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Developing a Strategy to Improve Solar Home System Sustainability In Rural Thailand

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Abstract

The goal of this project was to develop a strategy for improving the sustainability of solar home systems in rural Thailand. Heretofore, there has been no long term maintenance plan and many are failing. Communications, attitudes of users and organizations, and funding sources and requirements were researched through interviews with users, government officials, private companies, and experts. We have proposed both short and long term recommendations and developed a prototype web application to improve the overall lifetime of these systems.

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Executive Summary

Every day millions of people in the developed world depend on a reliable source of electricity. Recently, the Thai government donated approximately 200,000 solar home systems (SHS) to rural villages throughout Thailand. The recipients of these systems were households that could not be connected to the grid due to the high cost of connection or their location in nationally protected land. In this project, we assessed the current status of the SHS program in rural Thailand and developed a long term strategy to promote its ongoing sustainability.

Funded by the Ministry of Interior (MOI), the Provincial Electricity Authority (PEA) contracted with private companies to provide and install the SHS beginning in 2004. Within one year after the systems were installed, some of the SHS were found to be malfunctioning. An initial survey by the Border Green Energy Team (BGET) indicated that roughly 23% of the systems were malfunctioning in Tak Province. To remedy the situation, in the Tak Province BGET instituted the use of special forms to claim warranties, as well as classes to train villagers on how to maintain their systems. While these efforts appear to be helping, the sustainability, or long term functionality, of the SHS program was still in peril, due, in part, to the fact that warranties on the systems are now expiring.

There are multiple interlinked parties directly involved with the SHS program, including the government, private companies, and individuals. The communication between some of these parties to share information about the status and repair of SHS, is slow, unreliable, or nonexistent. This communication network has begun to change since the PEA has started transferring ownership of the SHS to the local governments, or tambons, thus increasing communication difficulties (Lynch, Greacen, Tavaranan, & Bjarnegard, 2006).

In order to assess the current status of the SHS program in rural Thailand and develop a long term strategy to promote the sustainability of the systems, we researched the existing communication network designed to maintain the systems, the attitudes of individuals and organizations involved in keeping the SHS functional, and possible avenues for funding sustainability. We organized our research using the following three research questions:

- *What are the weakest existing connections in the communication network and how can they be improved?*
- *How do individual and organizational attitudes affect the sustainability of solar home systems?*
- *How can improvements in solar home system sustainability be funded?*

Our research proceeded through two stages. In the first stage we conducted interviews with the various parties involved with the SHS program. Through the information acquired from these interviews, we identified the weakest communication links, the attitudes of parties involved, as well as possible funding sources. In the second stage we developed and refined short and long term recommendations with the input of experts in the field of SHS, as well as identified future areas of research. Combined, these recommendations formed a strategy for the sustainability of the SHS in rural Thailand.

The key parties that we interviewed were identified by various experts in SHS within Thailand. We conducted semi-structured interviews with representatives from two tambons, the Department of Local Administration (DLA), the PEA, as well as the SHS installation companies Acumen and Solartron. In addition, we interviewed a sample of villagers from two villages in both the Tak and Chiang Mai provinces, who fell into three categories:

- Users with SHS that had never failed (2 villagers from Tak, 3 from Chiang Mai)
- Users with SHS that had failed (5 villagers from Tak, 6 from Chiang Mai)
- Users with SHS that had been repaired (2 villagers from Tak)

From information provided by the PEA, we identified the existing communication network amoung the villagers, the tambons, the DLA, PEA, and the installation companies. Based on the data collected from the interviews we were able to draw conclusions as to the optimal communications pathways necessary to facilitate maintenance. The attitudes of each party towards the SHS program were also explored, as the attitudes of individuals and organizations affect their actions.

In order to identify funding options for SHS sustainability we first had to determine the types available for SHS programs. The funds that were needed to finance our recommendations, and consider any requirements to receive the funding. To accomplish this we examined different institutional models for solar programs around the world, such as fee-for-service, credit, government and NGO subsidization, as well as the possibility of using carbon-offset funding..

Through our research, fourteen findings emerged. Looking at the communication network, we found that information on system maintenance and warranties was not being consistently distributed among villagers. In addition, the tambons have not been consistently trained and informed about how to mangage the SHS program. Due to this inconsistency, the standard procedure for following warranty requests has not always been followed by the tambons. Finally, we found that information distribution concerning SHS at the government level could be facilitated by use of computers and the Internet.

Regarding the attitudes of the parties involved with the SHS program, it was found that villagers would like their SHS to work, but did not urgently pursue repairs when their systems broke. Another finding was that the villagers' opinion of the importance of personal responsibility for SHS maintenance and operation affects their willingness to subsidize eachother. At the tambons, we found that they have many responsibilities among which the SHS

are not their highest priority. In the national government, we found that the Department of Local Administration wants to provide general recommendations but will not be directly involved with the SHS program. Our final finding regarding attitudes was that the PEA's primarily concern was with the installation of the SHS, since it plans on withdrawing from the program once installations and trainings are completed.

In our research into possible sources of funding, we found that villagers have limited resources for purchasing equipment and providing long term funding for the systems. A further finding was that the national government, specifically the Ministry of the Interior (MOI), was a possible source of funding for SHS sustainability. Finally, we found that carbon offsets are not viable as the sole source of funding for SHS sustainability.

From these findings we developed several overarching themes. First, the implementation of the SHS program did not plan for sustainability. Second, understanding and practice of procedures for communication vary within parties involved with the SHS. Third, higher level government agencies' perceptions of the SHS program are not always consistent with the actual situation. Fourth, there are individuals in different parties who are actively interested in SHS sustainability. Fifth, installation companies are not responsible for the sustainability of the SHS. Finally, we saw that BGET's efforts had made a difference for the SHS in the Tak Province .

Based on these findings and themes we developed three sets of recommendations to further improve upon the sustainability of the SHS in Thailand. The first set of recommendations focuses on the immediate future and should be implemented as soon as possible. The second set of recommendations is focused on the long term sustainability of the SHS. The final set of recommendations provides direction for future research. Together, these recommendations form a long term strategy for the sustainability of the SHS.

Our first short term recommendation is that the national government should hold additional training sessions for the tambons. Since we found that tambons have not been consistently trained regarding SHS management. We recommend that additional training sessions occur in order to redistribute information pertaining to warranty claim procedures.

Our second short term recommendation is that tambons should contact villagers again to notify them about their warranty rights and how to file a claim. This information should be sent to the village tambon representatives to personally inform the villagers. Renotifying users in this manner will give them the opportunity to clarify any misunderstandings the may have about the systems or the pending expiration of the warranties.

Our first long term recommendation is for the tambons, installation companies, and higher levels of government to utilize a centralized web application to submit warranty requests and schedule repairs. This would provide improved communications and record keeping between the tambons and installation companies as well as increasing solar company accountability by allowing oversight by higher levels of government. We designed a prototype web application to allow for testing within Tak Province, which, if successful, could be implemented throughout the rest of Thailand.

Our second long term recommendation is that a long term maintenance program be initiated, funded by the villagers and the MOI. We recommend that tambons organize a monthly fee for each SHS, subsidized by the MOI, to pay for a designated village technician in every village and cover the cost of replacement parts. This recommendation is aimed at improving the long term functionality of the SHS by providing ongoing funding and maintenance of the systems at the village level.

The implementation of these long term recommendations should be tested with a pilot program. We recommend this pilot program is located in the Tak Province, overseen by BGET, and financed by carbon offset funding. This pilot program would test the web application and maintenance program on a small scale and serve as a model for the tambons in the rest of the country. Details, such as the amount and flexibility of payment collection, would be evaluated throughout the pilot. After completion and evaluation of the pilot program, the reccomendations should be implemented nationwide.

We also provide two recommendations for future research in SHS sustainability. These include a comprehensive survey of all the SHS in Thailand and the possibility of training refugees to provide SHS maintenance as part of a micro-enterprise.

In conclusion, we investigated the problem of threatened sustainability of Thailand's SHS program. We have seen what can occur when people do not consider the future management of technology and have provided recommendations for utilizing the technological and human resources currently available to resolve the issues at hand. Our final strategy took common practices in other SHS programs around the world and applied them to the specific situation in Thailand. We hope that this work will encourage future studies into the SHS program in Thailand, and that, when implemented, these recommendations will ensure that Thailand's SHS function as intended for many years to come.

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Chapter 1: Introduction

Every day millions of people in the developed world depend on a reliable source of electricity. A stable electric grid powers everything from our lights and refrigerators to our cell phones and computers. However, in rural areas of developing countries, reliable energy is not always available for basic necessities. In remote areas where extending the grid would be prohibitively expensive, small scale solar energy systems (SHS) are one option for providing electricity. Across the developing world solar home systems are used to provide basic lighting needs to villagers that previously had no regular access to electricity (F.D.J. Nieuwenhout et al., 2000). Not only can solar energy provide lighting, but it can also power simple communication devices and provide the energy for basic tasks, such as boiling water for sanitation (Luque, Hegedus, & Knovel, 2003).

Thailand is attempting to improve rural electrification. While 99% of the people in Thailand have access to the grid, approximately three hundred thousand homes in Thailand are not connected and must rely on alternative sources of energy. Since 2004, Thailand has funded the installation of nearly 200,000 SHS in rural villages. However, problems emerged with the initial installations. For example, surveys of systems in the Tak Province of Thailand indicated that approximately 23% of the SHS have failed (Lynch et al., 2006). In response to these failures, the Border Green Energy Team (BGET) has focused their attention on efforts to improve the sustainability of the SHS. Improving sustainability, or long-term functionality, of these systems will extend their useful lifetime, providing these villagers with a clean and economical source of lighting for many years to come.

Especially in large, government funded, SHS deployments around the world, several key issues have been identified that can undermine sustainability of the systems. In programs where

systems are donated to the users, initial training and ongoing maintenance are especially important (F.D.J. Nieuwenhout et al., 2000). In addition, BGET has found that communication between villagers, regional Thai governments, and solar technology companies regarding warranties, maintenance, and system status is often unreliable and inefficient. For example, villagers were not initially informed of the warranties on the systems, and the status of these systems and repairs were not monitored. In response to these problems, BGET developed a program to train a comparatively small number of villagers in SHS maintenance and to distribute surveys to collect data on the systems. However, these technicians are only able to repair minor problems with the systems (Lynch et al., 2006 p. 5) . BGET's efforts helped, but a strategy for long term maintenance and funding was needed.

While BGET wanted to further improve the sustainability of the SHS, they were unsure how to proceed. They desired improved communication regarding the SHS, such as current status, warranty requests, and maintenance instructions between the villages, regional tambon governments, the Provincial Electricity Authority (PEA), and the installation companies. In addition, the perceptions and attitudes of villagers and government officials towards the program were unclear. Without a clear understanding of these attitudes our recommendations could not take into account cultural or organizational limitations. In addition, to ensure long term sustainability it was necessary to find funding for replacement parts and ongoing maintenance after the warranties expired. However, it was unknown if any funding would be available to implement changes, or what the requirements were to secure financing.

Our project aimed to develop a strategy to enhance the sustainability of SHS in rural Thailand by improving the exchange of information between the major parties involved with the installation, use and maintenance of the SHS, exploring the attitudes of those parties, and

evaluating various funding options. In order to accomplish this we investigated the existing communications methods and designed improvements to enable convenient and accurate distribution of information regarding repair requests, system status, and maintenance information. In addition, we explored the attitudes of the parties involved in order to determine their effect on the ongoing sustainability of the SHS. Finally, we researched which funding options would ensure timely maintenance of the systems. This included researching various financing avenues, including carbon-offset companies, government agencies, and the villagers themselves, to fund our recommendations. This project provides recommendations to improve the sustainability of the SHS, helping to provide a reliable energy source for rural Thai villagers.

