Peer-reviewed version available at Energies 2018, 11, 1509; doi:10.3390/en11061509

Type of the Paper (Article)

The Key Scope and Challenge of Development Strategy for Solar Home System

Pimnapat Bhumkittipich*[1] and Hideaki Ohgaki [2]

[1] Department of Social Sciences and Humanities, Faculty of Liberal Arts, Rajamangala University of Technology Thanyaburi, Thailand; pimnapat_i@rmutt.ac.th
[2] Institute of Advanced Energy, Kyoto University, Kyoto, Japan; ohgaki.hideaki.2w@kyoto-u.ac.jp
* Correspondence: pimnapat_i@rmutt.ac.th; Tel.: +66-2-549-4960

Abstract: The fact that Thailand's energy policy has set a new renewable energy target of 30% of total final energy consumption by 2036. It also has the potential of solar energy and community demands in remote areas. However, most of the renewable energy technology will still be able to achieve renewable energy goals, similar to the case of the national policy that promotes Solar Home System (SHS) in remote areas, lack of good handling. Therefore, achieving the goal of the renewable energy policy should be in position using the right strategy. This article presents the result of a case study in the Akha upland community, northern Thailand, where we used the mixing method and factor analysis to analyze strategies for SHS related criteria. The key scopes and challenge included bottom-up planning concepts and subsidies from expert persons, while contributions to factors have an impact on developing sustainable SHS, include the creating approval of SHS technologies, developing of SHS management, promoting of SHS technologies, and supporting of SHS policies, respectively. Mainly, social factors provide positive effects, which thus influence the sustainable development of process SHS in terms of the creation of approval. Furthermore, there should be managed appropriately for each community, for the positive imagery of solar power.

Keywords: remote areas; solar home system; sustainable development

1. Introduction

In the world today, it is found that there is a tendency of global warming getting more severe, thanks to the increasing amount of greenhouse gas (GHG). The main cause of this is the increase of CO_2 emitted from industrial factories and the energy industry which relies on fossil fuel. Therefore, many countries show efforts to make the use of renewable and alternative energy more practical, in order to become low carbon societies. As for Thailand, there has been a policy concerning energy from the government: supporting investment in national projects like clean energy, railway system, electric transportations, water and waste management, putting the knowledge from researchers and development plans on Thai innovations to use properly [1]. A large-scale renewable energy project conducted by the Thai government in 2005 and 2006 was "Electrical Service Acceleration Project by Photovoltaic system (Solar Home System: SHS)". The installed SHS consisted of four parts: 120 Wp. PV module, the low-cost controller (Charger and inverter), 125 Ah battery, and AC load (2x10 Watt fluorescent and 14 inches color television) (Fig.1). The cost investment for SHS is around 7,631,295,000 THB [2]. The purpose of the project is to improve the social well-being in remote areas by installing PV standalone system where electricity lines cannot reach at the total of 203,000 households. Most of the households are located in northern Thailand, mostly in protected forests and mountains. According to the project follow-up, SHS did not succeed as expected, for the community's lack of budget for maintenance, the continuity of support from governmental SHS policy, and also the people cooperation [3]. Based on literature review, many studies focused on renewable energy had made way for the discovery of methods to improve the sustainable use of renewable energy by

examining steps and ways to increase its effectiveness: modeling, planning, and controlling problems. As part of the study, mathematic equations were developed for other proper use [4]. Also, decision analysis and knowledge on roles of renewable energy in protecting the environment under the concept of sustainable development were applied to make precise policies to improve the energy system under given physical capabilities [5] and to present the overall picture of the development plan and the scope of CO_2 reduction [6]. Moreover, some researchers have studied a method to optimize the allocations of PVs and energy storage systems (ESSs) based on vulnerability analysis, and utilizes the proposed concept of "slow" and "fast" ESSs [7]. In terms of social acceptance of renewable energy technologies (RETs), the study covers the topic of awareness and willingness to invest in the renewable energy technology [8], but it did not consider the allocation of SHS sustainable development. What is still needed to be studied is development strategies of SHS for improving social well-being, relying on the analysis of external factors, including politics, economy, technology, and society. Though the factors cannot be controlled, they give the information needed to discover the way to create opportunities to develop SHS through factor analysis. The content of the study is presented in the following sequence: Theoretical framework, methodology, data collection and results, discussion, conclusions and recommendation.

