to 2008). The SHS consists of a 80Wp mono-crystalline silicon cells photovoltaic module (the manufacturer indicates a power peak tolerance of $\pm 5\%$ and the program requires a minimum power of 75 W), a 150 Ah C_{20} lead-acid battery (modified SLI), a 15 A series charge controller with PWM regulation and without MPPT function, 4 compact fluorescent lamps (CFL) (3×7 W and 1×11 W), and a DC plug for small devices (less than 50 W). Electrical efficiency of this lamp model, according to recognized laboratory tests, shows a value of 81% at 13 V. Similarly, charge controllers have a charge and discharge efficiencies around 99%.

The photovoltaic PERG programme has been designed by the Moroccan utility ONE. The sizing of SHSs and the components requirements have followed the recommendations of the Universal technical standard for solar home systems [19], in addition to the IEC-61215 for PV modules, the IEC-60811 for wires, the EN61057:2000 and EN55015:200 for lamps and the EN55014-1 and EN55022 for charge controllers.

Table 1
Geomorphological distribution of the region.

Mountains (km^2)	Hills (km^2)	Desert (km^2)	Plain (km^2)
101,214	**2760**	**73,068**	**21,009**
51.1%	**1.4**%	**36.9**%	**10.6**%

The installed SHSs are subject to a 10 years maintenance period. The ESCO must guarantee the systems during this period and must repair or replace damaged components. The ESCO is also responsible of collecting the monthly fees that the users must pay for the maintenance service. These fees are established by the electrical utility ONE (*Office National de l'Electricité*) in 4.92 €/month/SHS (excluding VAT), that it is equivalent to 59.04 €/year/SHS. This fee amount will remain unchanged over the 10 years of maintenance service.

The PERG region is geo-morphologically characterized to be located, partly, in a mountainous area (50% of the region is covered by 3 mountain ranges: the Medium Atlas, the Grand Atlas and the Antiatlas), and partly by wide desert areas (Table 1). These features give to the region a difficult accessibility and a wide dispersion of villages and households.

In Fig. 1 appears the SHS density corresponding to the PERG provinces. The extremely low geographical density of SHSs is a remarkable feature of the region: 0.068 SHSs/km^2, what means that there is 1 SHS per 14.7 km^2. There are just two provinces, Al Kalaa des Sraghnas and Beni Mellal, whose density is largest than 0.4 SHSs/km^2. In the vast majority of the region, the density is lower than 0.1 SHS/km^2, coinciding with the most mountainous and desert areas.

3. Costs analysis

We will distinguish 3 main activities (see Fig. 2): installation, O&M and general management. The installation refers all the works and activities required to install the SHSs, as well as the purchase of equipments and the marketing. The operation and maintenance of the systems requires the technical maintenance of the SHSs (including spare parts) and the collection of user's fees.

The general management (ESCO headquarter, management staff, etc) is linked to the others, so, it can be considered as an indirect cost of them. However, the management has been taken into account as an independent activity in this study.

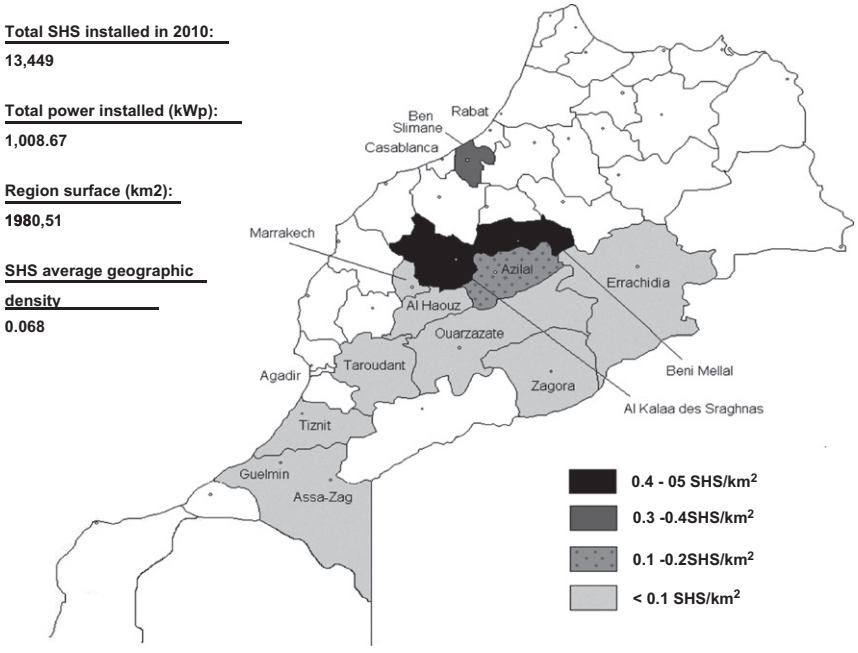

Fig. 1. Moroccan region belonging to the Isofoton PERG programme. The different areas. show the SHS density for each province (Province map before 2010 new region organization).