SOLAR HOME SYSTEM'S SUCCESS ANALYSIS

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1. Abstract

Solar Home Systems (SHSs) are considered an option to supply the basic electricity dependent energy services to dispersed rural households in unelectrified regions of world's Sun Belt. Recent experiences in China, India and Bangladesh have consolidated the view that for many applications solar PV is the least cost and the most environmentally preferred option for increasing access to electricity for rural households and small enterprises in these rural and remote areas. In some countries (e.g. Bangladesh) SHSs are considered to be successful but that is not the case in other places.

There is a need to determine the success of SHSs and to find out what factors influence this success. The objective of this research is to determine the stakeholders understanding on success of SHSs, success factors and the barriers impacting on the success, the indicators of success and how we can quantify the success.

To address the research objectives a desktop study is carried out to identify successful and failure programs. Based on this desktop research SHS's stakeholders will be interviewed on their views on success of the programs.

This paper proposes a framework for assessing the degree of success of SHSs including a consideration of the key factors that contribute to success. In future work feedback from relevant institutions will be incorporated in the process of developing the success framework and the relative importance of the various factors and barriers influencing the SHS's success. It is proposed to develop a weighting system for these factors that can influence the success of SHS's installations.

2. Introduction

Availability of modern energy impacts on development. The BMZ report (Marré, Krämer et al. 2008) proposes positive effects on employment, education, health, environment, preservation of resources, security of supply, peacekeeping, world market dependency, financial resources, and economical stability. (Koppers, Marré et al. 2007) (BMZ) structure the impacts of energy supply as depicted in Fig. 1.

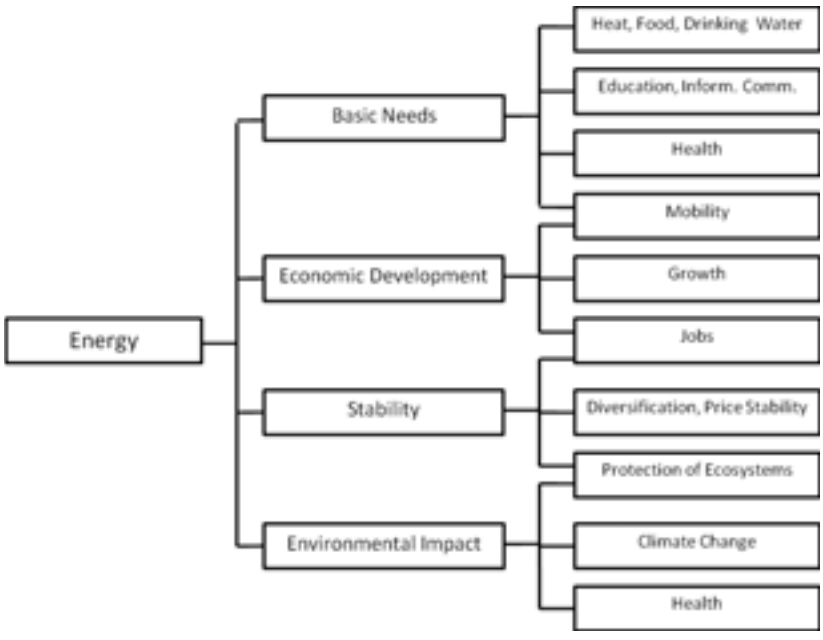

Fig. 1: Impacts of Energy (Koppers, Marré et al. 2007)

U.S. census data estimates the world's population to be 6,78E9 inhabitants (U.S. Census Bureau 2011) while the world's electricity generation is in the range of 20,1E12kWh/a (BP 2011) (both data for 2009). This

leads to an average daily electricity generation of 8,12kWh/d per capita.

At the same time, around 1,44E9 persons do not have access to any electricity (WEO 2011) meaning that one quarter of world's population misses out on the above mentioned impact of modern energy supply.

The benefits of electricity use in households are manifold, and include, when simply comparing kerosene or paraffin illumination to electric light:

- Reduction of local ecological impact, (e.g. indoor air quality)
- Safety of energy service supply (e.g. fire hazard)
- Efficiency of energy service supplied by electric applications (e.g. lumen/W)
- Economic advantages of energy service supplied by electricity ($/lumen hr)
- Operational reliability of electric energy service appliances (e.g. candle light extinction by a breeze)

Some energy services can only be provided by electricity, e.g.:

- Infotainment (radio, TV)
- Bidirectional (tele)communication

Even small amounts of electricity can make a considerable impact on the quality of life in the areas where conventional grid electricity is not available (IEA 2004).