Chapter 2: Background

Assessing the current situation and developing an understanding of how to improve the sustainability of solar home systems (SHS) in Thailand requires examination of a number of different issues. In order to understand the problem of failing sustainability, we examined the history of solar home technology around the world and in Thailand. In addition, we explored the technical, cultural, and financial issues that influence the sustainability of SHS. Understanding the history of SHS and common issues surrounding their deployment worldwide underpins the development of a comprehensive strategy. By applying the principles from best practices and addressing the most pressing issues, we can create a strategy to ensure the long term sustainability of the SHS in Thailand.

2.1 Solar Home Systems

Approximately two billion people across the globe, mostly in developing nations, are still without access to electricity (Luque et al., 2003 p.1044). SHS are a popular option for the electrification of remote towns or villages where grid electrification is not feasible. These systems are stand-alone photovoltaic panels that can be manufactured in various sizes to produce the needed amount of electricity with minimal maintenance and a long working lifetime. These systems help raise the quality of life of the users by satisfying some of their basic needs including light, communications devices, and heating water for sanitization (Luque et al., 2003 p.1048).

2.1.1 Institutional Models for Sustainability

As of the year 2000, approximately 1.3 million SHS had been installed across the developing world. From Latin America, to Africa, South Asia and even some Pacific Islands,

these deployments generally follow one of four institutional models: cash sales, credit, fee-for-service, or donations (F.D.J. Nieuwenhout et al., 2000). Each model requires different levels of funding and commitment from the local or national government, non-governmental organizations (NGO), private companies, and the users.

In the *cash sales* model, the users purchase the SHS from a dealer and are responsible for maintaining their own systems. The main advantage to this is the ease of financing the low transaction costs, and the absence of financial risk for the supplier (F.D.J. Nieuwenhout et al., 2000 p. 25). While this model has been implemented in countries such as Kenya and Mexico, studies have shown problems that have occurred with this model. Due to the lack of aid by the government or NGO, sales of SHS are limited to groups that can afford the systems. Thus poorer groups are often forced to purchase smaller or lower quality systems and replacement parts (F.D.J. Nieuwenhout et al., 2000)..

In the *credit* model, the user receives a loan in order to purchase all or a part of a SHS system. An advantage to this model is that users pay the least amount of money and can spread the payment out over time. This model also puts the responsibility of maintaining the systems in the hands of a financing institution (F.D.J. Nieuwenhout et al., 2000 p. 25). It has been found that this model better benefits groups with a regular income. One example of the credit model is the program implemented in Indonesia, where the dealers receive a portion of the cost of a system from an NGO, and are required to offer credit to the villagers (Martinot, Cabraal, & Mathur, 2003).

In the *fee-for-service* model, an electricity utility or private company installs the SHS and then charges a monthly fee for their use; this allows the user to spread out the cost of the system over a longer period of time, up to 10 years. This model has been successfully used in the

Kingdom of Kiribati, where SEC, a private company, provides the systems and maintains them for a fixed monthly fee. This scheme has also been used in Namibia and Swaziland, but studies there have shown that upwards of 90% of users prefer a credit model so that they will own the system outright after some period of time (F.D.J. Nieuwenhout et al., 2000 p. 7).

The final common institutional model, which was employed in Thailand, is the *donation* model. In this model, a government or charitable organization pays for the initial capital cost of the systems and their installation, but the users are generally responsible for their ongoing maintenance. While these programs have the advantages of economies of scale and equal distribution of the systems, they have disadvantages of suffering from a lack of user involvement due to the fact the receivers of the system do not feel ownership, and plans for long term maintenance are necessary. In addition, ample user education is necessary to ensure the sustainability, or functionality over a long period of time, of the systems, no matter which model is used. These models have been used with varying success around the world with the second largest program, behind Thailand, in Mexico (F.D.J. Nieuwenhout et al., 2000 p. 6).

It has been found that when SHS are donated, such as in the donation model, to their users they tend to feel a lack of ownership. Implementing a payment plan, such as in the fee-for-service model, has been found to directly increase user satisfaction and acceptance of the system, and the users' willingness to pay is directly correlated with how important the system is to the user. The feeling of ownership from having a payment plan increases villagers' willingness to keep the SHS working smoothly. In addition, having repercussions for nonpayment has been found to keep up user payment and maintain user satisfaction for the system (F.D.J. Nieuwenhout et al., 2000 p. 60).

2.1.2 The Technology of Rural Solar Home Systems

The SHS provided by the Thai government each consist of one photovoltaic panel, an inverter/charge controller, a 12-volt battery, and two AC fluorescent lights. These systems provide double the average output of common SHS, with sufficient energy to power two 10-watt light bulbs and a television for a few hours a day (Lynch et al., 2006 p.7). Figure 1 shows a picture of a standard SHS in Thailand.

Solar panels are photovoltaic (PV) cells that produce a direct current (DC) from the radiant energy of the sun that reaches the panel. An electrical field is created when the semiconductors located within the panels are activated by solar radiation (Luque et al., 2003 p.3). These panels are wired in series or in parallel to form an array to produce a higher or desired voltage across the circuit. This allows the electricity's voltage to be of a nature that is most usable for specific applications. (Florida Solar Energy Center, 2006).

Batteries are often coupled with PV systems to serve as storage devices. They store energy produced during the day and release it as needed, such as during nighttime or overcast weather. Batteries also serve to power the array, so that it functions at a stable voltage, since the amount of solar radiation being absorbed by the array varies throughout the day (Florida Solar Energy Center, 2006).

Figure 1 - Solar Home System PV Component and BGET Technicians

There are many general advantages to using photovoltaics to generate electricity. The sun is a practically infinite source of energy, which produces no extra emissions that contribute to global warming or pollution. SHS have few moving parts; so the operator does not have to deal with significant deteriorations due to mechanical wear on the SHS. In addition, the solar panels provide the user with a low operational energy cost, since no fuel is needed, installation is quick and easy, and the panels can be integrated into virtually any existing building (Luque et al., 2003 p.3). SHS do sometimes suffer from part failure such as the charge/inverter control units, ballast/lamp units, and overall system failure (Lynch et al., 2006). The most common problems are with the inverter/charge controller unit and the batteries, the least common problem being the photovoltaic cells (F.D.J. Nieuwenhout et al., 2000).

2.1.3 Solar Technology in Thailand

Photovoltaic technology was implemented in Thailand soon after it became available. In the 1970's the country began drawing up plans to extend electrification throughout the country,

including remote villages, to provide "basic needs" to every Thai citizen (Tuntivate & Barnes, 1997). In 1973 the Thai government approved the proposals, which were economically backed by USAID, to "accelerate rural electrification" and provide power for all villages within the following twenty-five years (Green, 2004/4). This plan was geared towards installing SHS in the "more economically backward and politically unstable regions" of Thailand (Tuntivate & Barnes, 1997). Many different organizations took a special interest in this program. The Medical Volunteers Foundation and the Ministry of Public Health first introduced solar panels to remote villages in 1976 for the purpose of powering medical equipment (Green, 2004/4). In 1992 Thailand passed the Energy Conservation Promotion Act (ECON Act), which outlined the long term focus for energy conservation programs in Thailand, including the implementation of solar energy throughout the country (Energy Policy and Planning Office, 2006). Other agencies such as the Telephone Organization of Thailand, the Ministry of Education, and the Energy Generating Authority of Thailand soon followed suit by installing their own remote solar panels (Green, 2004/4).

The Thai Constitutional Declaration of 1997 required Thailand to have 100% electrification. By 2002 the Provincial Electricity Authority (PEA) had provided grid electricity to 99% of the country (Thanarak, 2006). In 2004 the Thai government started a program aimed at electrifying additional rural areas that are inaccessible to the grid. The Ministry of Interior (MOI) financed the distribution of SHS to approximately two hundred thousand households in rural Thailand, occurring in two phases over two years. The PEA was responsible for contracting with various private companies for the installation of SHS across Thailand. Approximately half of these systems are located in northwestern Thailand. Many of these are in nationally protected forests and along the Thailand-Burma border, shown in Figure 2 below.

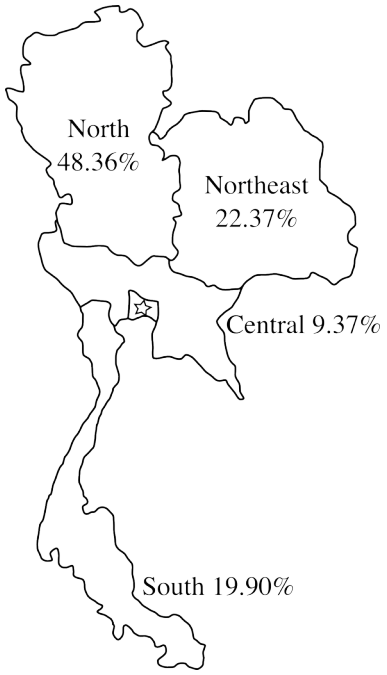

Figure 2 - Percentage of Solar Home Systems installed by region

Adapted from: (BGET, 2006)

Each household that was not connected to the grid was eligible for a free SHS owned by the MOI. Multiple companies manufactured the components and installed the systems, including Solartron and Acumen, with Solartron distributing the majority of the SHS. They built approximately three-fourths of the PV panels, while the remaining fourth were distributed by Bangkok Solar Public Company Limited. More recently, ownership of the SHS has been transferred to the local sub-district governments, or tambons, who oversee multiple villages (Lynch et al., 2006).

2.2 Threats to the long term sustainability of solar home systems in Thailand

In addition to understanding the historical context for these SHS, it was important to explore the current issues surrounding the systems. Working in conjunction with our sponsor the Border Green Energy Team (BGET), we identified several common areas where the

sustainability of the systems is threatened. As an organization BGET has several goals. The overlying theme is to promote the use of renewable energy in rural villages along the border of Thailand and Burma (Lynch et al., 2006 p.2). The main issues that have been identified are that these systems are not consistently being repaired and there were no long term, post warranty plan in place.

2.2.1 Breakdown in Maintenance

When the Thai government distributed the SHS to rural villages, they intended to bring electricity to those homes not connected to the grid. Unfortunately, a year after installations began, surveys conducted by BGET found that 22.5% of the SHS in two districts within the Tak Province had at least one component that had failed.

BGET has identified several widespread reasons for SHS. Types of failures include manufacturing defects, installation errors, and user errors (Lynch et al., 2006). Improper installation can cause failures later on as well. One such bad practice is setting up the charge controller and inverter device so that it is exposed to the weather and becomes compromised over time. In addition, a common source of user error is rewiring, which causes a reverse polarity that destroys components (Lynch et al., 2006 p. 7-15). Since the failure rate is so high, BGET has attempted to remedy the situation by training technicians for long-term maintenance. Maintaining the SHS properly helps to minimize the number of failures. Table 1 quantifies the types of failures. From the data, technicians can see trends within the malfunctioning systems and predict which aspect of the system has most likely failed, saving them time.

Table 1 - BGET Failure Survey Data

(Lynch et al., 2006 p.7:)

Broken Component	Total No. of System	No. of broken system by measurement	%	No. of broken system by measurement and observation	%
Solar Panel	405	3	0.7%	3	0.7%
Battery	405	6	1.5%	24	5.9%
Charge Controller / Inverter	405	39	9.6%	41	10.1%
Ballast / Lamp	405	35	8.6%	39	9.6%
Overall System Failure	**405**	**74**	**18.3%**	**91**	**22.5%**

Note: The overall system failure rate is not the sum of individual failure rates as multiple components can fail per system.

As seen in Table 1, the most common failures are in the charge controller and inverter unit, while the light and ballast are the second most frequent to fail. Failure of inverter/charge controller unit is likely due primarily to inverter failures as these are generally the first components to fail in SHS around the world (Herbert Wade, personal communication, 2007).

