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Research article

Incorporating the user perspective into a proposed model for assessing success of SHS implementations

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Abstract: Modern energy can contribute to development in multiple ways while approximately 20% of world's populations do not yet have access to electricity. Solar Home Systems (SHSs) consists of a PV module, a charge controller and a battery supply in the range of 100 Wh/d in Sunbelt countries. The question addressed in this paper is how SHS users approach success of their systems and how these user's views can be integrated in to an existing model of success. Information was obtained on the user's approach to their SHSs by participatory observation, interviews with users and by self-observation undertaken by the lead author while residing under SHS electricity supply conditions. It was found that success of SHSs from the users' point of view is related to the ability of these systems to reduce the burdens of supplying energy services to homesteads. SHSs can alleviate some energy supply burdens, and they can improve living conditions by enabling communication on multiple levels and by addressing convenience and safety concerns. However, SHSs do not contribute to the energy services which are indispensable for survival, nor to the thermal energy services required and desired in dwellings of Sunbelt countries. The elements of three of the four components of our previously proposed model of success have been verified and found to be appropriate, namely the user's self-set goals, their importance and SHSs' success factors. The locally appropriate, and scientifically satisfactory, measurement of the level of achievement of self-set goals, the fourth component of our model of success, remains an interesting area for future research.

Keywords: Solar home system; SHS user; energy service; success; success factor; measurement of success; contextualization

Abbreviation: BCC: Battery Charge Controller; BMZ: Bundesministerium für wirtschaftliche

Zusammenarbeit und Entwicklung (German Federal Ministry for Economic Cooperation and Development); CFL: Compact Fluorescent Lamp; ES: energy service; ESKOM: Electricity Supply Commission; ISSG: Importance of Self-Set Goal; LoA: Level of Achievement; NASA: National Aeronautics and Space Administration; PO: Participatory Observation; PV: Photovoltaic; RESCO: Renewable Energy Service Company; SF: success factor, SHS: Solar Home System; SSG: Self-Set Goal; UMEME: energy distribution network company in Uganda; UNCST: Uganda National Council for Science and Technology; USD: United States Dollar; Wp: Watt Peak (PV power at standard test conditions); ZAR: South African Rand.

1. Introduction

The availability of modern energy [1] has multiple impacts on society [1]. A BMZ (Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung; German Federal Ministry for Economic Cooperation and Development) report lists these as effects on employment, education, health, environment, preservation of resources, security of energy supply, peacekeeping, world market dependency, financial resources, and economic stability [2]. However, 1.3 billion of the world's population still do not have any access to electricity [3].

Bright illumination, telecommunication and information by radio and TV are some of the basic needs of rural dwellers [4], which require small amounts of electricity. To meet this demand of electricity, Solar Home Systems (SHSs) have been increasingly used in many countries over the last few decades. Van der Vleuten, Stam et al. (2007) list Kenya, Morocco, Sri Lanka, the Tibetian Plateau in Western China and Zimbabwe as areas of successful SHS implementation [5]. Bangladesh is listed by many authors as the model example for successful SHS dissemination [6–8]. However, it seems that all these publications agree that the number of installations is the key-indicator for the success of SHSs. Based on this assessment, other indicators such as the ratio between operational SHSs and installed SHSs are derived from this key-indicator.

There is a need to broaden the above definition of success for SHS implementations and to find out what factors influence this success. The objective of the research is to determine the stakeholders' understanding on success of SHSs, success factors impacting on the success, the indicators of success, and how we can quantify the success. The approach is to base the success on the achievement of self-set goals[2], which were stated by the key-stakeholders involved in the SHSs' environment [9]. A model of success was developed incorporating the considerations above. All stakeholders involved in the dissemination of SHSs at a certain site are considered: their self-set goals, the importance of these self-set goals, and the levels of achievement of the self-set goals. The weighted arithmetic mean of the importance of the individual stakeholder's self-set goals and the levels of achievement determine the stakeholder's overall success, as shown in the formula at the top of Figure 1 [9]. The approach can be used to determine the successfulness of individual stakeholders

[1] We use *modern energy* in the sense of energy emitting less hazardous substances per unit than the up to date energy; *modern energy* impacts on the advancement of the socio-economic conditions.

[2] *Self-set goals* in this paper are goals which a stakeholder actively sets by him or herself. The goals are related to the achievement of an energy service. The energy service can be supplied by a SHS. Example: The user says "I want bright illumination". The self-set goal is the achievement of bright illumination. A SHS can supply this energy service.

or the success of an entire implementation process. Additionally the model incorporates success factors for future consideration. Figure 1 presents the model of success with a focus on the users. This principle is applied to all involved stakeholders of a SHS implementation.

Users are one of the main key stakeholders of SHS environment [9] and therefore, their views on success of SHSs are important to refine the model of success. This paper aims to understand how rural dwellers view success in relation to SHS implementation and to incorporate this information into the model of success. To incorporate the views of the users, the following questions will be answered in this paper:

- What are the self-set goals of SHS users?
- What importance do the self-set goals have?
- How can users measure the level of achievement?
- Which success factors impact on the users' self-set goals?