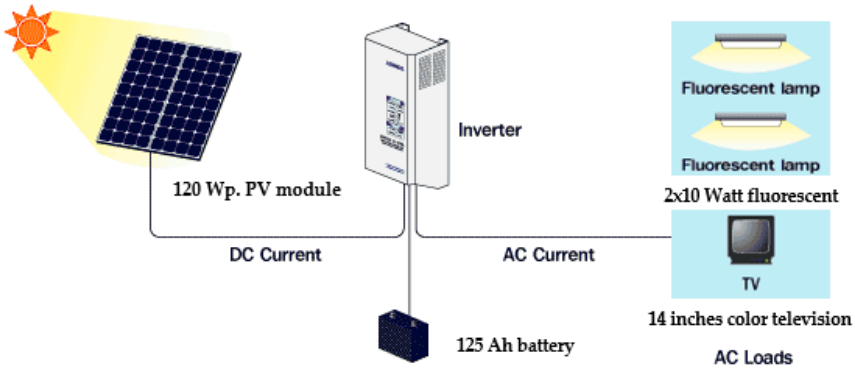

Figure 1. Sample application of PV standalone system in remote areas, Thailand [9]

2. Theoretical framework

2.1 Concept of developing SHS technology

In the past, the concept of developing renewable energy technologies was focused on the concept of sustainable development (SD) as follows: engineering, economics, and environment. The goal of which is to achieve the balance between environmental sustainability, economic sustainability and socio-political sustainability such as a framework for the development of sustainability indicators to assess renewable energy technology taking into consideration the economic, social, environmental and technical factors [10]. On the other hand, basic sustainability indicators for renewable energy systems are the most popular means of economic indicators and social indicators, the CO_2 emission indicator of environmental criteria [11]. In the economic consideration, costs indicator is widely used to analyze the system quality. A lower value of cost means better. There are two common social indicators: job creation and the number of residents benefited. However, there is no currently theoretical consensus on the definition of the sustainable community [12].

In this paper, the researchers defined the meaning of SD that came out of decision-making process under the issue of community. However, SHS is considered the new innovation of the Akha society. There are a variety of benefits to adopting a SHS. The government provides the better quality of life in the long run compared to non-electric sources of light at night and news from television. SHS has considered the starting point leads to acceptance of the renewable technology. It means a positive attitude toward end-uses from SHS. However, the main barriers to process SHS include lack

of knowledge of people in remote areas, lack of skilled workers to install and maintain. It is important to understand the needs of electrical users and the characteristics of the target communities. What is an important way that leads to the sustainable development of SHS?

2.2 External analysis

The external environment is still the most important factor of strategic management, so it can be assumed that the external environment influences the performance of the system or organization [13]. The external analysis is a type of macro environment analysis on the information of changes in factors that cannot be controlled by the organization. It is a tool for help private or public sectors prepare and respond to the effects of changes. The external environment have been grouped into "P-E-S-T", such as political, economic, social-cultural, and technology. However, it is also worth noting that the four paradigms of P-E-S-T will have different priorities, depending on your type of business [14]. Thus, summarizing the concept and scope of PEST analysis:

- Political factors – factors related to changes in the political situation that affects the boundary of the research.
- Economic factors – normal economic factors such as changes in interest rates affect the business.
- Social factors – social change factors which are related to people's daily life, such as attitudes, culture, etc.
- Technological factors – factors related to changes in technology that lead to new products or improvements in existing products or new techniques related to exchange, etc.

This research had applied the mentioned concept to create the external environment that affects the SHS development factor indicators, based on the focus group and in-depth interviews with the people involved. The results of this step will be taken to create an appropriate question for household interviews. However, the specific topics and the number of external factors in this study depend on the experience, skills and ideas of the key-informant. Figure 2. Show the scope of PEST analysis based on SHS project.

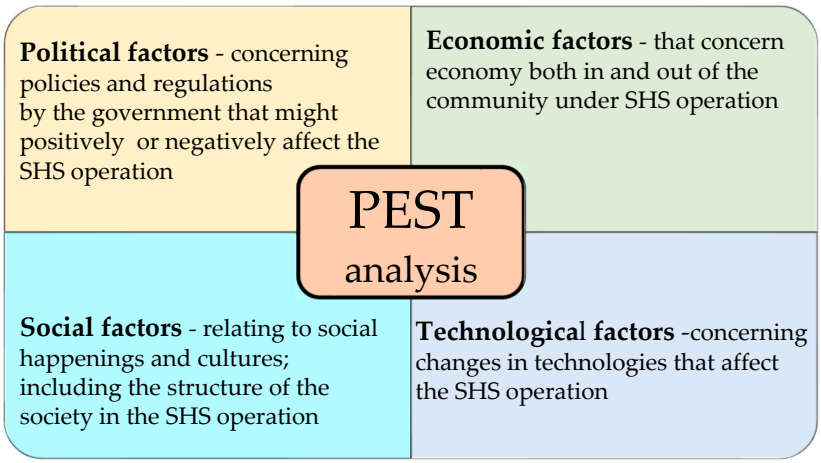

Figure 2. The paradigms of P-E-S-T based on SHS project.