Aid Effectiveness comes into focus of international development assistance. This debate primarily finds expression in two key international documents, the *Paris Declaration* of 2005 and the *Accra Action Plan* from 2008. Donors and partner countries are looking for ways to strengthen cooperation, efficiently design projects to achieve maximum impact - even in times of crisis. This development demands tools to gauge the quality and potential success of projects.

SHSs technically can fill the gap by supplying basic electricity related energy services in Sunbelt countries. Electricity supplied by SHSs can be an economically competitive option as compared to grid extension (Gabler 2009). A $50W_p$ SHS can provide in the range of 100Wh/d of electricity to a rural household in a Sunbelt country.

This paper will address the success of SHSs.

A conceptualized model will be developed for measuring the success of SHSs. The model will introduce sub-dimensions of success, identify a set of factors leading to success, and then propose a series of indicators and measurable quantities of success. Measurability of SHS's success may contribute to the improvement of the effectiveness of investments in rural electrification.

3. The Proposed Methodology for Measuring SHS's Success

This research has four main objectives: First, we want to learn what success in terms of SHSs is. Certainly success has different meanings for different stakeholders involved in SHS. We need to extract the key stake-holders and then determine their understanding of success. The different stakeholder's appraisals of success will be defined as sub-dimensions of success later in this paper.

Secondly, we want to elaborate on the factors leading to success of SHSs. Stakeholder's perspectives on success will differ but certainly intersectional success factors exist which contribute to multiple stakeholder's success. To define the success factors, indicators and measurable quantities for success need to be developed.

Thirdly, success factors need to be weighted to determine their influence on the sub-dimensions and the overall success of SHS.

Finally we want to supply a methodology to provide an indication of the degree of success of a SHS project.

Research on success of SHSs is not a one-time undertaking but a continuous process of further investigation. A major success factor is uniqueness (Nicolai and Kieser 2002). Once a specific uniqueness of a stakeholder

is known it will be copied by others, thereby losing its uniqueness and hence losing its role as a success factor.

We hope to develop a starting point for a hypothesis on success of SHSs. It can only be a qualitative explorative research at this point.

The starting point for this study is the statement of (Weindlmaier, Schmalen et al. 2006): "...dass trotz der Multidimensionalität und Multikausalität der Erfolg bzw. Misserfolg eines Untersuchungsobjektes auf einige wenige zentrale Faktoren zurückgeführt werden kann." (translated by the lead author as *... that despite multidimensionality and multicausality success or failure is based on few central factors*.) Applying "Abbildung 3: Methoden der Erfolgsfaktorenforschung" (translated as *Figure 3: Methods of success factor research*) of (Weindlmaier, Schmalen et al. 2006) leads to a qualitative explorative methodology of this SHS's success factor research. The research will help to discover structures and relationships by filtering the potentially relevant success variables. An explicit model for causal relationship does not exist at the start of the study and so the research can only be explorative at this stage of the investigation. The data acquisition will be qualitative. Some factors need to be considered which cannot be quantified. The identification of success factors will be direct by contrast to indirect identification. The success factors will be extracted from literature, by expert interviews and by user's interviews in field studies. In the field studies an analysis of contrasting groups (successful implementation of SHSs vs. failure of SHSs implementation) will be carried out in the future.

On one hand, homogeneity of research objects is a condition for success research. On the other hand the research should have a minimum coverage of relevant aspects. It is necessary to balance the homogeneity of research objects and the scope of research (Weindlmaier, Schmalen et al. 2006). In this project the research will focus on SHSs of a generator power smaller than $150W_p$ in un-electrified areas of rural sub-Saharan Africa.

The scope of the research will be broad in terms of the types of stakeholders investigated.

Multidimensional indicators and operationalisation of success limited to considering quantitative success factors such as financial quantities is a methodological deficiency. Weindlmaier and Schmalen (2006) state that qualitative entities need to be included. All factors of success found in the literature will be considered. Stakeholders interviewed will be requested to add factors and indicators of success to the initially identified list provided in the surveys.

The latter appears to contradict the opening statement "*... that despite multidimensionality and multicausality success or failure is based on few central factors*." A reduction of potential success factors can take place after having considered all possible factors and their indicators.

A precise definition of success indicators will be given so that all the respondents will add their statements based on a common understanding.