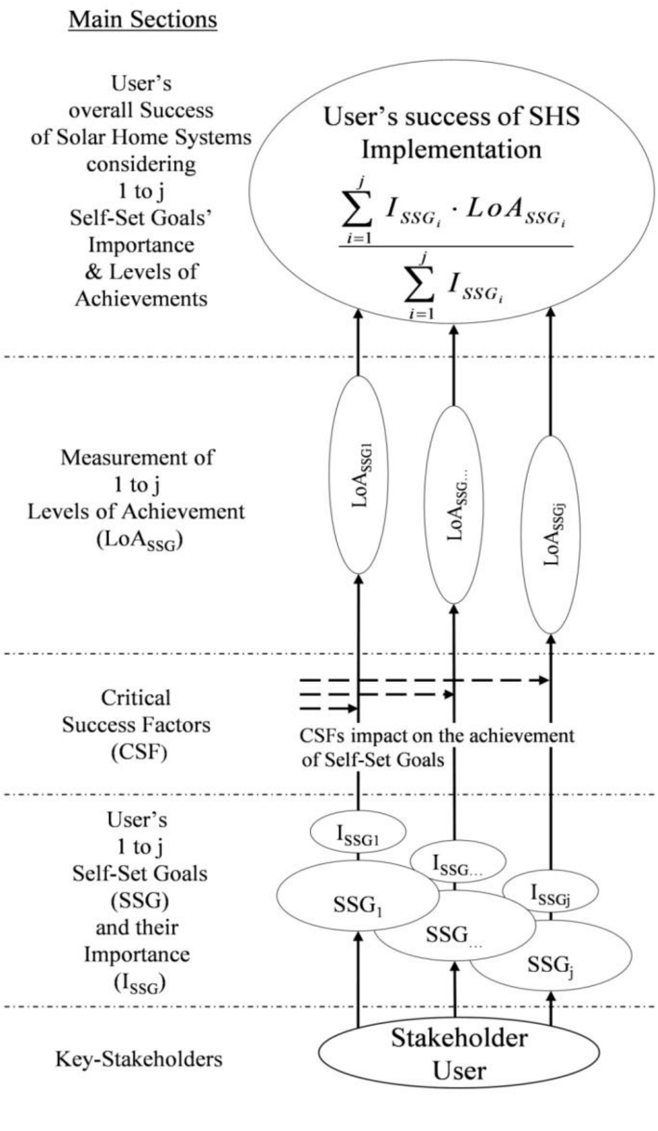


Figure 1. The model of success. Source: Modified from [9].

The paper is structured as follows: Section 2 describes the methodologies used for this research and the data collection. Section 3 describes the results. Section 4 discusses the results followed by the description of the improved model of success in Section 5. The conclusions are given in the final section.

2. Materials and Method

Figure 2 shows the methodology used in this research paper. The research uses qualitative data collection methods as the research is explorative in nature.

Three tools were used in this field study, namely:

1. Narrative interviews with SHS users: This type of interview is unstructured in its nature. It is unorganized to facilitate the development of a text that can be interpreted through qualitative content analysis. Additionally, a site visit was incorporated in every interview to verify the information collected.
2. Participatory observation[3]: This is a method of qualitative research in which the researcher understands the contextual meanings of an event or several events through participating and observing as a subject within the research [10].
3. Self-observation: The methodology is derived from the introspection used in psychological studies, where researchers carefully observe themselves and draw conclusions from them which are related to the research topic.

Triangulation of these methods helps strengthen the information collected from the field.

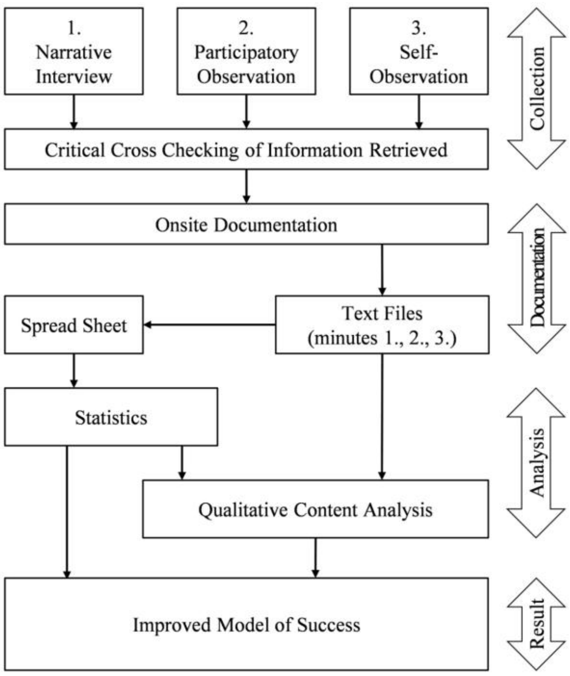


Figure 2. The research methodology.

[3] Participatory observation is observing the researched society while taking part in their activities [10]

This field research was approved by the Human Research Ethics Committee at Murdoch University under the Project Number 2012/076, and by the relevant local authorities in Uganda and in South Africa.

2.1. Selection of the target area and the respondents

In Africa field study regions were selected with the help of the researcher's professional network. Two rural districts were chosen purposively to represent contrastive types of installation models: Fee-for-Service (South Africa) and Cash Sales (Uganda).

The interviewees were selected randomly with the help of a local teacher (in Uganda) and a local leader (in South Africa). The preconditions were that the interviewees would reside in households fitted with a SHS that the households were accessible within 5 km radius from the researcher's local host.

In the Ugandan field study region 15 households had a SHS out of which 9 households were investigated. Although, this is a qualitative research and the sampling strategies was used as a typical case sampling [11], the number is also verified using Raosoft Calculator, with a margin of error 10%, confidence level of 85% and a response distribution 90%[4] [11].

In the South African case the houses were accessible by walking only. In total 8 households had a SHS which was in working condition. All households were approached but only 6 of them were available for an interview. None of the inhabitants of the other 2 households were available during the stay of the researcher. The same approach was used to see the validity of the respondent number using Raosoft [11].