The results of PEST analysis are shown by the average value and standard deviation, to offer the level of external factors that influence the SHS. In this respect, findings obtained the problem-solving strategies have relevance to the goals of the community, consistent with the bottom-up by the factor analysis method. The conceptual framework of this study, as shown in Figure 3.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 16 May 2018 doi:10.20944/preprints201805.0227.v1

Peer-reviewed version available at Energies 2018, 11, 1509; doi:10.3390/en11061509

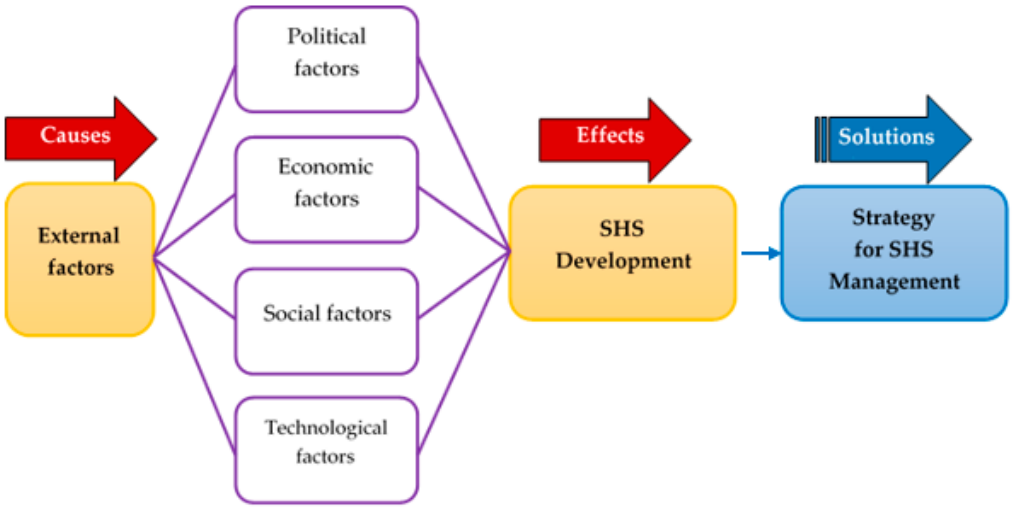

Figure 3. The conceptual framework of this study

The objectives of this research are as follows:

- To study problems and satisfaction with the development of SHS
- To find out the external factors affecting sustainable SHS development
- To analyze the important factors of sustainable SHS development

3. Methodology

The present study was part of a cross-sectional survey designed to assess dietary patterns in a representative sample of rural households from Akha upland community in Mae Salong Nai, Chiang Rai province, Thailand (Fig.4). having been under the care of the energy service expansion project, the community was provided solar energy generating system. This research uses a mixed method by applying the methodology of quantitative and qualitative research to find out the external factors affecting sustainable SHS development.

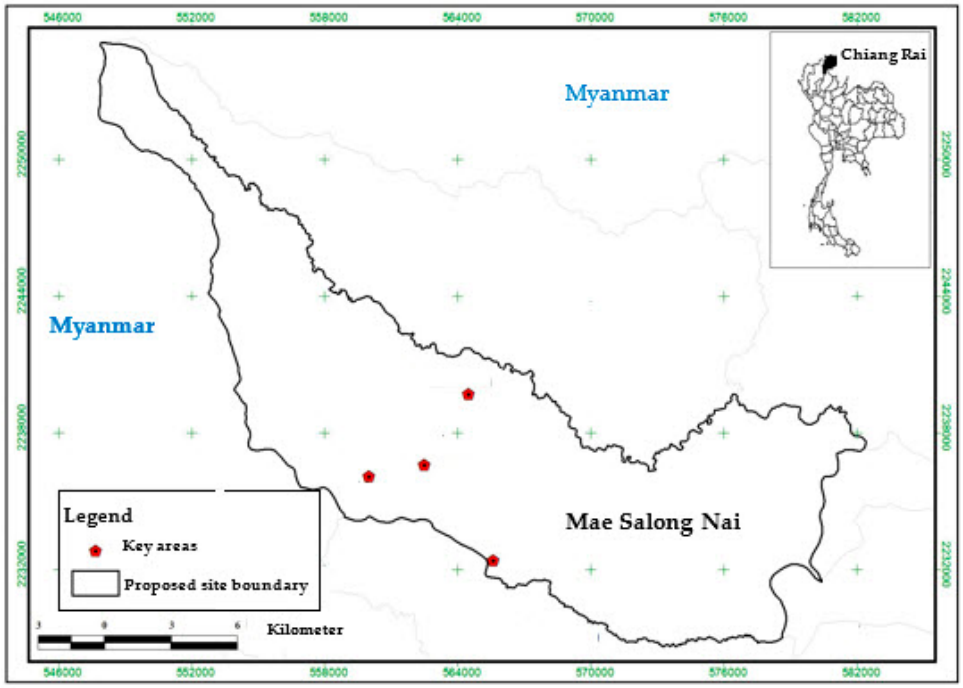

Figure 4. Map of study location [15]

3.1 Population and Research samples

The study's population consisted of 127 households that receive services from SHS project. Random sampling was used to select the cases; consisted of a total of 97 cases by using the formula of Yamane (1967: p 886) [16]. Semi-structured, face-to-face end-users interviews of objective two-three as problems and satisfaction with the development of SHS and problems and satisfaction with the development of SHS. Purposive sampling was used to select key-informant; consisted of 18 experts, including village leaders or representatives, the researchers and academicians. Key-informant interviews were conducted to assess the currency of SHS in the study area and brainstorm for the concept to create the external environment and SHS development factor indicators consist of political, social and technological factors (objective two).