Key informant bias needs to be addressed in the survey. "Given that many informants in studies of effectiveness and performance are themselves members or leaders of the groups about which they are making attributions, their reports are particularly prone to bias" (March and Sutton 1997). Cross-validation needs to be inserted in the interviews and it is necessary to assign answers to the interviewee and analyze the answers to try and identify key informant bias.

Survival bias arises when analysis covers surviving enterprises exclusively (Nicolai and Kieser 2002). In the planned field study it will be necessary to survey a region with successful SHS dissemination and a region with failed SHS implementation. Here the challenge is to find a region of SHS failure as reports usually describe success stories.

The overall research methodology is presented in Fig. 2.

Sub-Saharan Africa is chosen due to the homogeneity and high level of solar radiation. This fact is in favor of the economic operation of SHS. It seems that less research has been carried on the African continent as

compared to Asia (e.g. Bangladesh, India, and China). The predominant link languages English and French simplify the project for the researchers.

Two field studies will be carried out. The regions of the case studies will be determined based on the results of the stakeholder's interviews.

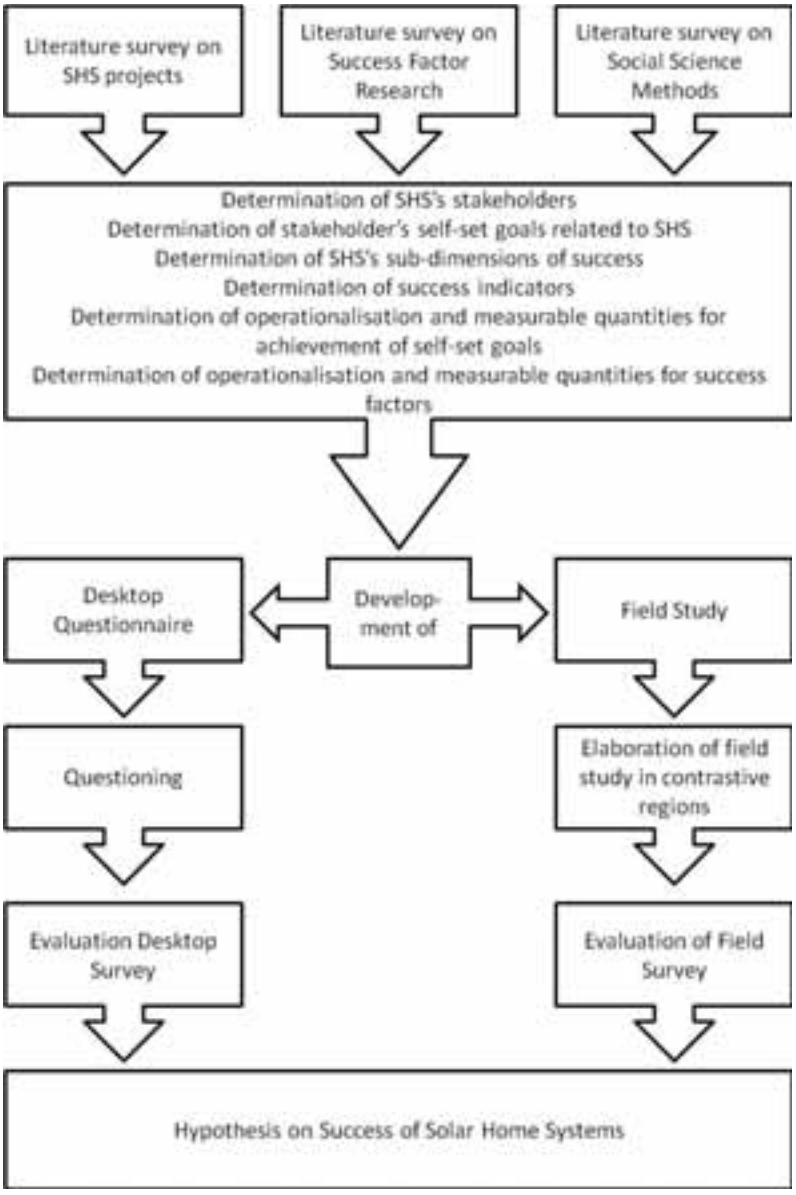

Fig. 2 Methodology of the research on success of SHSs

4. Conceptualized Model of Success of Solar Home Systems (SHS)

The conceptualized model for success of SHSs developed by the authors is depicted in Fig. 3. Stakeholders 1 to m exist in the SHS's environment. The stakeholders have (several) self-set goals for their engagement in SHSs. Success factors 1 to n lead to the achievement of self-set goals. The success factors may interfere in different stakeholder's efforts to achieve success. Distinct success factors may have an impact on multiple self-set goals. The indicator of each success factor and the measurable quantity of each success factor need to be determined.