In order to perform the self-observation, the researcher resided with a family in a SHS powered dwelling for one week in Ndejje, Uganda, and for three weeks in Ndumo, South Africa, to collect data related to his research. In selection of the host, importance was given to the following conditions:

- High social status in the community
- Long term experience on using a SHS in the house

2.2. Data processing and analysis

The information collected was documented, sorted and imported into a spreadsheet with the categories necessary to answer the research questions. With the help of the spreadsheet statistical evaluations were carried out. Qualitative content analysis[5] was performed on the documentation to process the collected information.

The main challenges of this research were language and cultural barriers. The host translated from the local language to English during the researcher's appointments. The misunderstandings and translation errors were minimized by conducting site visit after every interview.

[4] There is no specific answer for the questions and so all answer were taken into consideration. It is assumed that 10% of the interviewee may not answer at all.

[5] Qualitative content analysis is an approach to the step by step analysis of observations within their context without being aimed at rash quantification [12]

3. Results

This section describes the results retrieved from the field studies. Consistent with the research questions this section consists of subsections which deal with results related to self-set goals and their importance, approaches to the measurement of the level of achievement, and the success factors for Solar Home Systems. The results from 15 interviews, 2 participatory discussions and 2 self-observations, are sorted into these categories.

The respondents were asked about the year of installation of their system. Most of the systems were installed between 2005 and 2012. The average age of the systems was five years. Analyzing the Cash Sales model systems alone, they were comparably old, with an average age of 6.5 years. In contrast to this the SHSs installed under the Fee for Service model were, on average, 1.25 years old. It was observed that the batteries of systems implemented by the Cash Sales model were recharged at a charging station every now and then. This was confirmed by the respondents during the interviews. This option was not given for the Fee-for-Service systems as the users did not have access to the batteries.

3.1. Self-set goals of SHS users

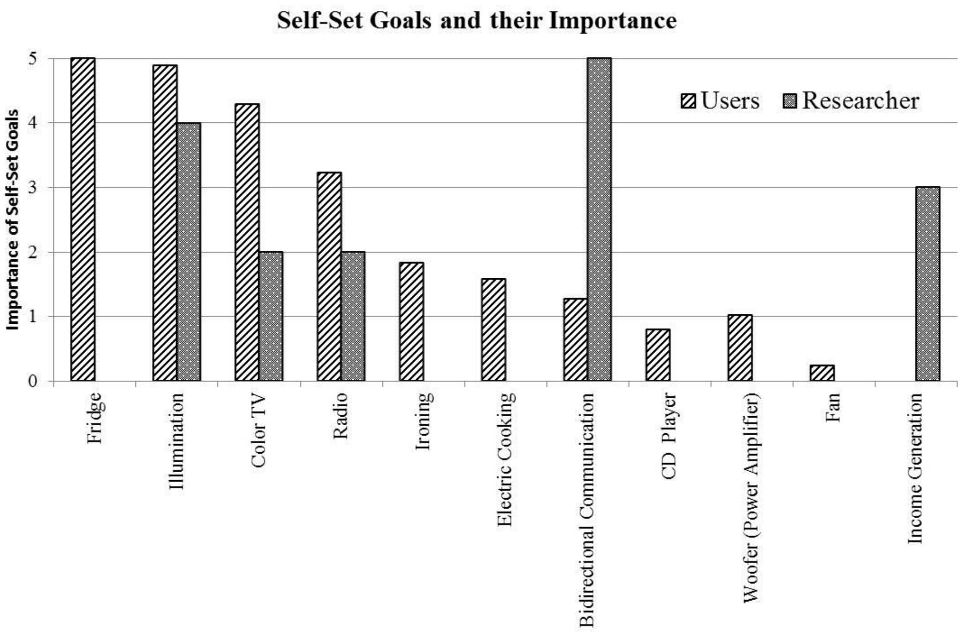
From the interaction with respondents it was found that energy services are the self-set goals related to Solar Home Systems. The energy services and their importance were further explored in this research. This section shows the results retrieved from the respondents themselves and from the self-observation of the lead author during the fieldwork.

To understand the self-set goals of the respondents, they were asked about their motivation to install a SHS. It was found that different users had different drivers to invest in SHSs. About 66% of the respondents (10 households), mentioned that SHS was the best option due to the distance to the grid and the cost of grid connection. 3 out of 15 (20%) mentioned that they installed the SHS as an intermediate solution while they were waiting for grid connection. 2 respondents (13%), whose houses were within the proximity of the electricity grid, mentioned that they installed the system for protest reasons against the high cost and the unreliability of the grid power supply.

The respondents were asked about the priority of the electricity services to understand the importance of self-set goals of those services. Through discussions with interviewees, observation of hosts and researcher’s self-observation, the energy services supplied by SHSs and their importance were collected and presented in Figure 3.

Figure 3 indicates the self-set goals of energy services from SHSs of the investigated users (found by interviews and participatory observation) and of the researcher (found by self-observation). The bars indicate the averaged, normalized importance of the energy services to the participants of the research. The most important energy service from the users’ point of view is refrigeration, while the researcher gives highest importance to bidirectional communication (mobile/email communication). This shows that the importance of electricity service is contextualized. The results show that the users were not aware of the capacity of SHSs and they did not have a clear perception on how SHSs work.

It was also observed during the field studies that apart from the desired electricity services, optimization of income and expenditure, minimizing the physical effort and minimizing economic efforts to achieve the desired energy services are also important.



Importance: 5: very high, 4: high, 3: medium, 2: low, 1: very low.