3.2 The stage of this research and research instrument

Regarding the case study methodology, information from various data resources was included three stages:

3.2.1 Stage one survey and empirical information

The first step applies field research as follows: (1) survey area (2) in-depth interview (3) non-participant observation and (4) literature review by analyzing the phenomenon's relationship with the social context and environment. This is to be done as an open-end question for data collection of quantitative in second steps.

3.2.2 Stage two identify factors affecting sustainable SHS development

Second stage interview with household sampling. The interview question was divided into three parts, which includes: Part 1 elicited respondents' background information (i.e. demographic data), Part 2 focused on the satisfaction of SHS technologies, and Part 3: focused on obtaining ideas on the development of SHS.

By part two and part three are answered on a three-point Likert-type scale, ranging from 3 (strongly) to 1 (disagree), Therefore, interpreting the average rating is three levels of translation criteria:

- The average rating between 2.34 – 3.00 refers to a high.
- The average rating between 1.68 – 2.33 refers to moderate.
- The average rating between 1.00 – 1.67 refers to low.

3.2.3 Stage three data analysis

The third stage of this study involves the statistics variables used were percentages, means, standard deviation and factor analysis. So, the article gives weight to the external environment of a community to describe the characteristics of the problem and SHS technologies to the people, also to analyze factors in order to identify what supports sustainable SHS development. For this, we need a workforce equipped with suitable skills and education within a framework to support them.

4. Data analysis and Results

In the progress, study areas, interviews of end-users in Akha community concerning SHS development such as characteristics of research samples, problems of SHS development and the SHS development policies by the government. The raw data were analyzed according to the social science methodology to depict the main barriers of the implementation of SHS.

193 *4.1 Survey and empirical information*
194
195 Mae Salong Nai of northern Thailand was the area of the present study. This area is the majority
196 of the Akha community, are highlands and mountains which were in protected forests (Fig.5). Four
197 out of twenty-two villages had SHS installed by the energy service expansion project, at the total
198 number of 127 households (Fig.6). Descriptive statistics of respondents have described the
199 characteristics of the sample group and evaluated data in section 4.2-4.3.
200

201
202
203 **Figure 5.** Geographic characteristics of Mae Salong Nai
204

205
206 **Figure 6**. SHS in Akha upland community

Of the 97 overall by survey respondents, 75.10% were male, 38.14 % were in terms of age between 30-40 years, 77.32% uneducated, 81.14% were living as dwellers who grew rice, and 63.29% having the average income of approx. 5,000 baht/month. After the SHS installation, of the respondents, 79.38% were lacked public relation concerning maintenance, 40.21% of the installed SHS usability was low, 43.30% primary cause was the deterioration of the battery. The interviewee has a comment on the SHS problem in high-level ($\overline{X}$ = 3.16, S.D. = 0.40). Considering main setbacks for SHS reinstallation were insufficient fund ($\overline{X}$ = 2.91, S.D. = 0.38), the lack of coordination with the government ($\overline{X}$ = 2.89, S.D. = 0.41), and the lack of knowledge of where and how to contact a place that could provide reparation for the SHS ($\overline{X}$ = 2.88, S.D. = 0.41), respectively.

4.2 Satisfaction of SHS development

The interview form regarding SHS development consisted of 16 questions. In overall, the interviewees' satisfaction level was low ($\overline{X}$ = 1.36, S.D. = 0.32). In details, it was found that the only question that had a moderate level of satisfaction was whether the SHS was appropriate for remote areas ($\overline{X}$ =1.87, S.D. = 0.85). All other regards, such as regulations on maintenance and maintenance fee collection ($\overline{X}$ = 1.66, S.D. = 0.60), whether the SHS was the suitable system for the community ($\overline{X}$ = 1.55, S.D. = 0.58), maintenance fees ($\overline{X}$ = 1.54, S.D. = 0.58), lifestyle and behavior's suitability with SHS usage ($\overline{X}$ = 1.52, S.D. = 0.52), presented low level of satisfaction.

4.3 Identification of factors which affected the sustainable development of SHS

According to group discussions and in-depth interview with 18 expert persons to identified four external factors affecting sustainable SHS development. Summary of findings from external factors which affected the sustainable development of SHS domain as showed in Table 1.

Table 1. Characteristics of external factors which affected the sustainable development of SHS

Component	Description
Political factors	- Governmental policies on developing SHS in remote areas - Clear regulations on maintaining the SHS - Roles of local governmental influence or the sub-district administration organization
Economic factors	- SHS users' socioeconomic status - The initial investment for SHS reinstallation - Monthly maintenance - Repair/replacement fees
Social factors	- SHS users' education - Increasing user population - Community lifestyle and behavior (accept/deny SHS) - Utility systems (electricity in/out of reach) - Transportation (personal car/motorcycle/on foot) - Communication with the government regarding SHS usage issues
Technological factors	- How to use SHS - How to maintain SHS - How to repair SHS

The researchers applied the information from Table 1 to synthesize and design the three-point scale (on importance) interview questions that would be used on 97 households of SHS users, whether we are trying to find out the opinion of end-users on factors affecting sustainable SHS development. The results showed that the interviewees' level of satisfaction toward overall sustainable SHS development was moderately important ($\overline{X}$ = 2.24, S.D. = 0.47). In details, end-users have very important toward political factors ($\overline{X}$ = 2.54, S.D. = 0.65), moderately important toward economic factors ($\overline{X}$ = 2.25, S.D. = 0.54), social factors ($\overline{X}$ = 2.15, S.D. = 0.51), and technological factors ($\overline{X}$ = 2.07, S.D. = 0.75), respectively, as showed in Table 2.