The achievement of self-set goals of stakeholders 1 to m need to be gauged. Therefore the indicators for

achievement are determined and measurable quantities for the achievement of self-set goals are defined. Self-set goals themselves are sub-dimensions of success of SHSs. The sum of achievement of self-set goals (sub-dimensions of success) will lead us to the overall grading of the success of SHSs in a distinct project.

Our current state of research on SHS's stakeholders and their self-set goals are as displayed in Tab. 1 for some stakeholders.

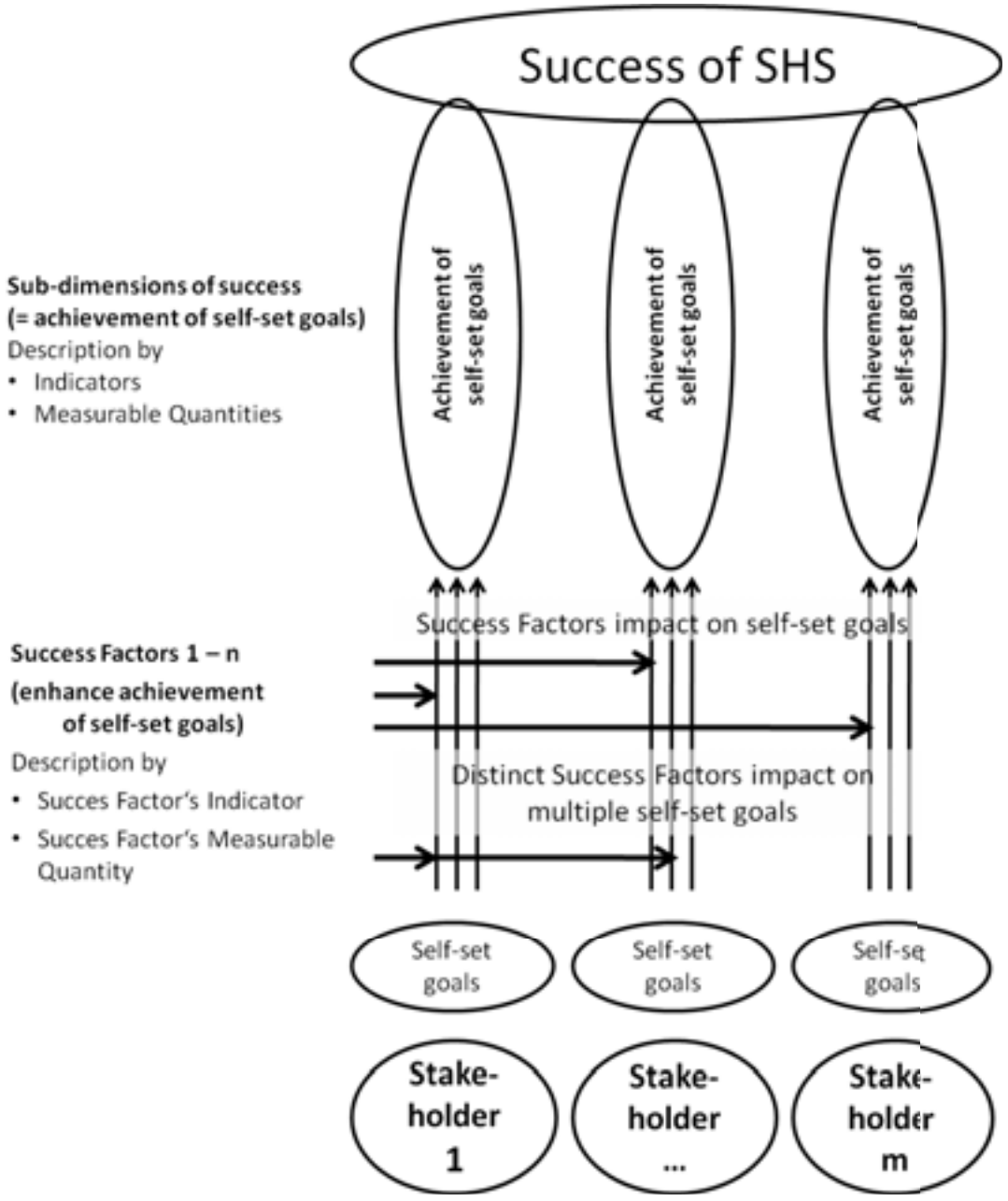

Fig. 3: Conceptualized model of success of SHSs

5. Stakeholders and Self-Set Goals

Stakeholders detected in the literature are: Project implementers, national governmental agencies, international governmental agencies, nongovernmental agencies (national and international), banks, utilities, donor agencies (Hellpap 2011), (Urmee and Harries 2011). Local society in the sense of a group of people related to each other through persistent relations may be considered a stakeholder. The persistent relationship could

be the collective goal to enhance easy and affordable access to electricity for the members of the society.