Figure 3. Self-set goal energy service and their importance identified during interviews, by participatory observation and researcher's self-observation.

3.2. Measurement of the level of achievement

To measure the success of SHS from users' point of view, it is important to measure the level of achievement of their self-set goals. From a research point of view and experienced from self-observation the level of achievement of self–set goals can be measured as shown in Table 1.

Table 1. Measurement of the level of achievement.

Self-Set Goal	Indicators of Measurement of Level of Achievement
Bidirectional Communication	quantity of information supplied per day
Illumination	No. of lumen hours supplied per day
Income Generation	hours of income generation activities per day or economic balance of income generated vs. SHS cost
Radio	radio hours per day at desired volume
TV	TV hours per day at desired brightness, contrast & volume

It was difficult to get answers to the question on how the respondents measure the level of achievement (LoA) of their self-set goals. Therefore, the level of achievement was measured by the level of satisfaction of the users. For example, if the users are fully satisfied with their lighting needs that they had mentioned in their self-set goals, the LoA was 100%, if they are dissatisfied then the LoA was 0% and so on. In this research a scale of 0 to 5 (excellent = 5, good = 4, satisfactory = 3, poor = 2, very poor = 1, and failed = 0) is used to measure the LoA.

Three households had excellent satisfaction (5), four households had good satisfaction (4), five of them had medium satisfaction (3), one household had poor satisfaction (2) and two respondents were dissatisfied (0). The average user satisfaction lies between medium and high with the user satisfaction of the Cash Sales model systems being classified close to high, and the user satisfaction of the Fee for Service model systems mostly being classified as medium.

3.3. Results related to success factors for Solar Home Systems

Miscellaneous observations which are related to success of Solar Home Systems were recorded. From the interviews, the participatory observation, and the self-observation, the success factors were derived as shown in Table 2.

The incorporated costs are still a success a barrier. Most of the users complained about the cost of the system and the follow up cost of the batteries.

The quality of the system and its components also plays a major role in the success of SHSs. Most users complained about the quality of CFL lamps and batteries. This was also confirmed by the self-observation. Furthermore it was observed that the installation of the systems was poor in case of the Cash Sales model. The appliances themselves constitute a success factor by their reliability, quality and price.

From the interviews it was found that the awareness on the SHS is very low. One respondent mentioned that not much information is available on SHS in the village and also the information provided is not explained to the households. This was confirmed by other interview as the interviewees wished to run a fridge or an iron by SHS electricity.

From the self-observation it was found that users constitute a success factor of their own when the preconditions awareness, financial capacity and interest in SHS are given.

SHS failed to supply certain services which are a success barrier. For example, people in the investigated villages requested fridges as the ambient temperature is very high and cooled drinks are only available from kiosks (nearest one was 2.5 km).

Theft is another barrier for SHSs. Some respondents (3) mentioned theft of solar modules. In the Cash Sales model, the households needed to buy a new module. In the Fee-for-Service model, the RESCO will not replace the module before the households had paid 50% of the total price of the solar module.

Reliability of SHS was mentioned as a success factor by the respondents. This was also confirmed by self-observation. System reliability is dependent on the quality of the system components and neat installation. It is enhanced by system parameter indication by the charge controller which allows the user to optimize load management.

Low maintenance and operation requirements are a success factor. This was highlighted by self-observation. The researcher tried to maximize the system's output by manually tracking the solar module. The goal was to adjust the azimuth of the PV module three times a day. Due to work commitment, the researcher failed to do so. Cleaning of the solar module was only carried out because the researcher's module was installed at the entrance of the researcher's living space and he was reminded whenever he entered or exited his rotunda.

In the observed Fee-for-Service systems the RESCO required users to call for maintenance which was then done by a technician. In the Cash Sales model systems, no indication of maintenance and monitoring was found. For example the solar modules were found soiled.

Table 2. Participants' views on success factors.

Success Factor/Barrier	Examples
Costs	battery is too expensive installation is too expensive
Quality	CFL lamps do not last long battery quality is low low quality of installation
User's Awareness Creation & User's Awareness	too little information on solar is available in the society incomplete or incorrect information of users importance of sensitizing on economizing of electricity usage solar seems expensive lack of economical awareness (SHS economic option)
SHS user	awareness of system's operation financial capacity interest in system
Unsupplied Energy Services	no ironing no fridge limited color TV
Theft	panels are stolen
Characteristics of the Solar Home System	reliability of the system (quality) fail safe system indication of system parameters by charge controller low maintenance & operation requirements neat installation
SHS Market	availability of key spare parts quick repair and maintenance available availability of SHSs
Major Advantages of SHSs leading to Success	light switch installed at a fixed location safety against fire hazard reliability of electricity supply lies in user's responsibility

Availability of spare parts plays a role for SHS success. When the local SHS market can supply major spare parts it contributes to the success of SHSs. Quick repair and maintenance given by the SHS local market can improve the reliability of the system. Delay on these services is a success barrier. From self-observation, the researcher experienced that replacing a CFL bulb take one working day hence causing loss of income and incurring travel expenses. It was found that the overall expenses for the bus tickets and the CFL bulb were in the range of one month's fees for the local RESCO.

Last but not the least, the simplicity and the safety of the operation of appliances driven by SHSs is a success factor of its own. For example switching on light, the safety of light and the reliability of light is highly advantageous when compared to conventional light sources (kerosene lamps or candles).

4. Discussion

The results shown in the previous section require thorough discussion in order to refine the model of success proposed in [9]. This section discusses the results to finalize the model of success for the users. The discussion follows the order of the presentation of the results.