Table 2. External factors affecting sustainable SHS development

Items	Component	Mean	S.D.	Description
	Political factors	**2.54**	**0.65**	**Very important**
1.	Government's continuity in SHS development policies	2.59	0.64	Very important
2.	Regulations on maintenance and maintenance fee collection	2.52	0.71	Very important
3.	Roles of the sub-district administration organization in SHS management	2.51	0.71	Very important
	Economic factors	**2.25**	**0.54**	**Moderately important**
4.	SHS improves the household economy	2.08	0.61	Moderately important
5.	The initial investment for SHS installation	2.54	0.69	Very important
6.	Maintenance fees (e.g. for distilled water)	2.11	0.76	Moderately important
7.	SHS repair/replacement fees	2.24	0.72	Moderately important
	Social factors	**2.15**	**0.15**	**Moderately important**
8.	SHS helps understand social changes	1.81	0.75	Moderately important
9.	SHS sufficiency for increasing users	2.44	0.66	Very important
10.	SHS is proper for Sufficiency lifestyle	2.04	0.76	Moderately important
11.	SHS is suitable for remote areas	2.05	0.70	Moderately important
12.	SHS is the utility suitable for the community	2.07	0.64	Moderately important
13.	SHS maintenance from government officials	2.43	0.78	Very important
	Technological factors	**2.07**	**0.75**	**Moderately important**
14.	SHS usage instruction	1.99	0.80	Moderately important
15.	SHS maintenance	2.07	0.78	Moderately important
16.	SHS device reparation	2.13	0.79	Moderately important
	Overall	2.24	0.47	Moderately important

After that, the factor analysis method was used to identify the underlying 16 items or external factors' effects on the development of SHS and select the items that best represent these factors, relation of factors within the group. Therefore, each of the components can be described according to what the factors indicate, which proves beneficial for planning developments. The data used to analyze the element must be characterized by several continuous variables that are stored in the sample group. Then, make sure that the variables are related. If a variable is very relevant or has a significant relationship. The factor analysis can be used if the variable is not related or is less relevant. It should not be used in factor analysis techniques.

The five-major steps [17] will be useful in this paper, which includes: (1) Precondition: evaluation of sample size adequacy using correlation matrix, Kaiser-Meyer-Olkin (KMO) and Bartlett's Test techniques, (2) Factor extraction: choosing factor extraction method such as principal components analysis, image factoring, maximum likelihood, alpha factoring, etc., (3) Factor rotation: selection of rotational method, whether orthogonal rotations or Oblique rotation, (4) Number of factors: such as percentage of variance explained, and (5) Interpretation and labeling of factors: factor loadings and factor scores. This study selects the KMO statistics (Kaiser-Meyer-Olkin Measure of Sampling adequacy) to use the measurement of the sample data as a value .790, which indicates that it is appropriate to analyze the elements in good order [18]. Thus, based on the results, it is appropriate to proceed with factor analysis to examine factors that affecting sustainable SHS development. And the results of Bartlett's Test ($p < 0.001$) is significant [19], that various variants have a sign at level 0.000, it factorability and sample size are excellent [20], showing that the variables can be used to analyze the elements (Table 3).

Table 3. Kaiser-Meyer-Olkin Measure of Sampling Adequacy and Bartlett"s Test of Sphericity

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.79
Approx. Chi-Square		928.76
Bartlett's Test of	df	105
	Sig.	.000

Table 4 displays the total variance explained at fourth stages for factors that affecting sustainable SHS development. Four factors were extracted because the survey elements have been analyzed by orthogonal rotation with a varimax method, under the conditions of variance eigenvalue greater than 1.00. When fourth factors were extracted, then 72.82% of the variance would be explained.

Table 4. The total variance explained

Factor	Rotation Sums of Squared Loadings		
	Eigenvalue	Percentage of Variance	Cumulative Percentage
1	4.00	24.93	24.93
2	3.62	22.64	47.56
3	2.29	14.29	61.85
4	1.76	10.97	72.82

Table 5 shows the rotated factor matrix for the data. Factor Loadings: Measure the relationship between the items and the factors. Factor loadings can be interpreted as correlation coefficients; ranging between -1.0 and +1.0. Tabachnick and Fidell [21] stated variable with factor loadings more than 0.45 were chosen in this study because loadings equal to 0.45 is considered average, whereas loadings 0.32 is considered less good. After performing varimax rotation method with Kaiser Normalization, the first factor comprised of 5 items with factor loadings ranging from 0.77 to 0.88; second factor, comprised of 6 items with factor loadings ranging from 0.52 to 0.91; third factor comprised of three items with factor loadings ranging from 0.73 to 0.92; and four-factor comprised of two items with factor loadings ranging from 0.546 to 0.813. The fourth new factors were successfully constructed using factor analysis and assigned as the factors effects on the development of SHS.