Warranties are provided for each component of the SHS. Each component is guaranteed for two to five years. Villagers are responsible for contacting their local government in order to file any warranty or repair claims. However, most villages are not informed of the applicable warranties, and therefore have not taken advantage of it. (Lynch et al., 2006). In addition, in the case of the Tak Province, the installation company, Solartron, Ltd., is required to make a checkup after eighteen months after installation. However, it is not clear that these checkups have been performed (Lynch et al., 2006 p.4-5).

2.2.2 Breakdown in Communications

A crucial part of a long term functionality schema is to have a reliable communication network to communicate when systems are malfunctioning and warranties are being claimed.

However, the implimentation of Thailand's ambitious rural electrification program did not include a standard for communications between the parties involved for the long term sustainability of the SHS. The PEA, who implemented the SHS program, intended the warranty information program to be supported by a communication network that had several stages of communication. Figure 3 shows these stages.

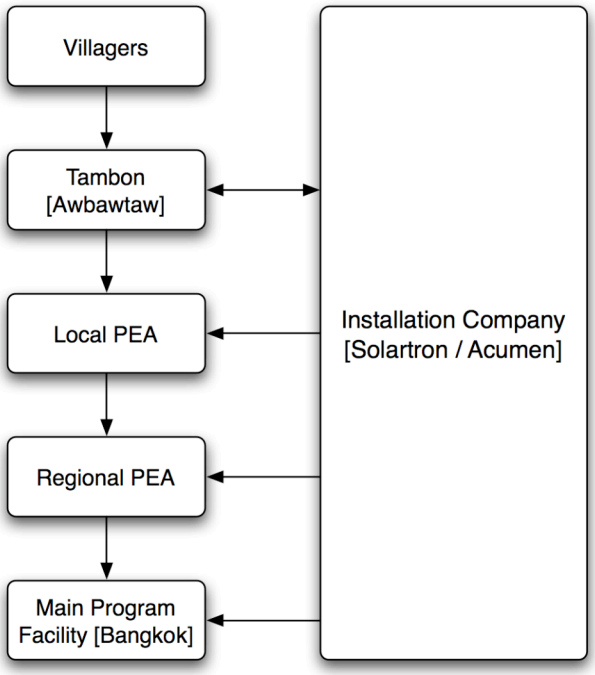

Figure 3 - PEA Warranty Diagram (Adapted from PEA SHS Manual)

In the event of SHS failure, the villagers were to contact the tambon representative in the village, who should contact the local tambon office. The tambon, after receiving word of a failure, should contact the installation company, who should then send out technicians to the site of the failure. In addition, records would be passed along to the different levels of PEA and eventually to the main program facility in Bangkok.

A lack of communication between end users and the various parties involved has resulted in a breakdown of the information flow, which might be the reason these systems are not being serviced. The lack of reliability in the communications network results in few warranty replacements, little maintenance, and a lack of governmental or NGO knowledge of their status. Each of these critical links and their reliability and efficiency must be addressed in order to improve the sustainability of the SHS.

2.2.3 Cultural Considerations

In addition to system malfunctions and communications failure faced by the SHS program, the influence of the users' cultural values and how they deal with situations may have an effect on getting their systems fixed. In Thai culture, it is a matter of respect to defer to ones superiors in order to avoid conflict. It is a possibility that the villagers are not taking any steps to fix their systems due to the fact they do not want to cause conflict. Corbett and Thanasankit have come to a conclusion regarding Thai conflict avoidance:

> *Thais try to avoid conflict and criticism at all times because of the face saving value. ... Therefore, whenever there is a problem to be solved, Thais would find softer approaches or tone down the negative messages used, avoiding confrontation in public, such as during meetings.*(Haynes, 2002)

Another cultural issue that might influence the sustainability of the SHS is the effect of rural electrification on the culture of the remote villages in which they are installed. Donna Green, from the University of California Berkeley, identified the problem of cultural dilution, the loss of culture, in her analysis of the solar battery charging program in northern Thailand (Green, 2004/4). While the cause-effect relationship is fairly complex, she argues that the introduction of electricity to schools and teachers housing encourages Thai teachers to work longer in the

village. Subsequently, children of remote tribal villages learn the Thai language and are better assimilated into Thai culture. This, she says, "sometimes created tensions in ethnic minority villages," in which, "the younger generation frequently tended to reject their ethnic identity as primitive or backward" (Green, 2004/4). This tension can cause blame to be directed at the SHS, which leads to failures in the systems through lack of maintenance. However, previous Worcester Polytechnic Interactive Qualifying Projects (IQP's) dealing with rural electrification in Thailand indicate that, for the most part, villagers welcome these systems. In fact, one IQP, dealing with cultural awareness coupled with solar technology, indicated that the systems had been successfully used to enhance cultural awareness and communication between the older and newer generations (Treat, Morel, Mar, Crafford, & Weininger, 2004). While interviewing a Lahu tribe member, who was the head of the cultural center, slated to be electrified, they learned that:

> *the solar technology that we would install would not be a detriment to their way of life because it does not affect what is essential to their culture … The conflict is not between Lahu culture and modernization but rather stems from a lack of cultural continuity amid the generations* (Treat et al., 2004 p.32).

It is important to be aware of cultural tensions that may be present in villages with these newly installed SHS. While this project does not seek to resolve these issues, it may be advantageous to gauge the villagers' feelings surrounding the SHS in order to learn the amount to which the systems are accepted. Knowing the attitudes of villages towards the SHS will allow for improved sustainability.

The attitudes of the organizations, government agencies, NGOs, and private companies, involved also play a role in the success of the program. The companies and local governments involved can implement policies and services to increase user satisfaction and acceptance of the SHS. For example training, retraining and education about the usage of their systems can help

booster acceptance and proper care of the systems among users. (F.D.J. Nieuwenhout et al., 2000 p. 30,90).

2.2.4 Investigating Funding

As seen from previous rural electrification programs, if the users themselves cannot provide the cost of the systems and maintenance, funding is required in order to successfully complete the program. If funding is not available then sustainability is harder to achieve. Outside of the villagers or the Thai government, possible sources of funding include the Thai government and international groups interested in supporting energy programs in developing countries, as well as carbon offset companies. Each option has strengths and weaknesses.

There are non-profit groups around the world that have an interest in the funding and support of renewable energy. Two of these groups are the World Bank and the Global Environment Facility, which have jointly funded SHS projects in the past (Martinot et al., 2003). The World Bank provides grants to poor developing nations to fund renewable energy projects, although the per capita income must be lower than Thailand's current per capita income (World Bank Group). The other option is to receive a low to no interest loan, which can be given to support policy reform and to support "economic and social development projects" (World Bank Group, 2006). The Global Environment Facility (GEF) provides funding for environmentally concerned projects in developing countries. Not only does GEF support renewable energy projects by establishing the mechanisms to reduce the cost of the renewable energy, but they also guide policy creation and help distribute information. Each supported project type has its own requirements for duration and environmental impact (Global Environment Facility, 2006). While the World Bank and GEF are viable options for many solar related projects, they might not be

appropriate for projects that are looking to implement changes in the near future, since the process for a funding request to be approved takes years (Wade, personal communication, 2007).

In addition to NGOs, a carbon-offset organization could provide funding. A carbon offset is used to quantify actions that remove, lessen, or avoid the effects of carbon dioxide equivalents on the environment. Practically, one carbon offset is equivalent to one ton of carbon dioxide or other greenhouse gas that would have been otherwise produced or allowed to exist if action had not been taken. By purchasing a carbon offset, an individual, company, or government in effect neutralizes their emitted ton of carbon dioxide equivalents. Of the two types of carbon trading available, project-based and allowance based transactions, project based transactions are of most interest to this research (Taiyab, 2006).

One way to obtain funding is through the Clean Development Mechanism (CDM). The CDM was founded to allow countries to contribute to carbon emissions reduction activities in order to meet the 1997 Kyoto Protocol. Contributing to projects within the CDM allows the countries bound by the protocol to receive credits towards their total released carbon emissions targets (*Clean development mechanism, 2006*). While the CDM does enable funding for renewable energy projects, it should be noted that most of the projects undertaken are large projects done in stable developing countries, requiring low capital and providing a high return. The CDM does encourage smaller projects, but the cost of fees and amount of imposed regulations limits their implementation (Taiyab, 2006).

Another way to obtain carbon offset funding is through carbon offset companies based around the world, and their projects take place in many different developing countries. There are two types of carbon-offset companies: for profit and non-profit companies. Both types

companies receive their money from individuals and companies who wish to offset their carbon emissions. Most companies finance a portfolio of energy projects, which includes renewable energy, reforestation, and energy efficiency projects.

In order for a carbon offset company to sponsor a project, it must meet their requirements. While the criteria that individual organizations place upon their supported carbon offset projects differ between organizations, there are requirements common to many of these companies. These requirements are characterized in the Gold Standard for Voluntary Emissions Reduction. The Gold Standard is an independent "best practice benchmark for emission reductions projects" (Ecofys, 2006), which provides credibility to projects and the carbon credits they generate. Projects must have a low environmental impact, avoid unnecessarily high costs, have procedures that can be handled by all parties involved, and abide by global standards (Ecofys, 2006).

Two important requirements seen in every supported project are *emissions* and *investment additionality*. Emissions additionality, requires that fewer emissions are produced as a result of the project than what would normally occur (Ecofys, 2006). Emissions additionality is measured against the baseline emissions, which are the emissions that would accumulate if no extra action were taken. Leakage, the amount of activities caused by the carbon offset project itself that reduce its effectiveness, is then subtracted to calculate the final emissions additionality. For example, if a project reduces emissions in one area but increases the need for diesel fuel in another area, the project would have a great amount of leakage. (Climate Trust, 2005). In addition to emissions additionality, investment additionality must be demonstrated. A project must demonstrate that it would not have occurred without the funding provided in order to be considered a carbon offset project. (Taiyab, 2006). In demonstrating emissions and investment

additionality, there must be verification that the stated carbon emission reductions are taking place. Some companies use an outside agency to carry out the verification, while others carry it out themselves. While the reduction of carbon emissions is a large concern, projects cannot cause harm to other aspects of life in the process. Projects must further sustainable development by not negatively affecting the environment while promoting social and economic development (Ecofys, 2006). It is important that any proposal submitted to a carbon-offset company clearly outlines its fulfillment of any requirements the company has specified.

There are many possible options for the funding of the SHS programs, including international aid organizations, and carbon offset companies. Before a decision can be made about which sources would be best, a full understanding of the requirements of each option must be understood. The best options will be found when all options are compared to the needs and long term desires of all parties involved.

2.3 Conclusion

The fundamental problem that this project seeks to address is the lack of SHS sustainability in rural parts of Thailand. The Border Green Energy Team believes that a large component of this problem is the lack of accurate communication between the SHS owners and those responsible for the warranties and maintenance of the SHS. In addition, there is no clear plan for funding repairs of the systems after the warranties run out. Thus far, BGET has attempted to deal with these problems through villager education and maintenance training.

SHS provide valuable energy for people living in remote locations in developing nations, increasing the standard of living for these rural peoples. Residents who have received these systems now have access to a renewable energy source, allowing them to power devices to provide for basic needs such as light, or even radios and televisions. Developing an electronic

efficient and reliable communication methods and funding strategies which will keep these systems running will benefit the villagers in many ways.

Chapter 3: Methodology

We developed a strategy for long term sustainability of solar home systems (SHS) by researching the current procedures, organizational and individual views, and available resources to maintain the systems. While there already have been efforts to provide for the long term sustainability of the SHS, the best method for communicating between all parties and the resources for funding the long term sustainability are still unknown. In order to gain the knowledge necessary to develop our strategy, we organized our research around the following three research questions:

- *What are the weakest existing communication links and how can they be improved?*
- *How do individual and organizational attitudes affect the sustainability of solar home systems?*
- *How can improvements in solar home system sustainability be funded?*

This research enabled us to provide recommendations for increasing the sustainability of SHS. Shown in Figure 4, our research proceeded through two stages.