4.1. Discussion of self-set goals and their importance

Goals are specific targets of stakeholders. Therefore, they contribute to the success of activities [13]. They are implemented in the model of success (see Figure 1). They need to be researched when the users' approach to success of SHSs is implemented into the model of success. As mentioned in the results in section 3.1., respondents were not familiar with the abstract term *self-set goal* and therefore they were approached with the general question: *"Why did you install a SHS?"*

From the list of energy services, other important information regarding the SHS program can be found. An example is the desire to operate a fridge and an iron by a SHS. This gives evidence that the users are not aware of SHSs' capacity. A chain of awareness creation steps was found by interviewing and by participatory observation:

- PV system suppliers give information to users on the SHS.
- Homophilous communication is involved in this process.
- Users understand the information given.
- Users accept the information given and create knowledge.
- Users apply the knowledge gained.

When one step in this chain fails (e.g. heterophilous instead of homophilous communication [14]) awareness creation fails. This may lead to exaggerated expectations towards the system, inefficient use of the system and in consequence to disappointment of the system.

Respondents exclusively listed energy services as reasons for installing SHSs and they were then asked *"What is the importance of the energy services you mentioned?"* The results are found in Figure 3. In this research it was also found that the accomplishing of energy services (being self-set goals) by Solar Home Systems is linked to two sets of factors. First, the supply of the energy service involves a series of optimization processes. Second, there are additional driving forces influencing the decision on a SHS installation. Figure 4 summarizes these influences. The details are explained below:

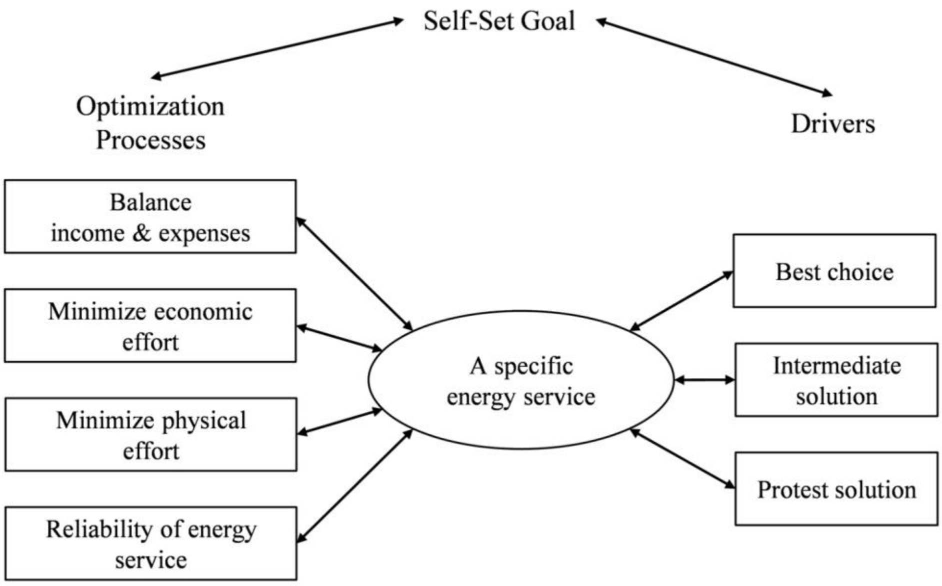


Figure 4. Self-set goals and the factors influencing the choice of SHSs.

4.1.1. Self-set goal

The overriding goal is to make specific energy services available–for example bright illumination.

4.1.2. Optimization process

Under the optimization heading there are multiple considerations that involve an optimization process. First the general income and the expenses for the energy service need to be balanced. Therefore, unaffordable energy services are excluded from the households.

The second optimization process involves the minimization of the performed physical and economic efforts. Utilizing a TV can be possible solely based on rechargeable batteries, but the recharging process is physically tedious and uneconomical. A grid connection may be unaffordable due to the high initial costs. In this case a Solar Home Systems may provide a solution when the TV set is devised as a low consumption appliance–either black-and-white or small size TV, or both characteristics combined. The final optimization process involves an attempt to maximize the reliability of the supply of energy services. In the researcher's observation, which was supported by respondents, rural grid connection electricity supply has proven to be less reliable than well managed SHS electricity supply.

4.1.3. Drivers

As mentioned above, the accomplishment of an energy service by SHSs is driven by a series of other factors. Some respondents had implemented their SHS as the best possible solution, some respondents had implemented the SHS as an intermediate solution while they were waiting for the grid connection and some respondents had installed the SHS as a protest against the utility.

Differences and similarities were found between the researcher's and the respondents' self-set goals. In the researcher's self-observation the bidirectional communication—in this case by simple text emails–was of highest importance. By contrast, recharging of mobiles was found important for the respondents but only four out of five had mentioned this service supplied by SHSs. This difference can be explained with the existing infrastructure for recharging mobiles in the researched region. Many respondents had access to free mobile charging at a neighbor's house or their workplace. As a foreigner the researcher did not have the necessary network. The situation changes when no grid electrification is available in the users' vicinity. Teshome (2015) describes the situation in South-West Ethiopia where 100% of users illuminate their dwellings with SHS electricity and 88% charge mobiles with their SHS. But as the SHSs in that region are rather small in capacity only 18% operate a radio and 1.8% run a TV with the SHS [15].

The differences in self-set goals and their importance found between the respondents and the researcher as well as the information given in the literature indicates that SSGs need to be seen in the context of the users in their region of SHS implementation. Zahnd (2013) underlines the importance of contextualization in his research related to energy service supply in mountainous villages in Nepal [16].

