



## Assessing users' performance to sustain off-grid renewable energy systems: The capacity and willingness approach



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### ABSTRACT

This paper investigates the sustainability of off-grid renewable energy systems (RES) installed in rural communities. Through a solar home system (SHS) case project in Alumar Island, Philippines, the performance of users to sustain their systems was assessed using a novel approach proposed by the authors: the capacity and willingness approach. This approach was an adaptation to advancements in human development theory—the paradigm shift from the traditional resources approach to the capabilities approach, as proposed by A. Sen. The actual financial and technical performances of users were predicted using ordered logit regression analysis. It was found that financial capacity attributes, e.g., income and expenses, were prominent in explaining financial performance; know-how-related attributes, e.g., education, were prominent in explaining technical performance; and willingness-related attributes, i.e., willingness to pay, explained both financial and technical performance. The findings aim to provide developers and communities with better strategies for beneficiary scoping, technology selection, and capacity development.

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### Introduction and objective of the study

Efforts have been made to improve the sustainability of renewable energy systems (RES) in rural settings by focusing on important aspects such as using appropriate technologies and financial mechanisms that cater to specific users' needs and capacities. According to the World Bank, determining the capacity of users and their willingness to pay are essential aspects in the technology selection process of off-grid projects (World Bank, 2008). The challenge, however, lies in properly defining users' capacity and willingness. There are difficulties in interpreting information about the users and communities amidst the limited time and budget constraints of most development projects. There are perceived merits in determining how limited information about users can be used to characterize their capacities and enable developers to effectively assess and foresee sustainability.

This study proposed a methodology to assess the relevance of capacity and willingness of users to the sustainability of RES. The objective is to predict or estimate the sustainability performance of users based on users' capacity and willingness attributes. The study focused on users' attributes which relate to the financial and technical performance in sustaining their power supply system. For this case, a solar home system

(SHS) project in a rural community setting, particularly in Alumar Island, Bohol, Philippines, was investigated. Having reliable users' performance foresight was thought to improve the process of planning and designing appropriate systems for rural electrification projects using RES.

### Off-grid RES and sustainability

#### Problem setting

Developing a sustainable power project requires a good understanding of not only the technology but also the community and recipient users. According to World Bank guidelines for off-grid electrification projects, calculating tariff roughly commensurate to the consumer's ability and willingness to pay is important for the viability of off-grid services (World Bank, 2008). Conducting detailed investigations, however, are not always feasible due to time and cost constraints. This is especially evident for developing countries, like the Philippines, with many rural areas simultaneously needing attention yet having limited resources, i.e., time, budget, and manpower, to develop such projects.

With resource limitations, developers resort to using easily accessible, simple, and general information about the community and users to design the projects, usually through rapid rural appraisals (RRA) (Chambers, 2009). Using such simplified data poses a challenge in processing limited information to meet the complex needs of a power project. To pursue sustainability, it is essential to adopt an effective

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methodology to characterize the capacity of users to sustain their systems.

#### Defining sustainability, capacity, and willingness

Sustainable development has taken its globally recognized definition from the United Nations' 1987 Brundtland report called "Our Common Future" (UNWCED, 1987). This investigation adopts a specific definition of sustainability: the capacity of a system to maintain output at a level approximately equal to or greater than its historic average (Lynam and Herdt, 1989). In this regard, we refer to the system users as the instruments that have the capacity to maintain and sustain a certain power system.

Capacity is defined as the ability of individuals, institutions, and societies to perform functions, solve problems, and set and achieve objectives in a sustainable manner (UNDP, 2007). Since capacity is quite multidimensional, we narrow down our scope to describe a certain facet of capacity: the capacity of a user to sustain a particular RES (SHS) system through time as measured by the user's ability to pay the financial requirements and perform the technical requirements of the system. For rural RES, the financial and technical aspects of projects are two of the most common sources of problems that affect the sustainability of such projects.

While user capacities to sustain the systems vary, it may not always be the case that those with good capability will have the same high interest in sustaining the system. Even if some users are capable they may still be unable and disinterested to perform the necessary actions, evidently leading to a failed or unsustainable project (Hong and Abe, 2011, 2012; Hong et al., 2011). This occurrence leads developers to discuss another dimension of RES projects sustainability that we refer to as the users' willingness to sustain.