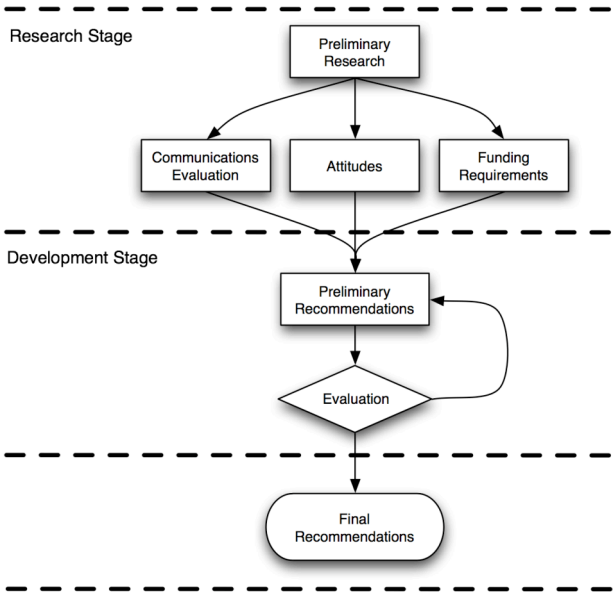

Figure 4 - Solar Sustainability Research Flow

First, in the research stage we collected information on the issues that needed to be resolved in order for the SHS program to be sustainable. In this stage we conducted interviews with parties identified through other interviews and in our background research. These interviews were centered around our three research questions. In the next stage, we developed recommendations that incorporated the information gained in the previous stage. These recommendations were reviewed by experts and parties involved with the SHS. The final product was a strategy for the sustainability of the SHS, comprised of both long term and short term recommendations.

3.1 Research Considerations

In order to be able to generalize beyond the specific villages and tambons that were a part of this research, it was important to select research methods that would provide the most validity while remaining within our limited time and budget. Ideally, a stratified sample of rural villages throughout Thailand would have been chosen, and a certain number of SHS users in each village would have been interviewed. Since we were limited by the cost of transportation and translators, the actual research was conducted in four villages in the Tak and Chiang Mai Provinces.

In the Tak Province, our research was assisted by members of BGET in Karen villages boarding Burma. The Tak province is one of the northern provinces in Thailand and is home to 25% of Thailand's hill tribes, including the largest population of Karen People. (Thailand Tourism, 2006b). Further information was gathered in villages in the Chiang Mai province with PV specialist Bruce Countryman. This province is located in the northwest and is the second largest province in Thailand. Approximately 14% of the population of Chiang Mai province is made up of hill tribes. (Thailand Tourism, 2006a)

To improve upon basic convenience sampling in the villages, we used 'quota' sampling techniques (Singleton & Straits, 2005). We determined three categories:

1. Users with systems that had never failed.
2. Users with systems that had failed.
3. Users with systems that had been repaired.

As seen in Table 2, in the Tak province, four villagers were interviewed from *Goudatah* and five in *Khun Huay Mae Thaw*. In each village we were able to select people for each category to ask a standard set of question prompts. In the Chiang Mai province, two villagers from *Hoi Som Poi 1* and seven from *Hoi Som Poi 2* were interviewed using the same standard set of question prompts. In addition, we interviewed a tambon representative, who is an elected villager, but with a different set of questions. In Chiang Mai, we did not interview any villagers in category three, as, according to our translator, there were no SHS in *Hoi Som Poi 1* and *2* that had been repaired.

Table 2 - Villagers Interviewed in Tak and Chiang Mai Provinces

Province	Village	1	2	3	Other
Tak	*Goudatah*	1	2	1	0
	Khun Huay Mae Thaw	1	3	1	
Chiang Mai	*Hoi Som Poi 1*	1	1	0	1
	Hoi Som Poi 2	2	5	0	

For each of these categories, villagers were chosen using convenience sampling. As Knight notes, these convenience samples pose "a problem for researchers who want to generalize from the sample to the population" (Knight, 2002 p. 123). Due to this, we analyzed our representative data alongside information from experts, governmental, and non-governmental organizations in order to develop recommendations that could be applied to the entire country.

We used semi-structured interviews with all of the parties involved in order to allow additional ideas to become apparent during the interviews. Making questions too specific would have limited our ability to identify themes that have "not been anticipated or considered" (Knight, 2002 p. 63). This helped prevent any preconceived theories from influencing the data collected. After each interview, we identified new ideas that had been presented, and modified our questions for following interviews to address these ideas. The questions we asked also took into account cultural differences, such as the tendency to avoid confrontation, which might affect the information that people would say. We did this through asking more open-ended questions, and then following up with specific questions to clarify answers.

We took steps to ensure the villager's confidentiality, since some of the questions that we asked the villagers dealt with their actions regarding the SHS, which may affect the warranties. Letters were assigned to each user to distinguish between the villager interviews. For villagers who were not in leadership positions in the village, no personally identifiable information was recorded.

Due to the limited number of locations in which we were able to conduct interviews, it is possible that our findings may be biased or skewed. This is because villages that are easily accessible, which we were able to get to, may have a different success rate with their SHS than villages that are very difficult to access. The language barrier is another factor that may have affected our data collection. In Tak Province two translators had to be used: Karen to Thai and Thai to English. In the Chiang Mai Province our translator was able to translate from Karen and Thai to English, but his English vocabulary was limited. This meant that the answers we collected were more paraphrased than literal translations of the actual responses. In addition, our

emails to the solar installation companies were translated by unknown third parties, making the accuracy of the translations unknown.

While there were limitations to the sample size and translation precision of our research, we strove to maintain a systematic approach. Even so, it is possible that subtle themes that our research was unable discover. Therefore, the results of our research should be used as starting point for future research regarding the SHS. In addition, while our recommendations are most suited for the villages that we visited, the general ideas are applicable for the SHS program as a whole.

3.2 Research Stage

The first stage in our methodology was the research stage. Using the information we collected in our background research, we identified the parties involved with the SHS and conducted interviews that focused on our three research questions. In the following sections we elaborate on the communication, attitude, and funding research questions and our methods of collecting and analyzing the data.

3.2.1 Evaluating and Improving Communication Links

Ensuring long term sustainability of a program requires reliable and efficient communications methods. Evaluating the current communications between all parties enabled us to identify any links causing a breakdown in the network of communication.

Communication can be defined as "the transmission of information, ideas, emotions, and skills, by use of symbols – words, pictures, figures, graphs, etc. It is the act or process of transmission that is called communication" (Blake & Haroldsen, 1975 p. 22). In our research, we used the sender-receiver model of communication to illustrate the communication between all of

the parties involved with the SHS. Shown in Figure 5, below, in this model there are four parts to every instance of communication: sender, receiver, message, and channel.

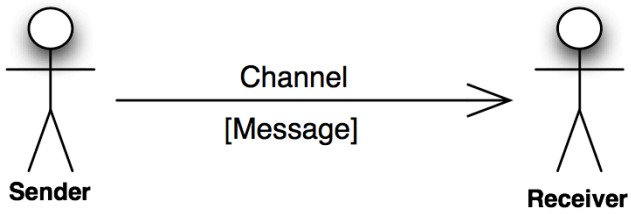

Figure 5 - Sender-Receiver Model of Communication

In this model, the sender is the source of the message, while the receiver is the destination. The message is the information that is being transferred between the sender and receiver, and it travels through the channel, or medium, of communication. A channel has multiple dimensions, including channel credibility, feedback, availability, permanency, multiplicative power, and ability to compliment other channels. Multiple sender-receiver links can be formed together to create a communication network, which is a "system for dissemination of information among members of a group" (Blake & Haroldsen, 1975 p. 22). There are two types of communication networks: formal, with a prescribed communication network, and informal, with communication that is not "assigned or enforced" (Blake & Haroldsen, 1975 p. 22).

Using semi-structured interviews with members of all parties involved, we identified the all parts of the sender-receiver model of communication between each of the parties involved with the SHS program. The list of parties interviewed is in Table 3.

Table 3 - Interviewed Parties

Village	Government	Company
Users	Tambons	Solartron
Tambon Representatives	Department of Local Administration (DLA)	Acumen
	Provincial Electricity Authority (PEA)	

Each party was questioned about the way information was distributed regarding general SHS information. For example, in the tambons we asked, "How was ownership of the SHS transferred to you?" (Appendix B), and to the PEA we asked, "How was ownership of the SHS transferred to the tambons" (Appendix B). By asking similar questions to different parties, we were able to compare the responses and give more validity to our findings.

Since we wanted to learn about the current formal communications network, we asked questions to identify the methods that are used to communicate between the villagers, tambons, PEA and the installation companies to obtain replacement parts and dispatch repair technicians. In doing so, we also explored the informal communications network that was taking place. Using the PEA warranty communications flow chart (Figure 3) as a guide, we asked each party if they followed the procedure. For example, we asked the villagers what they did when their SHS broke down, in order to see if they knew to contact their tambon representative (Appendix B).

While there were multiple companies involved with the SHS program, Solartron and Acumen installed the SHS in the areas we researched. Therefore, we focused our research on these two companies. Questions directed to them (Appendix B) focused on how they currently

communicated with the other parties included a question regarding how many warranties had been received.

After conducting the interviews, we used coding techniques to analyze the data. In this method, we grouped our data into similar "themes, ideas, examples or cases"(Knight, 2002). With each interview conducted with multiple parties we identified all responses that dealt with communications questions and then identified common ideas within those responses (Appendix C and Appendix G). For those interviews conducted with only a few parties, such as those with tambon offices or government agencies in Bangkok, we developed interview summaries for each interview and then identified common themes as well as individual data that related to the sender-receiver models (Appendix K-Appendix Q). Exploring Attitudes of Organizations and Individuals

3.2.2 Exploring Attitudes of Organizations and Individuals

Attitudes of those involved with the SHS in Thailand will directly affect the sustainability of these systems. In a social science context, an attitude can be defined as an "interlocking set of understandings, feelings, and actions towards a social object" (Blake & Haroldsen, 1975 p. 69). Thus, we explored the attitudes of parties involved with the SHS.

It was important to obtain the users' opinions, since implementing organizations are often so far removed from actual users that the effect of the system on the villagers may be different than the effect perceived by the implementers (F.D.J. Nieuwenhout et al., 2000). For example, in programs where SHS are donated to the users it seems that user apathy and a lack of a feeling of ownership can be a problem (F.D.J. Nieuwenhout et al., 2000). Loss of cultural practices or traditions to the introduction of new technologies is not only a moral concern, as discussed in the background chapter, but may affect how people care for their SHS. By developing an

understanding of the concerns and views of the villagers, local and national government officials and the companies that build the systems, we developed our recommendations with consideration of the cultural and social needs of the participants. We achieved an understanding of this through asking open-ended questions about the villager's feelings toward the system in each interview.

Based on the data we collected from these interviews we were able to draw conclusions as to how the attitudes of the villagers toward the SHS affected the frequency of notification and the amount of basic upkeep, or lack thereof, performed by the villagers. We organized our data as seen in Appendix C and drew conclusions based on the patterns that formed from the individual responses to each question.

In addition to our evaluation of the villagers' attitudes, we explored the attitudes of the organizations using the semi-structured interviews. We interviewed officials at the PEA, the implementers and overseers of the SHS program, and asked questions regarding their role in the SHS program in the past and in the future. We also interviewed the DLA, and asked questions to understand their feelings about the SHS program. From the interviews with the tambon office employees, both in the Tak and Chiang Mai provinces, we were able to determine the procedures the tambons follow to ensure sustainability of the systems in the villages within the tambon's jurisdiction. In our interviews with the solar installation companies, it was difficult to determine the accuracy of the translation. Therefore, we withheld from making direct claims about their attitudes towards the SHS.