4.2. Discussion on the measurement of the level of achievement

For the proposed model of success, it is important to have stakeholders indicate the level of achievement of their self-set goals. In consequence, the users of SHSs must be able to measure the level of achievement of their SHS related self-set goals. As mentioned in section 3.2., it was found that abstract gauging of levels of achievements is not a common approach for SHS users. Furthermore, as a starting point, it was assumed that the user satisfaction could be a measure for the level of achievement. Therefore, in this research the measurement of the level of achievement was indirectly approached by querying and discussing the user's satisfaction with the system. The rationale for their gauging was difficult to assess except for users of non-operable systems.

From the user's quotes and from the previous discussion it is proposed that the important factors influencing user satisfaction are: the user's awareness of the system technology on one hand; and the user's awareness of the system's capacity for energy service delivery on the other; and last but not least, the user's expectations towards the system (example: *importance of fridge operation,* see Figure 3).

Three other approaches to measure the level of achievement are given in the following:

From the authors' point of view the level of achievement could be expressed with the ratio between the energy services supplied and the theoretical services which could be supplied considering the system's rated capacity and the meteorological conditions. However, this approach would require intensive data collection and would entail expensive measurement equipment. Systems do exist where time series of data are collected in order to inform the RESCO of system problems. However, in these systems the data collection is limited to the PV power, the battery power, the load power, and the PV temperature [17]. This approach for measuring level of achievement is excluded for economic reasons.

With reference to using user satisfaction as a measure of the level of achievement Komatsu (2013) proposes to assess the user satisfaction by a list of independent variables related to the categories Solar Home System, energy saving, and benefits from electric lighting [18].

In order to reduce emotional and awareness / unawareness impacts, it is proposed that SHS users should measure the level of achievement by comparing the operational hours of their appliances to the operational hours rated by the system's supplier. However, this still needs a recording of the operational hours. This is a challenge without costly operation hour meters (they are less costly than the measurement setup proposed earlier). It will be a difficult task for the person responsible for the operation of the SHS especially in larger families, when different persons are at home operating different appliances at different times. This is supported by the researcher's experience of self-observation that despite the high level of his own interest in the operational hours of the hosts' appliances he did not manage to fully record the hours of operation.

From the results, discussion and from the feasibility point of view it would appear that the user's level of satisfaction with the system may well be the best indicator of the level of achievement of their self-set goals (i.e. the energy services), and this indicator could relatively easily be expressed in terms of this numerical scale as used in this research. However, the uncertainty caused by users' misconceptions needs to be accepted.

4.3. Discussion on success factors for Solar Home Systems

Many interesting results were found relating to the success factors for Solar Home Systems. In the model of success the success factors are shown as impacting on the level of achievement. A selection of some of the success factors are listed in the results section (Table 2).

Awareness development on new technology is very important for the success of SHS implementation [19–23]. The results obtained from this research also support this view. It shows that user awareness impacts on the success of SHS in multiple ways – refer to the example of operating a fridge. One respondent was disappointed that the SHS did not operate the fridge and this respondent had to go for bottled gas to meet this energy service. The respondent said that *"in any case grid connection is much better than (name of the RESCO) electricity"*.

This disappointment was shared without any prompting. It can be assumed that this disappointment on SHSs would be shared in other communication by this user, which would impact on the success of SHSs in this area. A similar situation exists where a user did not charge his mobile using the SHS. Obviously, this user was unaware of the possibility of mobile charging by SHSs.

Despite the numerous channels available for creation of user awareness, misconceptions can still arise, as shown in the examples above. This is explained by Rogers (2003). Homophilous communication is a precondition for awareness creation [14].

A side effect of the lack of the user's awareness is the inappropriate use of SHSs which results in a reduced energy supply as described by Azimoh (2014), [24]. Therefore, user training before implementation of SHSs is called for as a success factor, e.g. by Mufiaty (2014) [25].

4.3.1. The success factors "quality" and "SHS market"

In Table 2, *Quality* and the *SHS Market* are listed as success factors. These have significant impacts on the success of SHSs as shown in multiple examples in Table 2. The results also confirm that high quality is a success factor and low quality is a success barrier. It also shows that spare parts availability in the local areas is an important success factor.

4.3.2. The success factor "operation and maintenance"

Maintenance is called for in the literature as a must for the success of SHSs [26]. As explained in section 3.3., it was not granted for the researcher to perform the self-imposed maintenance. The researcher managed to clean his module as it was not installed on the roof of his building and it was easily accessible. This experience shows that the maintenance and operation of a SHS should incorporate as little user attention as possible as even highly interested, well aware and excellent qualified persons would fail in doing the necessary tasks. Therefore, a success factor is a low requirement of maintenance and high understanding on system operation.

But even when a system does not require a high level of attention for its maintenance, users are not released from carefully managing the operation of their energy appliances. The need for *sensitizing on economization of electricity* is inevitable (refer to Table 2).

4.3.3. Exogenous and endogenous success factors

When investigating institutional stakeholders within this research [27], success factors can be divided into exogenous and endogenous. From the lists of success factors depicted in Table 2 it is clear that most of the success factors are not within the users' influence. From the users' point of view these success factors are exogenous.

An allocation of the relative weight of the success factors listed above was not possible within this research. The respondents could not relate to the concept of weighting success factors and the researcher's sojourn in the target area was too short to give weights to the observed success factors. However, this weighting could show whether SHS users can compensate for the lack of success factors within the list of exogenous success factors in order to make SHSs successful in their region.