Table 6 shows the name of the new factors and percentage of variance explained for each of the factors. The new factors associated with each dimension in the framework which influences SHS development of factors described below:

Table 5. Factor structure of the sustainable SHS development factor weights after Varimax rotation

Items	Item Label	Factor Loadings			
		Factor 1	Factor 2	Factor 3	Factor 4
15	SHS maintain	.88	-	-	-
16	SHS device reparation	.83	-	-	-
14	SHS usage instruction	.82	-	-	-
8	SHS helps understand social changes	.81	-		-
4	SHS improves the household economy	.77	-	.-	-
11	SHS is suitable for remote areas	-	.91	-	-
12	SHS is the utility suitable for the community	-	.81	-	-
10	SHS is proper for Sufficiency lifestyle	-	.70	-	-
5	The initial investment for SHS installation	-	.69	-	-
2	Regulations on maintenance and maintenance fee collection	-	.65	-	-
6	Maintenance Fees	-	.52	-	-
3	Roles of the sub-district administration organization in SHS management	-	-	.92	-
1	Government's continuity in SHS development policies	-	-	.81	-
13	SHS maintenance from government officials	.-	-	.73	-
9	SHS sufficiency for increasing users		-	-	.81
7	SHS repair/replacement fees	-	-	-	.55

Note. Factor loading > .50 are in boldface.

• The first factor, creating approval of SHS technologies shows the highest percentage of variance explained when it was extracted. When the first factor, creating approval of SHS technologies: 24.93% of the variances could be explained. 5 important items were "SHS maintain", "SHS device reparation", "SHS usage instruction", "SHS helps understand social changes" and SHS improves the household economy. This group dealt with education, understanding in SHS, and the benefits the society receives.

• The second factor, developing of SHS management: 22.64% of the variances could be explained. 6 important items in this group included "SHS is suitable for remote areas", "SHS is the utility suitable for the community", "SHS is proper for Sufficiency lifestyle", "Initial investment for SHS installation", "Regulations on maintenance and maintenance fee collection", and "Maintenance fees". The factors in this group dealt with methods to improve the SHS and proper community management.

• The third factor, promoting of SHS technologies: 14.29% of the variances could be explained. Three main items in this group were "Roles of the sub-district administration organization in SHS management", "Continuity in SHS development policies", and "SHS maintenance from government officials". It was found that the minor factors in this group contained policies on supporting the use of SHS and giving knowledge about SHS to the community.

• The fourth factor, supporting of SHS policies: 10.97% of the variances could be explained. Two major factors in this group were "SHS sufficiency for increasing users", and "SHS repair/replacement fees". The group's minor factors included the cost of installation and expense for maintenance.

Table 6. Name of new factors with the percentage of variance

New factors	Name	Percentage of Variance	Item Label
1	Creating approval of SHS technologies	24.93	15. SHS maintain 16. SHS device reparation 14. SHS usage instruction 8. SHS helps understand social changes 4. SHS improves the household economy
2.	Developing of SHS management	22.64	11. SHS is suitable for remote areas 12. SHS is the utility suitable for the community 1. SHS is proper for Sufficiency lifestyle 5. The initial investment for SHS installation 2. Regulations on maintenance and maintenance fee collection 6. Maintenance Fees
3	Promoting of SHS technologies	14.29	3. Roles of the sub-district administration organization in SHS management 1. Government's continuity in SHS development policies 13. SHS maintenance from government officials
4	Supporting of SHS policies	10.97	9. SHS sufficiency for increasing users 7. SHS repair/replacement fees

Following, Table 6 was used to create a conceptual framework for a sustainable SHS development. This strategy recommends the cooperation of all sectors, companies, communities, and Governments as lead to social acceptance.

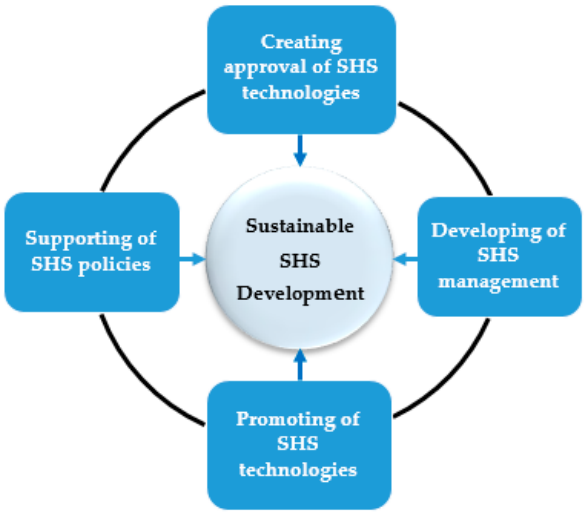

Figure 7. A conceptual framework strategy of sustainable SHS development

Figure 7. shows significant factors for the development of SHS designed by the bottom-up, which this approach leads to creating the sustainable network in Akha community, and the organizations, subdistrict administrative organization (SAO) can use those elements to determine the priority of problem-solving. The following are four key scopes and challenges:

- The first priority is creating approval of SHS technologies.
- The second priority is developing of SHS management.
- The third priority is Promoting of SHS technologies.
- The fourth priority is Supporting of SHS policies.