As with any subjective data such as interviews, analysis was challenging. Especially with large organizations such as the PEA, cause and effect relationships are often complex and difficult to determine. Thus, any specific attitudes that we attribute to these organizations are

simplifications of a complex reality (Knight, 2002). Due to the limited amount of time available to gather data and the complex subtleties of Thai communication, it was likely that we missed some aspects of these attitudes. However, with a general understanding of the relative attitudes – positive or negative – of the various parties, it was possible to make recommendations that reflected the attitudes of the parties involved.

3.2.3 Determining Funding Options for Improvements

Funding has played a large part in whether past SHS programs around the world have been sustainable. Since the goal of this project was to develop a strategy for the sustainability of the SHS in Thailand, the different possible avenues for procuring and distributing necessary funds between parties involved with the SHS were researched. This problem was threefold: we needed to identify the types of available funding, determine the funds that were needed to run proposed strategies, and also consider any requirements that would be involved with receiving the funding.

In order to identify different types of funding available for the SHS sustainability, we researched previous SHS programs that have used different institutional models for funding the ongoing costs associated with sustaining the systems, including fee-for-service, credit, and government or NGO subsidization, as we discussed in the background chapter. Another option was receiving funds from a carbon-offset company, which would have specific requirements that must be fulfilled in order to secure their funding.

We asked questions regarding funding to all of the parties that are involved with the SHS (Table 3). While ideally we would have interviewed the people in charge of distributing funds, due to time limitations the interviews only occurred with people who were related to the SHS

program. Questions included how much money could be provided and which requirements were necessary to meet in order to secure funding.

We interviewed two national government agencies and two tambon offices. The first interview was with Narin Doknark of the PEA in Bangkok, who was responsible for the deployment of SHS. As seen in Appendix B, questions regarding funding asked whether the PEA would be able to provide money for the SHS. We also interviewed the Department of Local Administration and asked them where the money would come from to support the SHS in the future. Finally, we interviewed representatives from the *Sam Muen* and *Doikeaw* tambon offices regarding their part in providing financing for the SHS. They were questioned on the amount of funds that were available for the SHS.

Other parties that we gathered information from were the SHS companies. The questions asked, as seen in Appendix B, were about replacement parts and possible offers of credit. We also asked how much it costs to send a technician to repair the SHS.

The final party we interviewed was the current users of the SHS, residents of the rural villages. The funding-related questions directed to the villagers had two purposes. The first was to gauge the amount of money that villagers could afford to put towards the maintenance of their SHS. As seen in Appendix B, some questions were very open-ended, such as “Would you pay a monthly fee to have someone take care of your SHS?” These questions only gauged the amount that an owner was willing to pay per month, while other questions were more direct, asking how much money was spent using other forms of lighting when the SHS was broken. The second purpose of the funding questions was to gather information that would be necessary to receive carbon offset funding. The village members were asked questions regarding their usage of other energy sources when not using their SHS, both while it was functioning and when it wasn't. They

were also asked about their typical uses for the SHS, since carbon offset funding would only provide funds when lights, as opposed to TV and radios, were the main purpose of the SHS.

3.3 Design and Evaluation

In the final stage we iteratively developed a comprehensive strategy for SHS sustainability based on the findings from the research stage. Part of this involved designing improvements for each weak communications link. For the creation of new channels of communication we borrowed from standard methods of computer interface design. This included identifying the users, or the sender and receiver in the communication link, and the information they were communicating (Stone, 2005 p. 39). In addition, we considered variables such as language, usability, and even limitations, caused by different levels of motivation or user attitudes (Stone, 2005 p. 45), to ensure that we took into account all factors that could affect the communication link.

After we developed our recommendations, they were reviewed by multiple groups, including the potential users in the development of recommendations was important to the future acceptance of the recommendations. Thus, we solicited feedback from representatives of identified user groups, including the PEA and tambons. Concurrently, using both phone and e-mail correspondence, we solicited feedback from organizations and individuals who could provide valuable insight based on their extensive experience. We interviewed Herbert Wade, an international consultant familiar with similar SHS programs around the world; Bruce Countryman, who works with solar rural electrification at both the local and regional levels; Dr. Wattanapong and Dr. Prapita Thanarak from the School of Renewable Energy (SERT) at Naresuan University, and Jamal Gore, the director of the carbon offset company Carbon Clear to identify additional improvements or flaws in our preliminary recommendations,. We employed

all of these suggestions in the development of our recommendations. These interviews walked the users through our recommendations and solicited feedback regarding applicability and ease of use. After each interview we iteratively improved our recommendations incorporating their feedback. All of their suggestions were employed in the development of our recommendations.

3.4 Conclusion

Utilizing two stages we investigated our research questions in order to provide recommendations for repairing the weak linkages in communication and solidifying funding for the sustainability of SHS, while being sensitive to the attitudes of the parties involved. The first phase used semi-structured interviews with villagers and tambons from the Tak and Chiang Mai Provinces, along with interviews with the Provincial Electricity Authority, Department of Local Administration, Solartron, and Acumen. The second phase used the findings from the previous phase to develop recommendations, which were reviewed by experts, including SHS consultants and carbon offset providers. The recommendations were then modified based on their feedback. Together these recommendations form a strategy for the sustainability of the SHS program.

Chapter 4: Findings and Discussion

Through the analysis of our data, we arrived at thirteen findings regarding the sustainability of solar home systems (SHS) in Thailand. They are grouped into three categories: communication links, attitudes, and funding. In addition to these findings, we have identified six overarching themes.

4.1 Communication Links

Through the process of interviewing the parties involved with the SHS we developed, using the sender-receiver model, two pictures of the communications links involved with the sustainability of SHS. The first picture outlines the communication network regarding the dissemination of SHS information.

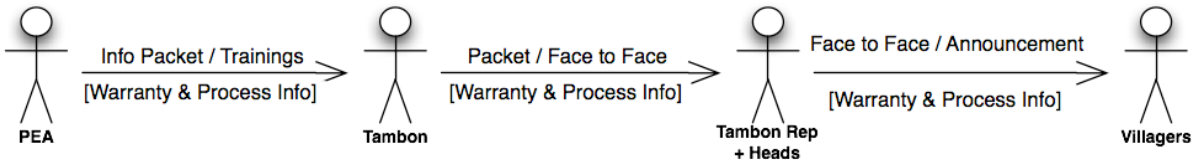

Figure 6 - SHS Information Distribution Communication

Information regarding the SHS either sent by the PEA to the tambons or given in a training. The tambons then communicated this information to the tambon representatives and heads of the village. The tambon representative then distributed this information to the villagers. Based on the official network of communication designed by the PEA (Figure 3) and augmented by our research, we developed a second picture of the communication network for warranty requests, seen in Figure 7.

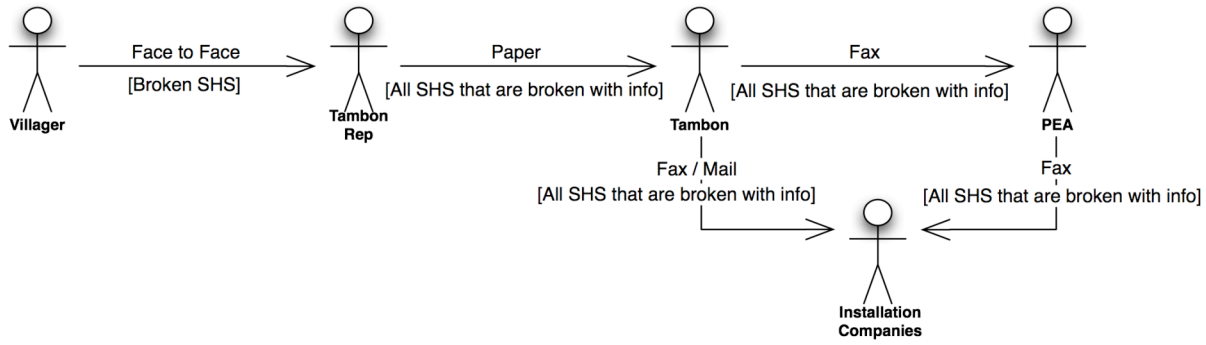

Figure 7 - Warranty Claim Communication (Sender - Receiver Model)

Finding 1 *Information on SHS maintenance, warranties, and procedures is not consistently and uniformly distributed among the villagers*

Through interviews with villagers in the Chiang Mai and Tak provinces, we found that the information concerning SHS maintenance and warranties was not consistently and uniformly distributed among the villagers. Figure 8, using the sender-receiver model, shows that the communication of this information was supposed to occur between the tambon representatives (sender) and the villagers (receiver), with the channel being face-to-face communication and the message being information about the warranty, SHS operation and maintenance, and the process that should be followed if an SHS breaks down.

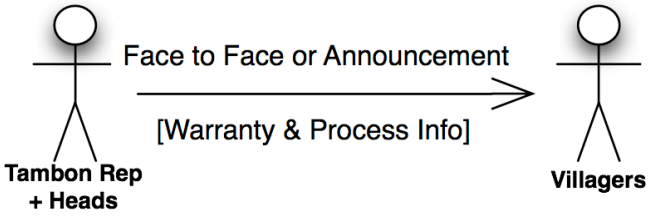

Figure 8 - Communication of SHS Information Between Tambon Representative and Villagers

In our interviews it quickly became apparent that most villagers were not completely informed of the warranties on their system or how to claim them. In the Tak Province, only two out of the nine villagers we interviewed responded that they knew of the warranty, and in the Chiang Mai Province two villagers knew of the warranty, while four villagers had partial or no knowledge at all. In the Tak Province, the two villagers who knew of the warranty were the Vice President of the *Sam Muen* tambon and the Head of *Khun Huay Mae Thaw* village, both of whom had regular contact with the tambon office (Appendix C, Interviews A,H). In Chiang Mai Province, while more villages had at least partial knowledge of the warranty, only Noi, our translator who had worked with Bruce Countryman previously, and the Vice President of the tambon knew the specifics (Appendix G, Interviews J,Q). Overall, we saw that those who knew of the warranty were in contact with the tambon on a regular basis.

While it can be seen that failures of communication are occurring, the cause of the failures is not always the same. In some cases it appears to be a failure in the message, that is, the information that is presented. Villagers have been found to have only partial knowledge of the warranty, maintenance, or procedure. One man in Chiang Mai knew of the two-year warranty on the battery but had not been informed of the warranties on the other parts (Appendix G, Interview L). Another villager in Chiang Mai knew of the warranties but did not know how long the warranty lasted for each component (Appendix G, Interview O).

We have also found an example of failure of communication in the channel, the medium through which the information is transferred. Especially in Chiang Mai Province, many villagers said that they did not know how to request a system repair. When we asked how some of the villagers knew to contact the tambon representative when their systems had failed, we were told that the procedure was announced once over the daily morning loudspeaker (Appendix G,

Interview P). In this case, while the channel was credible and multiplicative, since it was used often to relate other messages and reached the entire village, there was no permanency. If villagers missed the message due to being in the fields or asleep, they were unable to receive the message through this channel. There was also little ability of the villagers, the receivers, to give timely feedback to the sender. In the end this inconsistency in information distribution has led to confusion among the villagers about how to address the problem of a failed SHS.

Finding 2 *Tambons have not been consistently trained and informed for the management of SHS.*

The tambon governments, who received ownership of the SHS in their villages after the PEA had completed installations, have not been consistently trained in the management of the SHS program. Interviews with the PEA, *Sam Muen* and *Doikeaw* tambons, and the Department of Local Administration (DLA) convey different ideas of how tambons were prepared for ownership.