4.4. Strengths, weaknesses and significance of this research

The strengths of this research were the participatory observation and the self-observation. Much information found in literature could be confirmed by first-hand experience. Of higher importance were the additional insights, for example, the challenge of operation and maintenance. This is mentioned in the literature [26], but the real-life experience of the lead author showed the difficulties associated with operation and maintenance efforts.

A major weakness of the research was the need of a translator in the rural areas. Bias is incorporated in the process of the translator understanding the researcher's question, translating it, understanding the answer of the interviewee, and translating this answer back to English. Furthermore, issues of politeness, understatement and overstatement of respondents may have led to wrong information. Uncertainties are expected due to the researches limited time period. No extreme weather situations, such as very low solar radiation periods were observed in this research.

Only two field studies were carried out. The area of the research was limited to the radius of a motorcycle taxi in Uganda and the walking distance in South Africa – both approximately 5 km. Therefore, the results, although very useful in this research, are far from being universal in coverage. Four results of significance from this research are:

i. The confirmation of many results found in literature through applying this research's different approach (PO and self-observation),
ii. The understanding of the significance of the optimization processes and the drivers related to the self-set goals of achieving energy services demanded by rural dwellers,
iii. The similarities between the importance of SHS related energy services for hands on experts and for an academic expert in the field of SHSs. Despite the different nature of SHS experience the evaluation of energy service's importance bear a striking resemblance, however,
iv. Despite the similarities found between respondents and researcher, differences were disclosed in their approach on the success of the SHS. These indicate that the success of SHSs needs to be seen in the context of users and their environment.

An open question is how the investigated rural dwellers manage low irradiation periods. However, the seasonal variation in the two locations is rather low as compared to northern or southern hemisphere locations [28][6].

5. The model of success for users

From the above discussion a refined model of success for users is developed. The model is an advancement of the model presented in Figure 1. Figure 5 presents this improved model.

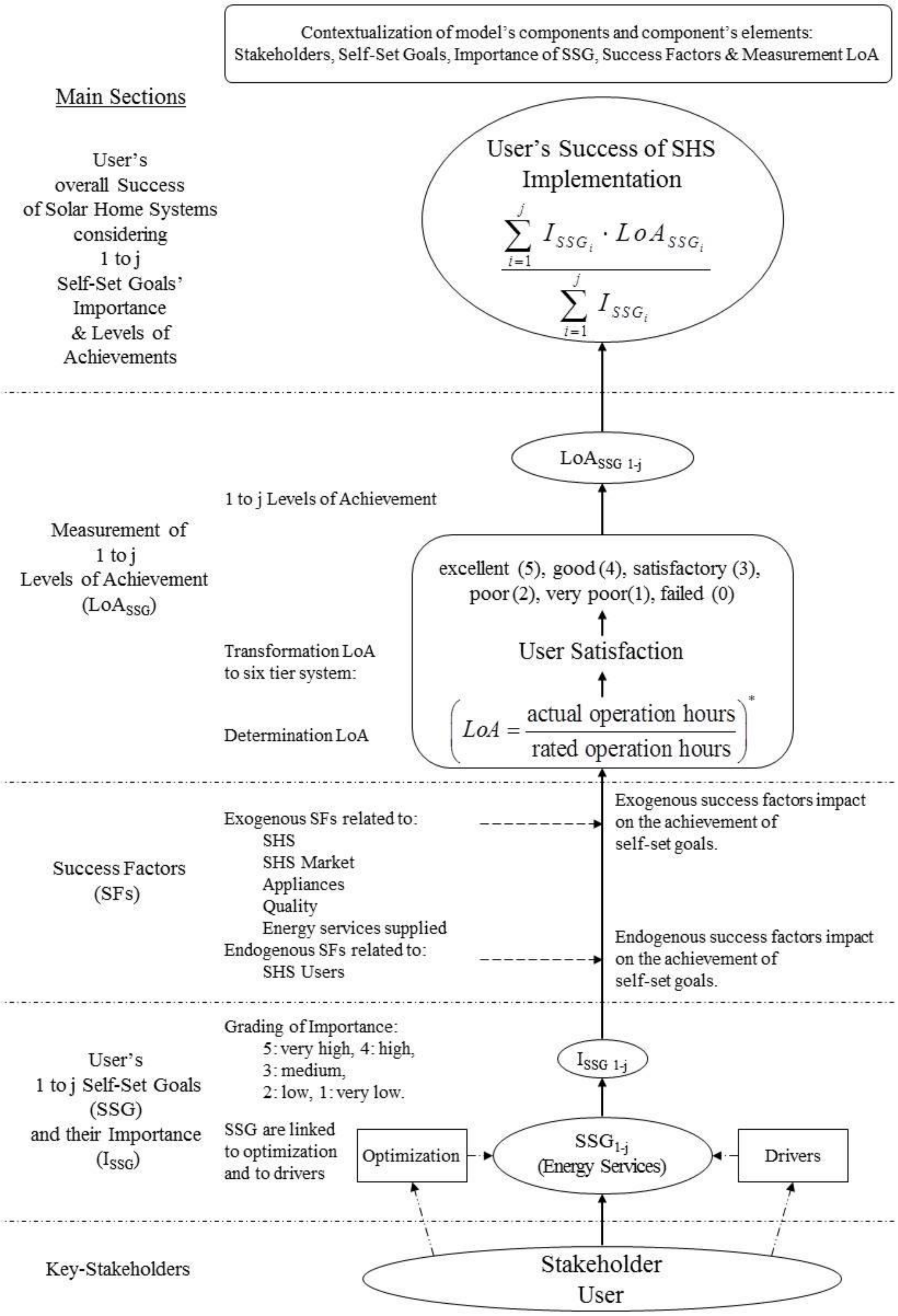
Users' self-set goals as they were found from the research are inserted into Figure 5. Users need certain energy services, some of these energy services can be supplied by SHSs, for example, illumination and communication (radio, TV, telecommunication). The decision on supplying these self-set goals by SHSs is influenced by optimization processes and by drivers (refers to Figure 4). The self-set goals have different importance. Figure 3 indicates that SHS users of this study give the highest importance to fridges and color TV and the lowest importance to electric fans. The importance of energy services may differ in different contexts. This is shown by listing the researcher's choice of energy services in Figure 3. In any case, the importance of these self-set goals, energy services respectively, needs to be graded from 5 (very high) to 1 (very low).

