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Practical constraints for photovoltaic appliances in rural areas of developing countries

Lessons learnt from monitoring of stand-alone systems in remote health posts of North Gondar Zone, Ethiopia

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ABSTRACT

Photovoltaic stand-alone systems are largely regarded as a viable option for decentralized rural electrification in developing countries. However, literature review reveals lack of documented experiences with installed PV systems such as Solar home systems as well as general problems with system maintenance and battery up keeping. This paper presents results from monitoring 31 stand-alone PV systems in remote health posts of North Gondar Zone in Ethiopia from installation until system failure; several systematic factors were found to have contributed to failure: lack of clear responsibility for the systems due to regular job rotation among health workers and lack of upfront, gender sensitive training, lack of equipment for maintenance work, very slow and unreliable chain of information in case of system failure and costly double tracking of energy supply. Nonfunctioning PV systems were found to threaten the technology"s reputation by word of mouth. The results gained in this research provide important lessons for future programs of rural electrification by means of PV systems: they stress the importance of awareness building amongst funding agencies as well as the imperative of intense and sensitive training for users, especially women, and advocate for considering living conditions of users in system design.

Introduction

Lack of access to electricity is frequently indicated to dampen or even hinder economic development in rural areas of developing countries. Existing literature on electrification stresses the hopes for benefits on socio-economic effects. Three areas of impact are assessed: educational benefits because of increases in study time, improvements in income because of increased non-agricultural activities, and decrease in respiratory diseases because of decreases in usage of open fire, candles and kerosene.

To this background, the United Nations set their aim of universal access to electricity by 2030 via their initiative Decade of Sustainable Energy for All (2014–2024) (The Secretary-General's advisory group on energy and climate change (AGECC), 2010). More than 1.3 billion people in developing countries lack access to electricity today; Out of these, 590 million live in Africa where the rural electrification rate is only 14% (International Energy Agency, 2012: 226). The investment requirements for electrification on the continent are therefore enormous: International Energy Agency (2011: 483) quantified them to 390 billion US Dollars if universal access to electricity should be achieved by 2030.

Given these requirements, photovoltaic stand-alone systems[1] are largely held as a viable option for decentralized rural electrification in developing countries. Ecological sustainability of renewable energy sources such as PV, paired with the general abundance of solar energy in the regions in question, have frequently been cited as prerequisites almost demanding the adoption of this specific technology in remote areas of the Global South, especially as "few connected households consume an amount of electricity and require peak loads that cannot be provided by off-grid technologies." (Peters and Sievert, 2015).

Additionally, low running costs of PV systems are perceived as beneficial for poor and marginalized sections of the rural population, diminishing their dependence on increasingly costly and unsustainable fossil fuels – this is regardless of the actual devices powered by electricity generated by photovoltaic panels. Furthermore, health risk reductions are identified in regard to lighting when candles and kerosene lamps are replaced by CFLs (Compact Fluorescent Lamps) resp. LEDs Light Emitting Diode; whether they are powered from PV generated electricity or grid connected). These lamps significantly "reduce" both the quantity of fume inhaled by household members and the associated fire hazards.

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[1] PV generators (panels) not connected to a public electricity grid and thus relying on suitable storage media such as batteries.

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While this last causality remains largely uncontested and valid, doubts have increasingly arisen with regards to the general suitability of the PV technology in the said rural context. So while Vervaart and Nieuwenhout (2001), for instance, give a figure of 1 million solar home systems which had been built until early 1999, they state: "Very little information is available about the actual use of solar home systems[2] in practice. There are some scattered monitoring activities." They see ownership as an important factor in the attitude of people toward their PV systems and their maintenance: "A sense of ownership is a strong incentive for maintaining the system. For this reason, projects where the government provides the systems at no charge usually show much higher failure rates than commercial schemes."

Similarly, Nygaard (2009) cites Togola (2001), Afrane-Okese and Mapako (2003) and Martinot et al. (2002) as finding that "donor supported PV projects have in a number of cases only been operational for a few years due to economic, technical and organizational reasons".

Villavicencio (2002) has analyzed the viability of solar home systems[3] using indicators such as affordability, efficiency, freedom from risk of obsolescence, flexibility and technological capability. Based on this analysis he contests that PV systems are a universal energy strategy for rural households in developing countries, because, as he argues, solar home systems are expensive, inefficient, have a high risk of obsolescence and are far more difficult to maintain than expected.

It turns out that maintenance requirements center around battery quality: "It is not always realized that batteries are usually by far the most expensive part of a solar home system over the lifetime of the system. Lifetime of batteries vary considerably from project to project, from less than 1 year to more than 4 years." (Nieuwenhout et al., 2001).