According to the DLA, the PEA held trainings with the tambons after the initial SHS were installed (Appendix Q). This was when the tambons received ownership. Conversely, the PEA states that there were no trainings held initially (Appendix O). In the *Doikeaw* tambon, Chan Khasem, the civil engineer in charge of the SHS, stated that he had not received any training (Appendix N). In the *Sam Muen* tambon, Rotchana Phanthip, who was in charge of the SHS for the tambon, explained that the MOI had sent a letter to the tambon stating that they had received ownership of the SHS. She was not initially aware of the SHS warranties until BGET informed her (Appendix K).

More recently, the PEA has begun to distribute information and training to the tambons throughout Thailand. Chan Khasem explained that he had been sent two packets of information

from the PEA, one written by the PEA outlining and warranty information and procedures and one written by the installation company, Acumen. This occurred on November 2, 2006, two years after the oldest SHS that we had viewed had been installed in the region (Appendix N). Rotchana Phanthip also had this packet, and both employees were able to explain the warranty process that it outlined. Regarding general SHS information, Chan Khasem was not confident in his understanding of what was broken and why in the SHS since he had not received the training, and he stated that he had to teach himself about the SHS.

In addition to sending out the forms that outlined the warranty process that should be followed, the PEA began holding trainings around the country at the end of 2006. These trainings were done in collaboration with the solar installation companies, and covered 80% of the tambons that have SHS. Continuation of the trainings was cut short after the coup (Appendix P). In the *Sam Muen* tambon, a training was held in September 2005 for the civil engineers and end users (Appendix L). More recently, in January 2007, the PEA and Solartron held a three-hour training in the Tak Province at which information was distributed regarding maintenance and warranties. This was the final training planned to occur in this area (Appendix O). The PEA office in Bangkok did not know if trainings would be held in the Chiang Mai Province in the near future (Appendix P).

Finding 3 *The standard procedure for following warranty requests is not always followed by the tambons.*

The standard procedure for claiming the warranties, as outlined by the PEA, is not always followed by the tambons. This formal communications network was outlined in the documents that the PEA sent to tambons (Figure 3). In this network, the tambon is supposed to send the

warranty forms to both the solar company, in order to request the repair, and the PEA, to have a record of the claims.

In the *Sam Muen* tambon the warranty forms, once collected by the tambon office, would be mailed to the PEA. These warranty forms were not the ones that were created by the PEA, but rather forms that BGET had created previously to facilitate warranty communication (Appendix K). There was no direct communication with Solartron, the installation company for that area (Appendix M). The communications link between the tambons and installation companies (Figure 7) is therefore missing, and the channel between the tambon and PEA is different from the standard.

In the *Doikeaw* tambon, Chan Khasm would collect the PEA created forms brought by the tambon representative. While interviewing him, he told us that he had received forms from villages, but was waiting to receive more before delivering them to the solar companies on February 15th. When asked why he was refraining from sending the forms, he stated that he was waiting until he had a large group to send to the installation company. While the plan was for him to send them in on the 15th of each month, in January he did not send any in because only three villages had submitted forms. He explained that the company wanted him to wait until he had a significant number of forms before submitting the warranty requests (Appendix N). In the communications picture (Figure 7), the links connecting the PEA and installation companies to the tambons were missing. The PEA, when informed of this, stated that he should fax the forms to the companies when he receives them. A copy of the forms should also be sent to the PEA to keep as evidence the warranties had been submitted (Appendix P). While Solartron and Acumen were unavailable for comment on this issue, we did learn that Solartron had been receiving four to five hundred claims per month (Appendix Y) and Acumen had been receiving sixty per month

(Appendix X). This shows that warranties are being claimed, though it is not clear through what channel they are received.

Finding 4 *Information distribution about SHS at the government level may be facilitated by use of computers and the Internet.*

The Internet is a possible future channel for communication between the different parties at the government level and the solar installation companies. Figure 9 illustrates this connection.

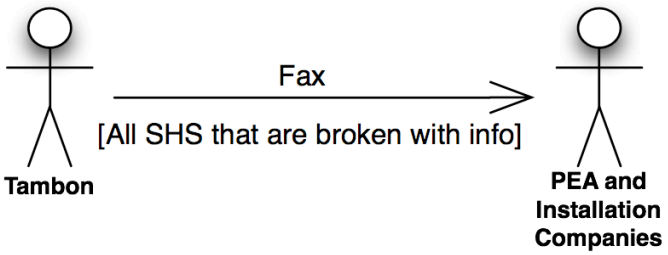

Figure 9 - Communication Between Tambons, PEA, and Installation Companies

Currently, communication between these parties relies on the transfer of paper documents via fax or mail between the parties. A copy of the warranty is either sent to the solar installation company, the PEA, or both. Another option for this channel is to use computers and the Internet.

Installation companies are already using computers to keep track of the SHS installed throughout Thailand. The PEA will be receiving a CD from each company with the information about each company's installed SHS when the second phase of installations ends. When the installations are complete, the PEA will distribute this information to the tambons on CDs (Appendix P). When asked specifically if using a website would be beneficial, we were told that other routes of communication between the tambons and the solar installation companies had already failed, so the benefit of the website was question. In addition, the data would change quite a bit. However, the PEA was already in the process of developing a web database of the

SHS in each tambon's area, to be released to the tambons with the CDs. The tambons could update their local district information, while the main office would have full control. It would up to the individual tambons to make use of this data (Appendix P).

While the PEA representative we spoke with estimated that 10% of the employees at the tambons actually used computers, the *Sam Muen* and *Doikeaw* sub-district offices that we visited use computers and the Internet on a regular basis. In the *Sam Muen* tambon, each desk had its own laptop for the employee as well as a freely accessible public computer. In *Doikeaw* there were also computers. *Doikeaw* normally had Internet access, however it was not working from September 2006 until February 2007 due to renovations to the tambon office. Both of the tambon employees we spoke with used Microsoft Word and Excel, as well as websites such as Google. Chan Khasem, from the *Doikeaw* tambon, used Hotmail for personal use while Rotchana Phanthip had used email previously (Appendix M, Appendix N). The DLA later seconded this when they said that the tambons generally do not use email (Appendix Q). When told about the possibility of using a website to communicate with the installation companies and the PEA, the civil engineer became very enthusiastic because he felt it would make the warranty claiming process quicker and easier (Appendix N). Rotchana stated that the Internet speed at the *Sam Muen* tambon was very slow, but, if the speed was faster, then using a web application would be better than mailing the warranty requests (Appendix M).

4.2 Attitudes

The attitudes of each party involved in the SHS program are essential to the success of a plan for sustainability. Since no one group can implement this program itself, each group in the network of communications must have a positive outlook on the program and feel it is important to pursue

Finding 5 *Villagers would like their SHS to function properly.*

Overall, villagers would like their SHS to be functioning. In both the Tak and Chiang Mai provinces, all the villagers we asked who had broken SHS said that they would like them fixed. In one case where a system was suffering from a faulty switch, the owner expressed frustration that the system did not work reliably (Appendix C, Interview C).

All of the villagers used their SHS for lighting, and the more affluent villagers used them for electronic devices such as TVs, radios, and CD players. For many, the systems allow them to save money on buying candles or kerosene. In the Tak Province, the villagers that we interviewed spent an average of about 100฿ per month on lighting when their SHS did not function properly (Appendix E). In the Chiang Mai Province villagers said they spent between 20฿ and 100฿ (Appendix I). When the SHS were functioning, most villagers said that they did not spend money on candles or kerosene lamps. The one villager who continued to burn candles used less than one candle per night (Appendix C, Interview E). In addition, one villager in the Tak Province said that she could not always see properly with the light from candles and preferred the light provided by her SHS (Appendix C, Interview B). In the Chiang Mai province, even through they had the micro-hydro to also provide electricity, the SHS were desired in the dry season when the micro-hydro would not work (Appendix G, Interview L).

Finding 6 *Villagers do not urgently pursue repairs when the systems break.*

Even though the each of the villagers stated that they would like their SHS to work properly, few of the villagers with broken systems demonstrated much urgency seeking repairs . In the majority of cases, villagers asked only once for the system to be fixed and did not follow up after a long period of time, typically three to six months, if it were not fixed. The responses of the villagers are seen in Table 4.

Table 4 - Actions of Users Whose SHS Broke

	User	SHS fixed?	When Broken?	Who was contacted?
Tak Province	B	No	June-July 2006	Employee of tambon took information Doesn't know if actually reported to office Reported soon after broken, has not asked again
	C	No	February 2006	Tambon representative took information Never attempted to inform anyone else
	D	Yes	June-July 2006	Informed tambon member once, guy took information Took a month before fixed by company
	G	No	Early January 2007	Haven't contacted anyone Plans to contact tambon representative
	H	Yes	October 2006	Contacted tambon representative SHS fixed in a month
	I	No	October-November 2006	Contacted tambon representative Tambon representative did not collect any information
Chiang Mai Province	L	No	October 2006	Told tambon representative Was told to fill out form but wasn't given it Nothing else was said, even though they saw each other
	M	No	November 2006	-
	N	No	-	Talked with tambon representative once, 3-4 months ago Filled out and handed in paper
	O	No	A few months after installed	Told tambon member over a year ago When asked a second time why system wasn't fixed
	P	No	Before January 2006	Told Noi and Bruce, but no one else

In the Tak Province, some villagers waited as long as 6-11 months for a repair and still did not follow up with their tambon representative when the repairs had not been completed. One villager in Chiang Mai Province was told that he should fill out a warranty form to request repairs on his system. However, he never received the form and never followed up with the tambon representative to obtain it (Appendix G, Interview L). In the Chiang Mai Province, we inquired why the villagers had not brought up the matter of warranties and repairs of the systems in their regular village meetings and were told that the SHS were not deemed as an important topic. More pressing issues, such as road maintenance, took precedence (Appendix G, Interview J).

Finding 7 *The villagers' opinion of the importance of personal responsibility for SHS maintenance and operation affects their willingness to subsidize each other.*

The villagers' opinion of the importance of personal responsibility for SHS maintenance and operation affects their willingness to subsidize each other. This trend was found through questions to the villagers and tambon representative in Chiang Mai Province. According to Noi, one of the villagers responsible for caring for the micro-hydro, members of the community would pay varying amounts of money, depending on how much they used the micro-hydro electricity. (Appendix G, Interview J). If the system broke, members would pay according to their income (Appendix G). When asked if this system could be implemented with the SHS, the chief of the village responded that electricity provided by SHS was not the same situation as electricity provided by micro-hydro. The SHS were a household responsibility, and it would not be fair to the village if certain houses did not take care of their systems. The vice president of the tambon echoed this idea when he mentioned he was afraid that some people would not take care of their systems if money were collected by the tambon in return for maintenance (Appendix G). Overall, people were concerned about the effects of another individual's actions on their personal SHS.

Finding 8 *The Department of Local Administration wants to provide general recommendations to tambons but will not be directly involved.*

Through an interview with Mr. Oi Chai of the DLA we learned that they wish to provide support and standards to the local administrations to improve their quality of work (Appendix Q), but will not be directly involved with the program. The DLA is currently working on a second manual, to be distributed by April, containing general SHS information as well as maintenance and operation instructions. This is meant to be a guide for the tambons as they manage the SHS in their area. The DLA had not been in contact with the installation companies,

and it was stressed that the tambons were responsible for contacting the PEA if there were any SHS problems (Appendix Q).

The representatives from the DLA believe the decentralization of the government has caused some of the discrepancy in what the tambons knew. Since the change in government, there has been an emphasis on moving more power and responsibility to the local level. Due to this policy information is not always being passed down from the central government.