In the sections on success factors, factors were found which relate to a. SHS itself, b. SHS Market, c. Appliances, d. Quality, e. Energy Services supplied and f. SHS users (refer to Table 2). Referring to earlier findings these success factors can be either endogenous or exogenous in nature [27]. The success factors related to a.–e. are exogenous success factors while the success factors related to the SHS user are endogenous success factors. A weighting of the individual success factors subsumed under a.–f. cannot be given at this stage of the research. The knowledge on success factors is important as they impact on the achievement of self-set goals.

The measurement of the level of achievement is a precondition to apply this model of success. As a quantitative measure it was proposed to determine the level of achievement through the ratio of the actual operation hours over the rated operation hours. However, the qualitative measure of the user satisfaction seems to be much closer to the reality of the model's application. To make the model work, this level of achievement needs to be transformed into a standardized grading system. A

[6] The difference between the annual average radiation and the maximum radiation is 13% in Ndejje and 26% in Ndumo. The difference between the annual average and the annual minimum is 8% and 24% respectively.

six tier system was proposed for the level of achievement of the institutional stakeholders involved in SHSs [27] and for consistency this system is applied to users as well.



* The LoA approach would be the desirable quantitative approach for users but its feasibility is questionable.

Figure 5. The improved model of success for users.

The resulting numbers of the LoA (between 5 and 0) and the importance of the energy services (5 to 1) are used to determine the *user's success of SHS implementation*. This is calculated using the formula below

$$\frac{\sum_{i=1}^{j} I_{SSG_i} \cdot LoA_{SSG_i}}{\sum_{i=1}^{j} I_{SSG_i}}$$

where I_{SSGi} is the importance of the self-set goal i and LoA_{SSGi} is the level of achievement of the self-set goal i.

Using the above formula, the user's level of success calculated for Uganda is 1.9 and for South Africa it is 1.7 (5 = excellent success, … 2 = sufficient success, 1 = very low success, 0 = failure). This result is based on the current samples in Uganda and South Africa and the result shows the applicability of the model for measuring the SHS success from the user's point of view.

The contextualization of the model's components (*Stakeholders, Self-Set Goals, Importance of SSG, Success Factors and the Measurement of the Level of Achievement)* and the component's elements is shown at the top of the model. It advises institutions investigating success of SHSs with this model, that all components of the model of success are impacted by the local context of the SHSs' implementation.

6. Conclusion

The conclusions drawn here are limited to the findings in a rural area in Uganda and a rural area in South Africa. They do not represent the population in the surveyed regions and cannot be generalized. However, the findings contribute to the refinement of the model of success and they give insights of what needs to be considered when applying the model of success:

- Knowledge on SHSs found in literature was confirmed by these research methods which represent a relatively uncommon approach. However, additional findings were also made.
- In the overall picture it was found that SHSs cover only a small part of rural households' energy demands. However, as SHSs supply electricity, self-set goals (energy services) of high personal importance for the user, but not indispensable for survival, are enabled by these systems. Yet, SHSs do not have the monopoly to supply these services. Even when a SHS is installed energy services such as illumination and communication (mono- and bi-directional) are partly supplied by other sources. Still, a SHS reduces the efforts required to obtain the desired services.
- The users' self-set goals related to SHSs are impacted by a variety of underlying motivations. There is a need of optimization on different levels. There are drivers for the selection of SHSs in case of multiple choices.

- The user's awareness is important for the success of Solar Home Systems. It keeps the user's expectations on a realistic level and prevents disappointment resulting from unmet expectations. In addition it allows an optimal operation of the system. Nevertheless, even at high levels of awareness drawbacks in the operation of SHSs cannot be excluded.
- The operation of a refrigerator by a SHS at appropriate cost seems to be impossible at present. The solution for this energy service could constitute a breakthrough for SHSs.
- The charge controller's importance must not be underestimated. By giving information on the system's condition to the user and with the user's careful application of this feedback the charge controller enables a higher reliability of the SHS's electricity supply than the grid connection can provide in the observed rural areas.
- Systems should not require intensive efforts for operation and maintenance. Even very motivated users fail in giving enough attention to the operation and the maintenance.
- A dense network for repair, maintenance, and spare part supply is a success factor.
- Productive use is a success factor for SHSs as found in the literature. However, only niches of productive use can be served by the small amounts of electricity supplied by a SHS.

The model of success now incorporates insights from the perspective of the user and is now available for application to evaluate the success of SHS implementations and programs. The measurement of the level of achievement of self-set goals remains the largest challenge in applying this model. Here the research was not able to present a fully satisfactory approach that meets quantitative scientific standards on one hand, and is appropriate for rural dwellers and their Solar Home Systems on the other hand.

The linkage between success factors and the achievement of self-set goals/energy services and the weights of success factors related to users remains an interesting area of future research.

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Conflict of interest

All authors declare no conflicts of interest in this paper.

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