5. Discussion

According to the results of the study, it can be concluded that most of the user households were the people of Akha hill tribe who were uneducated, had low income, and had never received the information about 79.38%. The causes of this reasons could be the lack of personnel in the sub-district administrative organization who was proficient in SHS operation and maintenance. The second cause was the area of installation, which was hard to reach, about 74.13%. The battery deterioration as the main source of the technical problem was about 43.30%. As a consequence, the end-users had a negative attitude toward the SHS. According to this proposed reason, the policymakers need to understand which end-user objectives had considered to be the most important and were related to end-users opinions on the energy technologies [22]. Moreover, the knowledge limitations of end-users, especially, understanding, and maintenance of the technology of the Akha had caused of external factors that affect to the SHS development. The first priority of social factors which consist of SHS education, the increasing number of SHS user households, acceptance/denial of SHS, public utilities, transportation, and communication with the government in case of problems should be positive effects on SHS developing. This factor could be the effect of the SHS technologies being hard for the Akha. The shared experience would affect the attitude and acceptance of the use of the community's solar technologies [23]. Therefore, the process of choosing goals, priorities, and indicators, details of a social well-being will have to be filled by the community itself. Additionally, the basic needs of community for sustainable development were technology improvement, proper management and continuous follow-up, which will cause sustainable energy management [24]. The policymakers could subsidy the SHS to end-users for social acceptance. The research of energy field of study was already skewed away from the social sciences towards disciplines such as engineering and economics [25]. The method of SHS sustainably developing in the Akha area is to create the learning and understanding.

6. Conclusions

This paper focuses on the key scope and challenge of development strategy for solar some system (SHS). The SHS maintenance and improving of Quality of Life (QOL) were highlighted. Stakeholder management is the key success to SHS development which are included: the standard of SHS components and after-sales service. Akha upland community can operate the SHS to be the SHS sustainability which need to learning and understanding the SHS by themselves. . Designers and researchers should track and monitor the SHS for receiving the feedback from community groups regarding their involvement in the process. Therefore, the process of SHS development should consist of six steps as follows: (1) Survey areas and understand electricity demand from the bottom up, (2) Study solar resource potentials and design technology appropriate with end users, (3) Social impact assessment from SHS technology (4) Create awareness of social benefits from SHS, (5) Evaluate of SHS knowledge and ability management and (6) Community planning appropriate SHS management. Therefore, the further research in the field of renewable technology, the policymaker should be a focus on hybrid renewable technology and demand side management in order to increasing power generation.

7. Acknowledgments

This article is based on a research project titled "Environmental impact factor modeling for sustainable development of Thailand's solar home system" The author acknowledges the funding provided to the research project by National Research Council of Thailand. (Grant no.146610).

8. Author Contributions: All the authors have developed the concept and design the study. While data collection, supervision of the survey implementation, writing, and analysis was done by Pimnapat, K. The manuscript was proofread and revised by all authors. All authors read and approved the final manuscript.

9. Conflicts of Interest: "The authors declare that they have no competing interests."

References

1. Alternative Energy Development Plan (AEDP2015). Available online: http://www.dede.go.th/download/files/AEDP%20Action%20Plan_Final.pdf (accessed on 25 Much 2018).
2. Watjanatepin, N; Boonmee, C; Unhalekha, P; Srisongkhram, V; Kurehong, T; Wannasut, C. Evaluation of electrical service acceleration project by the solar home system in Thailand. In proceedings of 4th Conference on Energy Technology Network of Thailand ENETT, Nakronpatom, Thailand, 2008.
3. Iemsomboon, P; Waiprom, N; Ngaemngam, S; Bhumkittipich, K. Environmental impact factor modeling for sustainable development of solar home system, 2015., in press.
4. Banos, R; Manzano-Agugliaro, F; Montoyab, F.G.; Gila, C; Alcayde, A; Gómez, J. Optimization methods applied to renewable and sustainable energy: A review. *Renewable and Sustainable Energy Reviews* **2011**, *15,* pp.1753–1766, DOI.https://doi.org/10.1016/j.rser.2010.12.008.
5. Annika, S; Mats, L; Alf, R; Marcus, L; Rafael, W. On the physics of power, energy, and economics of renewable electric energy sources - Part II. *Renewable Energy* **2010**, *35*, pp. 1735–1740, DOI. https://doi.org/10.1016/j.renene.2009.08.031.
6. Panwara, N.L.; Kaushikb, S.C.; Surendra, K. Role of renewable energy sources in environmental protection: A review, *Renewable and Sustainable Energy Reviews* **2011**, *15,* pp. 1513–1524, DOI.https://doi.org/10.1016/j.rser.2010.11.037.
7. Panwara, N.L.; Kaushik, S.C.; Surendra, K. Role of renewable energy sources in environmental protection: A review, *Renewable and Sustainable Energy Reviews* **2011**, *15,* pp. 1513–1524, DOI.https://doi.org/10.1016/j.rser.2010.11.037.
8. Moula, M.M.E.; Maula, J; Hamdy, M; Fang, T; Jung, N; Lahdelma, R. Researching social acceptability of renewable energy technologies in Finland, *International Journal of Sustainable Built Environment* **2013**, *2,* pp. 89-98, DOI.https://doi.org/10.1016/j.ijsbe.2013.10.001.
9. Sample application of solar home system. Available online: http://www.leonics.com/system/solar_photovoltaic/solar_home_system/shs-00130_en.php (accessed on 5 May 2018).
10. Sustainability Assessment Framework for Renewable Energy Technology. Available online: www.reading.ac.uk/web/FILES/tsbe/Luong_TSBE_Conference_Paper_2012.pdf (accessed on 25 Much 2018).
11. Liu, G; Li, M; Zhou, B; Chen, Y; Liao, S. Development of a general sustainability indicator for renewable energy systems: A review. *Renewable and Sustainable Energy Reviews* **2014**, *31*, pp. 611-621, DOI.https://doi.org/10.1016/j.rser.2013.12.038.