The DLA does have plans for improving the sustainability of SHS systems, but they are dependent on tambon participation. They are planning on having training sessions in Bangkok, where tambon technicians from throughout the country will learn from DLA personnel how to properly maintain the systems, as well as contact the necessary parties when the systems malfunction. They also recommend each tambon set up a committee of at least three residents per village. This committee would be responsible for maintaining and collecting payments from other villagers with SHS. Since this program was a pilot program, the DLA believes it is essential to have an evaluation in two years to see what still needs to change within the program to ensure sustainability, but they are not planning on conducting this evaluation themselves.

Finding 9 *The tambons have many responsibilities, of which the solar home systems are not their highest priority.*

Tambons have many responsibilities to devote their time, attention, and resources to, of which the SHS are not a high priority. The actions and decisions of the *Doikeaw* and *Sam Muen* tambons demonstrated this attitude. We discovered that the tambons are responsible for many projects. In both tambons, the one person in charge of the SHS also devoted their time to other jobs. In the *Doikeaw* tambon, Chan Khasm was also in charge of planning the roads and wells, as well as creating construction laws (Appendix N). In the *Sam Muen* tambon, Rotchana was also

responsible for administration and the tambon Internet. She estimated that 20-30% of her time was devoted to the SHS (Appendix M).

The tambons we spoke with also did not have money allocated for the maintenance of the SHS. In the *Doikeaw* tambon Chan Khasm stated that there is no available money to spend on maintenance and replacement parts of the SHS, since the budget is small and there are many projects (Appendix N). Even so, an effort was being made to provide for the future of the SHS. The vice president of the tambon mentioned that they talked about collecting money at the tambon office, but they wondered where the money would come from. Still, even though they understood the villagers needed to understand there was limited amount of time left in the warranties, there has been no attempt to notify the villagers again or collect money (Appendix G, Interview Q). In the end, the tambons, while certainly interested in the sustainability of SHS, will not be able to devote very many resources to this cause.

Finding 10 *The PEA is primarily concerned with the installation of the SHS.*

Through interviews with PEA representatives in the Bangkok office and a local PEA representative in Tak Province, we found that the PEA while interested in seeing the SHS program sustained, are primarily concerned with the installation of the SHS.

According to the PEA, there were two phases of the SHS installation program. In the first phase, starting in 2004, approximately 150,000 SHS were installed, and in the second phase the remaining 50,000 SHS were installed. At the completion of each phase trainings were conducted by both the PEA and installation companies in the areas where the SHS were installed. The obligation of the PEA for the SHS officially ends when these trainings in the second phase are completed, the PEA tentatively will withdraw in December of 2008. While their official commitment ends in December, we were told that there have been 40,000 new requests for SHS.

If the Ministry of the Interior provides the PEA with additional funding, a third phase may begin. Overall, the PEA stated that they are not responsible for the future management of the SHS (Appendix P).

While the PEA is withdrawing from the SHS program, the employees we spoke with were still concerned with the ability of the SHS to continue working. Narin, responsible for the SHS in the PEA main office, said that he had met with tambons that have had no complaints about their systems. We were also told that if the SHS were still working in seven years, then the program would have been a success. Over time, there is a hope that the grid will be extended to those areas that are currently without it (Appendix P). In addition, when we visited the *Sam Muen* tambon, the local PEA representative was making a visit. He showed concern for the systems, but still emphasized that final trainings were occurring, and the tambons were responsible for future maintenance and warranties (Appendix L)

4.3 Funding

Finding funding options was necessary to sustaining the SHS. It was found that the villagers, PEA, and MOI could not fund the sustainability program themselves. From these findings we determined that, a combination of several different funding sources to finance the sustainability of the SHS.

Finding 11 *Villagers have limited resources for purchasing equipment and providing long term funding for the systems.*

We have found that villagers have limited resources for purchasing equipment and providing long term funding for their SHS. In both the Tak and Chiang Mai provinces, all villagers said that they would be willing to pay for a replacement part, but affordability was consistently mentioned in their responses. According to the *Sam Muen* tambon office, the

average yearly income for a villager in that area is 20,000฿ (Appendix K). When asked how much they could afford to pay to fix their SHS, most villagers indicated that 100 - 300฿ would be the maximum amount that they could afford to pay. Comparatively, the cost of a new battery from Acumen is 3,000- 45000฿ (Appendix X). Similarly, the cost to have Solartron fix the inverter unit is 1,000฿ (Appendix O). The question of affordability was also a concern for the Vice President of the tambon in Tak Province. He said that he would be able to pay to fix his system if it broke, but he thought that most villagers could not afford to do so (Appendix C, Interview A).

We also asked the villagers about their ability to pay a monthly fee in return for maintenance and replacement of broken parts. Most villagers consented and their estimates of affordable cost ranged from 20฿ to 200฿, with an average response, in Tak Province, being 128฿, as seen in Table 5.

Table 5 - Cost of Energy Without SHS and Suggested Monthly Fees for Maintenance by Villagers in Tak Province

Interview	Cost of Energy per month (baht)	Suggested Monthly Fee (baht)
A	30	-
B	225	-
C	150	-
D	60	100
E	30	200
F	60	300
G	100	20
H	62.4	100
I	150	50
AVERAGE:	96	128

As with the cost to replace broken equipment, these amounts may be less than what a villager would actually pay. We also asked villagers how much they would spend per month on

items for lighting before they had the SHS or after it stopped working. In the Tak Province the villagers would use candles or kerosene lamps, and spent an average of 96฿ a month. However, more than half of the villagers in the Tak Province spent less than 75฿ per month, In the Chiang Mai Province the villagers used their micro-hydro system, candles, or pine sap, for an average of 50฿ per month. Generally, it appears that people would be willing to pay more for SHS maintenance than they do for other energy sources. In the Tak Province there were two villagers that suggested monthly fees that were less than they paid for other sources of electricity (Appendix O, interviews G, I). It is also possible villagers did not understand the cost benefit of renewable energy. In the Chiang Mai province, our translator, Noi, explained that he had trouble making some villagers understand that the micro-hydro would cost them less than what they spend in candles. This lack of knowledge could explain the few people who suggested low monthly fees (Appendix G, Interview J).

Finding 12 *The national government is a possible source for funding SHS sustainability*

Through interviews with different government agencies involved with the SHS, including the *Sam Muen* and *Doikeaw* tambons, the PEA, and the DLA, we found that the national government is a possible source of funding for SHS sustainability.

The initial funds for the SHS program came from the Ministry of the Interior (MOI), through the PEA. Since the PEA's obligation ends when the installations are complete, the PEA will not have more money to dedicate to the SHS program, unless the MOI chooses to extend their involvement. We were also informed that the MOI might be able to provide funds, perhaps subsidizing up to half the cost of a replacement part, to the tambons (Appendix P). The MOI, through the DLA, has already issued a regulation that the village committees should collect a 50฿ fee per month from each SHS user. According to the DLA, if this money is not enough, the

committee can appeal to the tambon for additional funding. It is then up to the discretion of the tambon whether to provide the additional funding (Appendix Q). There are also limits to what money the government could provide. At the tambon level, their budget is distributed to multiple projects, including roadwork and construction (Appendix N). Also, due to the recent changes in the Thai government, the MOI is currently going through a number of changes (Appendix P). These governmental changes make the availability of funding uncertain.

Finding 13 *Carbon offsets are not viable as the sole source of funding for SHS sustainability.*

Carbon offset funding was explored as a possible source of funding. Basing our calculations off of the Gold Standard, as discussed in our background, for voluntary emission reductions (Ecofys, 2006), we calculated, from our collected data, that every household uses an average of two liters of kerosene per month. In our calculations, based on data from the Tak Province, we assumed BGET's estimate that 20% of the SHS had failed, and in a best-case scenario any project that carbon offsets fund would lead to the repair of these failures. According to Jamal Gore, director of Carbon Clear, there are 2.55 kg of CO_2 per liter of kerosene (email with Jamal Gore, January 30, 2007). In our second interview with him we learned that one ton of carbon offsets would provide approximately $5.88 (Appendix W).

First we found the amount of kerosene used per year by the failed SHS in the tambon. The SHS, with BGET's initial estimate of a 20% failure rate, use approximately two liters of kerosene per month per house. With 768 SHS in the Sam Muen Tambon, the usage comes out to 3,700 liters of kerosene per year.

$$\left(\frac{2 \text{ liters kerosene}}{\text{month}} x \frac{12 \text{ months}}{\text{year}}\right) x\left(768 \text{ SHS}\right) x\left(20\% \text{ failure}\right) = 3696.4 \text{ liters kerosene} \Big/ \text{year}$$

We then found the amount of carbon offsets that would be produced by this kerosene. Assuming that the funding would eliminate all of these failures, with 3,700 liters of kerosene saved per year and 2.55kg of CO_2 per liter of kerosene and one ton of carbon offsets equal to 1000kg of CO_2, each tambon would produce about 9.4 tons of carbon offsets per year.

$$\left(\frac{3696.4 \text{ liters kerosene}}{\text{year}}\right) \text{x} \left(\frac{1 \text{ ton carbon offset}}{1000 \text{ kg } CO_2} \text{x} \frac{2.55 \text{ kg } CO_2}{1 \text{ liter kerosene}}\right) = 9.4 \text{ tons carbon offset} \Big/ \text{year}$$

Finally, we found the amount of money that could be provided. The 9.4 tons of carbon offsets, at $5.88 per ton of carbon offset is equivalent to approximately 1,933 baht.

$$\left(\frac{9.4 \text{ tons carbon offset}}{\text{year}}\right) x \left(\frac{\$5.88}{1 \text{ ton carbon offset}}\right) = \$55.27 = 1{,}933 \text{ baht}$$

Thus, the average carbon offset funding that would be received by each tambon per year would be around $55, or 1,933฿, which is less than the cost of one battery.

With this amount of funding, we found that carbon offset funding cannot be the sole source of funding. In addition, the systems need to work the majority time in order to produce these offsets. the director of Carbon Clear, indicated that unless a carbon offset funded project occurred for multiple years, even one-month downtimes would be significant enough to require that they are taken into account (Appendix W). He did believe that carbon offsets could be paired with other sources of funding to help finance the maintenance of SHS, as they have been used with projects in other countries.

4.4 Themes

Through our research, we have identified the following overarching themes. These themes are general trends that we have found to cross the boundaries of several findings or research areas.

4.4.1 The implementation of the SHS program did not plan for sustainability.

The first theme that we have identified is that the installation of the SHS focused on the installation of the SHS rather than the continuing function of the SHS Not all parties involved were trained on maintenance of the systems and the longevity of the program was not planned in advance. The fact that the PEA was still distributing warranty information to tambons as recently as October 2006 and the lack of any implemented maintenance program or fee structure indicated that the program was rushed. Currently, there are some communications breakdowns, since the tambons involved were not always trained on how to properly manage the program. Also, financial responsibility for SHS sustainability was placed on the villagers and tambons, but the groups were not aware of this or set up for managing this money when the systems were installed. In addition, according to Herbert Wade, this program has violated many best practices developed through other SHS deployments around the world, such as relying on end-user maintenance, and was implemented with substandard parts not designed for the areas in which they were installed (Appendix R).

4.4.2 Understanding and practice of procedures for communication vary within parties involved with the SHS.

Another common theme that emerged from our visits to the villages and tambons was that the knowledge and actions of individuals with respect to the SHS varies from individual to individual. This is illustrated by the differences we found between the formal communication

network created by the PEA and what actually is occurring. The knowledge level of the users with regards to the system warranties was also very inconsistent. Some villagers knew to contact the tambon representative in the village, others knew about parts of the warranty, and still others did not know what to do at all. Similarly, in the tambon offices, practices were widely divergent.. In *Sam Muen*, the employee in charge of the SHS had received some level of training and was sending warranty forms via mail to the local PEA offices. On the other hand, the engineer in *Doikeaw* had not received any training and was not sending on the forms immediately as he was told that he did not have enough (Appendix M, Appendix N).