In this study, we define a user's willingness to sustain as the intention or readiness of the user to sustain a particular energy supply system through time. This can be measured by the amount of resources/efforts/utility a person is willing to exchange to sustain the system. Willingness as a concept is not new. Quite related, the term willingness to pay has since been used as a tool to approximate the value of certain non-market goods according to the perceptions and intentions of users and stakeholders (NREL, National Renewable Energy Laboratory, 1999).

Willingness to sustain, however, does not aim to value in monetary terms but rather to measure the readiness of an individual to achieve a certain goal, e.g., paying for electricity.

While capacity deals with abilities and willingness deals with intention or readiness, it may not be as easy to interpret, much less quantify, these qualities in a person. In this study, it was postulated that these qualities are manifested in certain user attributes which are more obvious and measurable. It was inferred that distinguishing capacity from willingness and ability from intention, can improve a developer's understanding of the limited information about users in relation to project sustainability.

#### Case study of a solar home system in a rural island in the Philippines

In order to further understand the concepts of capacity and willingness to sustain, a rural island case scenario where an SHS project is in operation was investigated. Solar home systems (SHS) are compact photovoltaic (PV) generation systems composed of only a few key components: PV panel, charge controller, and a battery. These compact systems can generate power for a typical rural household and are especially applicable when households are situated far from each other and far from the main electricity grid. The system utilizes the solar PV modules to charge the batteries during daytime to power light, radios, and cell phone chargers well into the night. These types of systems have been used to power millions of households in Asia, Africa, and many more developing areas (World Bank, 2008).

This paper investigated a project in Alumar Island, a small rural island located 3 km from the main island of Bohol, Philippines. The island has a population of about 800 people (170 households) with fishing and seaweeds farming as the main means of livelihood. While rich with aquatic resources, electricity and basic lighting has been the main challenge for the island residents.

In year 2008, the Philippine Department of Energy (DOE), the Japan International Cooperation Agency (JICA), and the Alumar local government unit (LGU) came into partnership to provide 50 households in the community with their own solar home systems (SHS). Each SHS unit was composed of a solar panel (55–75 Wp), a charge controller, a lead-acid battery, and a few lighting appliances, i.e., 3 U of 11-W compact fluorescent lamps. While the units were provided on a first-

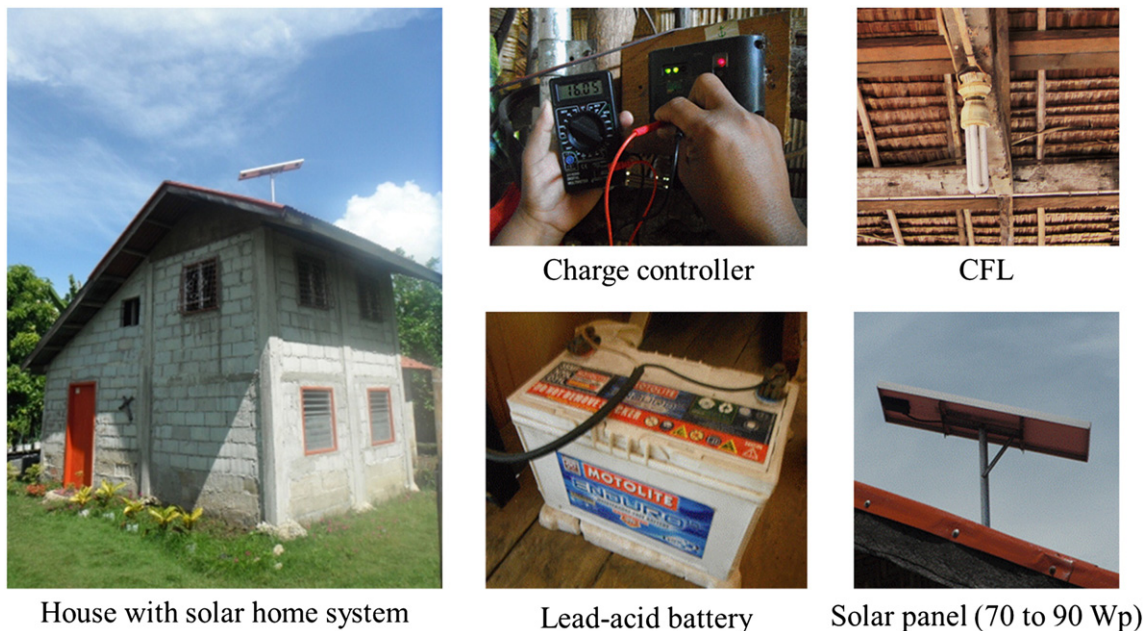


Fig. 1. Photos of the project and solar home system.

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