Vervaart and Nieuwenhout (2001), too, stress this point when finding: "The total costs of the different components, over a life cycle of 20 years, present a different picture than for the initial costs. […].. the cost of batteries increases from 13 percent to 46 percent, substantially greater than the life-cycle cost of the modules. […] To reduce the 20-year cost of solar home systems, it is therefore of utmost importance to increase the lifetime of the batteries used."

One crucial factor for battery life expectance is system maintenance: Erkkila (1990), examining the case of solar refrigerators, comes to the conclusion that "contrary to the unfortunate common perception, solar refrigerators are not miracle machines which can be forgotten once installed and have no need of maintenance and repair thereafter. Indeed, experience has shown that […] solar refrigerator projects, without ….well – established support system for maintenance have minimal chance of succeeding."

Foley (1995) agrees that "perhaps the greatest weakness of PV programs to date has been the serious underestimate of the need for adequate repair and maintenance systems" Hence, he identifies user awareness as the second key issue for the avoidance of system failures in the long run: He claims that "People need to be made aware […], what systems can provide, and, equally important, what they cannot. They need to be told of the need for maintenance and how to carry it out. They need to know about the management of loads on the systems – for example, restricting the use of lights and appliances during cloudy periods". The technicians involved in the installation, maintenance and repair of PV systems need to be trained if they are to do their jobs properly. But Foley warns: "Simply providing training courses for technicians will not meet this need. Unless these technicians are employed and appropriately compensated for their knowledge, they will not consolidate their skills, and the training will be wasted."

It is evident from these findings that electrification by means of PV solar technology has to be regarded as a yearlong process rather than the mere installation of the required devices at the beginning. Therefore Nieuwenhout et al. (2001) come to the conclusion that "For a considerable number of these [hundreds of solar home systems (SHS) projects which have been conducted in the past few years], descriptions of the organizational set-up exist, but only very few studies describe in some detail how SHSs are actually used by households. Some early successes might have given the impression that everything is running well and there is no need to spend time and money at this stage on further research. But relatively high failure rates, even in some recent projects, prove that there is still scope for improvement. … Those studies that were available usually deal with the first 1–2 year of the project, while information over longer periods of time is more relevant to conclusions regarding lifetime of equipment and sustainability in general. Negative experiences are seldom narrated. Monitoring needs to be continued after the installation stage of the project."

Need for further research in this respect is clear. Accordingly, keeping track of systems' performance after installation until system failure therefore was one of the main purposes of the investigations presented in this paper which studies PV systems in remote rural health posts in Northern Ethiopia. Not surprisingly, the issues of maintenance, user awareness and training with regards to system operation turned out to be of crucial concern in this instance again.

Finally, against the background of public efforts to effectuate the broadest possible rural electrification, related policies turn out to be of major influence on outcome and sustainability of PV projects and they therefore have to be explicitly addressed in project design and implementation. Martinot et al. (2000: 14) reports that some participants in his investigation "cited unrealistic political promises or planning about rural grid extension as a serious barrier to solar home system market expansion, …". And he states: "Of course, all else being equal, households would prefer to be connected to a grid than obtain energy services from a solar PV system. Still, in most countries, 100 percent grid extension is too costly and unrealistic." Thus, in monitoring the long term functioning of PV systems in remote rural health posts in Northern Ethiopia, several supply systems (PV, public electricity grid, kerosene, diesel generators) existing in parallel were found to pose questions on reliability and sustainability as well as donor driven development.

Material and methods

General description

In 2010, several remote rural health stations in Amhara Province of Northern Ethiopia were equipped with stand-alone PV systems for lighting and solar refrigerators.

This partial rural electrification program was implemented in close cooperation of the Amhara National Regional State Bureau of Health (ANRS BoH) and the Provincial Government of Lower Austria (PGLA) as funding partner.

The two partners agreed on a recurring monitoring of the installed systems to keep track of their further functioning; regular visits aim at updating information on the current state of the systems and at thereby providing a data base for decisions on further measures required to maintain the functionality of the PV systems. So far, two monitoring visits to the project area have taken place in 2011 and 2013 respectively.

While monitoring is ongoing, results up to date stress the importance of training on PV maintenance for the concerned health workers, – most of them female -, their empowerment and the clear definition of responsibilities within the organizational framework of ANRS BoH. The monitoring has thus proven to be a reliable key for engaging both donor and local agency in a sound collaboration to the end of supporting and improving electrification of rural health care by means of Photovoltaic.

[2] A small, photovoltaic (PV) system that consists of one or more solar modules, a battery and several 12 Vdc appliances.

[3] Small PV systems of a few W_p (Watt peak) capacity only, deployed mostly to private households, primarily for energy use in lighting, radio, TV or refrigerator.