12. Qin, X.D., Zhang, Y.H., Lei, J. Review of research on sustainable community. *In:Applied Mechanics and Materials* **2013**, pp. 102-106, DOI.10.4028.www.scientific.net/AMM.361-363.102.
13. Njoroge J. K.**;** Ongeti W. J.; Kinuu D.; Kasomi, F. M. Does External Environment Influence Organizational Performance? The Case of Kenyan State Corporations. *Management and Organizational Studies*, **2016,** *3*, pp. 41-51, DOI. 10.5430/mos.v3n3p4
14. PESTLE Analysis. Available online: http://www.free-management-ebooks.com/dldebk-pdf/fme-pestle-analysis.pdf, 2013; ISBN 978-1-62620-998-5. (accessed on 5 April 2018).
15. Iemsomboon, P. Modeling Community Quality of Life Indicators for Developing Solar Home System in Remote Areas. Ph.D. Thesis, Kasetsart University, Thailand, 2012.
16. Determining Sample Size. Available online: http://www.psycholosphere.com/Determining%20sample%20size%20by%20Glen%20Israel.pdf (accessed on 20 May 2018).
17. Chin, L.P.; Kulathuramaiyer, N; Awg, N.D.; Kang, C. Towards semantic clustering: Grouping image visual features through exploratory factor analysis. Processing of IIEEJ Image Electronics and Visual Computing Workshop 2012, Kuching, Malaysia, November 21-24, 2012.
18. Yalçın, M. T.; Ereş, F. A Study of Validity and Reliability on the Instructional Capacity Scale. *Universal Journal of Educational Research*, **2018,** *6*, pp. 57-67, DOI.10.13189/ujer.2018.060105.
19. Bentler, P. M.; Kano, Y. On the Equivalence of Factors and Components. *Multivariate Behavioral Research,* (1990). *25*, pp. 67-74.
20. Young, A.G.; Pearce, S. A beginner's guide to factor analysis: Focusing on exploratory factor analysis. Tutorials in Quantitative Methods for Psychology, 2013. 9, pp.79-94, DOI.10.20982/tqmp.09.2.p079.
21. Tabachnick; B. G.; Fidell; L. S. Using Multivariate Statistics. Fourth Edition. Published by Allyn and Bacon, Incorporated, Boston, U.S.A., 2000; ISBN 0321056779.
22. Singhonniyom, S; Thamsatitdej, P. Factors Affecting Behavior Recognition Technology to Generate Electricity with Solar Cells. In Graduate Research Conference 2014, Khon Kheng, Thailand, 2014. pp.536-544.
23. Meenakorn, S. The study pattern Energy Management Appropriate for Amphawa District. Bangkok: Suan Sunandha Rajabhat University, 2012, in press.
24. Bertsch, V; Hyland, M; Mahony, M. What drives people's opinions of electricity infrastructure? empirical evidence from Ireland. *Energy Policy,* **2017,** *106*, pp. 472-497, DOI. http://dx.doi.org/10.1016/j.enpol.2017.04.008.
25. Devine-Wright, P; Batel, S; Aas, O; Sovacool, B; La Belle, M.C; Ruud, A. A conceptual framework for understanding the social acceptance of energy infrastructure: Insights from energy storage. *Energy Policy,* **2017**, *107*, pp. 27-31, DOI. https://doi.org/10.1016/j.enpol.2017.04.020.
26. Kabir, E; Kim, KH; Szulejko, J.E. Social Impacts of Solar Home Systems in Rural Areas: A Case Study in Bangladesh. *Energies,* **2517**, *10*, 1615, DOI. 10.3390/en10101615.