As described in section 4 of this paper, stakeholders have self-set goals when investing in SHS technology. For all stakeholders detected self-set goals are determined by the surveys of this research starting from literature and personal experience.

Tab. 1: A sample selection of stakeholders and their possible self-set goals

Stakeholder	Possible self-set goals
User of SHS	• Access to a certain energy service • Light • Infotainment (radio/TV) • Bidirectional (tele)communication (mobiles) • Improvement of energy services • Quality • Reliability • Access to a minimum amount of electricity • Reduction of energy related expenses • Access to society (e.g. by communication) • Income generation • Increase of wealth • Increase of study hours • Decrease of health related cost • Reduction of workload for household members supplying energy
Manufacturer of SHS's components	• Development of a market for manufactured components • Growth in sales • Growth in profit • Publicity
Members of supply chain of SHSs	• Generation of income • Growth in sales • Growth in profit • Publicity

6. Success Factors and their Measurement

From literature and from personal experience we develop success factors and measurable quantities related to SHSs. These will be confirmed, modified and upgraded by stakeholder's interviews and field studies. As an example of the first step in this procedure we list some user related success factors and measurable quantities in Tab. 2.

A similar list has been developed for all SHS's stakeholders listed above.

Some success factors may share the same measurable quantity; for example the success factors *user's appreciation of SHS's electricity* and *user's wish to change energy supply technology*. Both are measured by the amount of money user is willing to pay for SHS.

Further on the distinction between a success factor and a measurable quantity may be challenging. For example, *Willingness to pay* may either be a success factor or a measurable quantity.

Tab. 2: Initial list of SHS`s users related success factors and measurable quantities (from literature and from personal experience)

Success Factor	Measurable quantity
User's satisfaction	User's estimate of grade of satisfaction (a qualitative indicator)
User's economic situation	User's monthly / seasonal / annual income and savings
User's willingness to pay for electricity	Amount of money user is willing to pay for energy and especially for electricity
User's income generation based on SHS	Income before and after installation of SHS
User's need of electric energy service	User's prioritisation of competitive choices Amount of money user is willing to pay for electricity
SHS's maintenance	Amount of payments / time invested in maintenance
User's mental model of SHSs	User's perception on: - Amount of service deliverable - No. of advantages of SHS and their weight - No. of disadvantages of SHS and their weight
User's awareness of technology	User's estimate of grade of awareness (qualitative indicator)
User's knowledge on the operation of SHSs	No. of users with a correct understanding of e.g. charge controller's indications
User's neighbourhood experience	User's estimate of experience in the neighbourhood (qualitative indicator)
User's appreciation of SHS's electricity	Amount of money user is willing to pay for SHS
User's wish to change energy supply technology	Amount of money user is willing to pay for SHS
User's trust in SHS technology	User's estimate of trust in SHSs as compared to other technologies (qualitative indicator)
User's trust in members of supply chain	User's estimate of trust in SHS supplier (qualitative indicator). User's prioritisation of competitive suppliers.
User density	Mean distance between users in km / travelling time / travelling cost

The multidimensionality of SHS's success can be captured from the great number of stakeholders, their related sub-dimensions of success and the variety of success factors.

7. Conclusion

Until now there has been little research on success factors of SHSs. In reports on successful SHS projects one finds mere figures of SHSs installed or project cost per SHS installed as an indication of success. We want to deepen the understanding of success of SHSs. To date, the wide field of SHS's success has been reviewed and analysed: A methodology for this research has been developed, the conceptualised model for success of SHSs is established and an initial list of stakeholders, as well as their self-set goals, has been

determined. Indicators and parameters that can be quantified to measure success have been described. In the next step of this research, the input of stakeholders will be sought by interviews and field studies. The final goal is a comprehensive hypothesis on success of Solar Home Systems in the rural sub-Saharan African context that can be expanded into wider contexts.

8. Acknowledgement

This project is financially supported by the *School of Engineering and Energy* at Murdoch University and the *International Relations Office* at University of Oldenburg.

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