4.4.3 Higher level government agencies' perceptions of the SHS program are not always consistent with the actual situation.

In addition to the general lack of consistency at the village and tambon levels, the perception of higher level government agencies differs both between the agencies and from the situation that we observed. At the DLA we learned that they had recommended the tambons form committees within the villages in order to facilitate the collection of fees for the SHS program. However, at the PEA, no mention was made of such committees. Similarly, the DLA thought that trainings happened at the beginning of the SHS program whereas the PEA indicated that the trainings had only been happening more recently, approximately one year after the start of the program. However, in our interview at the *Doikeaw* tambon, we learned that the engineer in charge of the SHS for the tambon had not received any training. In addition, the PEA developed a warranty communications network, however, at the tambon level, this was not always followed. This theme highlights comments that the DLA made regarding the policy of decentralization in the current government. Their focus on individual tambon control and responsibility limits consistency of procedures between tambons. While decentralization

certainly has its benefits it must be accompanied by additional resources so that the tambons can fulfill these additional responsibilities. (Appendix K-Appendix N, Appendix P, Appendix Q)

4.4.4 There are individuals in the different parties that are actively interested in SHS sustainability.

One theme that lends hope to the somewhat dire situation of communications breakdowns and lack of knowledge is the existence of individuals at many levels that provide genuine interest in the ongoing success of the SHS. One example is the PEA engineer that we interviewed at the tambon offices in *San Muen*. Although the tambon in the Tak Province was not following the PEA established protocols regarding warranty claims, in that they used BGET forms and sent them to the PEA rather than Solartron, he still worked with them to ensure that the requests passed on to the correct parties. In addition, the tambon engineer at *Doikeaw*, despite his lack of training, exhibited personal initiative by studying the packets he received to determine how to process the warranty requests and showed genuine interest in learning more about what can be done to further the sustainability. Finally Noi, our translator from *Hoi Som Poi 1*, was also actively involved with the SHS. Even though he was not a tambon representative or village head, he was motivated to follow up on the warranty requests that we identified while visiting *Hoi Som Poi* 1 and 2. In the end it will be individuals like these that will ensure that any strategy for sustainability is successful in the long term. (Appendix K, Appendix L, Appendix N, Appendix G)

4.4.5 Installation companies are not responsible for the sustainability of SHS.

Through interviews with both Solartron and Acumen we discovered that installation companies will not take responsibility for the sustainability of SHS. Both companies have stated that they have preformed their mandatory post instillation check up and provide maintenance and

replacement parts free of charge while the systems are under warranty, but have no maintenance plans for when the warranties expire. Each company has stated that if a part breaks and it's warranty has expired the owner of the SHS must pay for it outright. They have stated that they are not willing to provide any type of credit to the villagers. Both companies state that the training they have provided to the tambons regarding the basic maintenance of the system components should be enough to keep the systems functioning once the warranties expire (Appendix X,Appendix Y).

4.4.6 BGET's efforts have made a difference for the SHS in the Tak Province.

Overall we have found that BGET's efforts to sustain the SHS program in the Tak Province have made a difference in multiple areas. Since BGET's initial survey of the SHS in the Tak Province, there have been several changes that have resulted in a number of repairs under warranty. BGET's training sessions, and the PEA's efforts to distribute warranty information and basic training of the tambon engineers, also seem to have improved the situation.

BGET's initial survey of the Tak Province estimated that 22.5% of the SHS in that area had failed. In addition, there was no standardized warranty procedure in place for the villagers and tambons to follow. However, in *Khun Huay Mae Thaw* village in the Tak Province we found that since that survey was taken, 8 out of 9 failed SHS have been fixed and that the remaining system was not fixed due to minor communications problems (Appendix C). Additionally, in the *Sam Muen* Tambon, the civil engineers working for the tambon sub-district have been through a series of two three hour training sessions approximately a year apart (Appendix L). These have been welcomed by the tambon and have increased the tambon's ability to process the warranties, since they are able to better understand the differences within the SHS in regards to warranties.

In contrast to the Tak Province, the situation in the Chiang Mai Province is not as improved. In an interview with Noi, a villager who is often contacted by fellow villagers about their SHS, he estimates that there are more than 20 out of 123, or 16%, of the SHS in the village were not working (Appendix G). The greater cause for concern is that none of the failed SHS had been replaced yet. After Bruce Countryman conducted a survey of SHS in *Hoi Som Poi 1* and *2* in January 2006, he filed thirty warranty claims with the *Doikeaw* tambon office. None of these have been followed up (Appendix N). In the *Doikeaw* tambon office it became apparent that the PEA trainings were not as prevalent in the Chiang Mai Province and that the warranty process had only been received by the office in November 2006, approximately 2 years after the first installations. In addition, warranty claims that had been submitted to the tambon office by some of the villages had not been submitted to the PEA or the installation company for review. The fact that no repairs occurred in the village we visited in the Chiang Mai Province while several occurred in the two villages in the Tak Province shows the disparity between the two provinces.

4.5 Conclusion

Our findings stem from our research into the communication networks of the SHS program, individual and organizational attitudes, and possible avenues of funding. Overall, we found that while communication is not optimal, there is potential for a new channel of communication to be created. In addition, we have found that while the villagers do want their systems to work, this is not an urgent matter for them. Also, the tambons do not have much time to dedicate to these SHS, and the national government will primarily play an advisory role after the PEA has withdrawn from the program. Regarding funding, we found that since resources of villagers are limited, multiple sources of funding are required to sustain the SHS. In addition, we found that the national government and carbon offsets are a possible source of funding. Finally,

we found several overarching themes, which span several areas of research. These findings and themes have been used to create a long term strategy to promote the improvement in SHS sustainability.

Chapter 5: Recommendations

From our findings we have developed three sets of recommendations, which form a strategy for solar home system (SHS) sustainability. First, we have identified two short term recommendations that should be implemented nationwide to expedite the warranty claims and the checkup process. Next we have developed two long term recommendations that we suggest are implemented as a pilot program within the Tak Province, overseen by BGET and supported by carbon-offset funding. Finally we have formed recommendations for future research to further enhance the sustainability of SHS in Thailand.

5.1 Short Term Recommendations

While the following recommendations will not address all of the problems that we have identified with the sustainability of the SHS, they will address urgent issues that warrant immediate attention. As warranties continue to expire, it is vital that these recommendations are implemented as soon as possible. This is beneficial to both the villagers and national government, as the replacement cost of all parts of the SHS is high (Appendix X, Appendix Y).

5.1.1 The national government should hold additional training sessions for the tambons.

First, the national government should hold additional training sessions for the tambons, in order to bring all tambons to the same level of knowledge pertaining to the warranty and basic SHS maintenance. As seen in Findings 1, 2, and 3, pertinent information about the warranties and proper means of claiming them has not been uniformly distributed to neither the tambons nor the villagers. This official training would act as a means to uniformly and consistently distribute information.

The Department of Local Administration (DLA) has indicated that they will be distributing information through manuals and are considering offering training for the tambons in the future. These trainings would be located in Bangkok, where the DLA already holds classes for tambon members. The classes would be expanded to include information regarding the management of the SHS (Appendix Q). These plans are a step in the right direction, and it is vital that they are followed through.

5.1.2 Tambons should contact villagers again to notify them about their warranty rights and procedures for filing claims .

Second, each local tambon should inform all villagers who have a SHS about their warranty rights and the process for filing a claim. This information can be distributed through the tambon representatives, who already are the liaisons between the tambon and the villagers. Each tambon representative should clearly understand the implications of the fact that warranties are expiring, and have a specific set of information to tell the villagers. The tambon should set up a town meeting or go house to house distributing information about the warranties and answering any question the owner might have.

Some of the warranties on the first set of SHS installed have already expired, and each month more SHS will not be covered by the manufacturer's warranty. As seen in Finding 1, Finding 5, and Finding 6 that even though villagers want their SHS to function properly, they do not always have all the information needed to take the steps necessary to keep their SHS functioning and are not actively pursuing repairs when they do know. It can be seen in Finding 11 that, in general, villagers will be unable to pay for the replacement parts when their SHS break. While the government may be a source of subsidization, as seen in Finding 12, as more SHS fail and are not repaired before the end of their warranty, costs will increase.

5.2 Long Term Recommendations

Our long term strategy for the sustainability of SHS in rural Thailand is comprised of two recommendations. First we deal with the communications issues that we identified and then tackle the problem of funding and implementing a long term maintenance program.

5.2.1 A web application should be used as a centralized location for warranty requests to expidite the process of repairing malfunctioning solar home systems.

Our first long term recommendation is to improve the communication and record keeping between the tambons and installation companies by utilizing a centralized web application to submit warranty requests and schedule repairs. Based on our findings that the communication between the tambons and installation companies is currently limited and unreliable, and that there are limited resources at the tambon level, we designed and implemented a prototype application to facilitate this communication.

Specifically, we recommend the following:

- Develop and implement a web application supporting:
    - Warranty requests, scheduling, and repair confirmation.
    - Focused and direct displays of information to the relevant parties.
        - Tambons can view warranty requests for their area.
        - Installation companies can view pending requests of their SHS.
    - Overall system status and statistics
        - Monitoring average time to repair and average downtime
        - Ensuring prompt warranty repairs
        - Identifying commonly failing parts
    - Automated notification of overdue repairs and excessive failures
- Training tambon and installation company representatives in the use of the program
    - Distribute manual to provide clear instructions on the proper usage of the systems and communications channels to follow

This application may be used to supplement existing forms of communication and its use may be expanded incrementally as its success is determined in individual tambons. As part of this recommendation we have developed a prototype application that may be used initially and improved as needed to adapt to the needs of the tambons. Screenshots and usage information may be seen in (Appendix Z).

This recommendation is based largely on our findings surrounding the tambons in the Tak and Chiang Mai provinces. As seen in Finding 2, Finding 9, and Finding 12, our interviews with the tambons both revealed that they are interested in the sustainability of the SHS, but have limited resources such as manpower, funding, and training, to keep a sustainability program running. Since each tambon had its own idea of how warranty requests were supposed to be filed, claims were sent to different places and the standard communication scheme was not followed. This lead to wasted time, resources, and, potentially, fewer fulfilled warranty claims.

A centralized communications hub would expedite information transfer, save money, reduce confusion, and increase efficiency. The most practical way to create such a communications hub was through the implementation of a web application. The tambons will be able to file warranty claims into the database online, thus quickly providing the installation companies with the information they need to repair the SHS. This eliminates time delays, costs, and common problems associated with current communications such as fax and postal services. This information would be collected using the same forms that the PEA has already created, which eliminates the need to develop new procedures at the villager level. Also a centralized database to submit warranty requests will lighten the workload of the tambon since they will not have to keep a paper trail of the entire process. Anything that decreases work or cost for the tambon is very attractive, as the tambons have limited resources to dedicate to the SHS. The

organized format in which the installation companies will receive the claims will allow them to group the claims more easily and make batch repairs more efficiently, and the tambons will still have the security of having reported the broken systems.

The web application will also improve SHS warranty accountability. With quick access to SHS statistics, a higher level of accountability can be provided through the use of the web database than through the current paper trail. Since the government or third parties can see the status of the systems, the SHS program has greater credibility. This could serve as a written record for the functionality of the systems, which would allow for greater subsidization and funding for future programs regarding SHS sustainability.

Our finding that communications at the government level can be facilitated by computers and the Internet provides support for the feasibility of the web application actually being utilized. Since basic Internet skills are present among local and national government employees, the technical capabilities of the users are sufficient for the operation of the website.. The interface was kept as simple as possible in order to be a valuable tool to everyone, regardless of technical expertise. It is important to note, however, that the Internet at the tambon offices is not always reliable or fast. In order to address this issue we designed the web application for low-bandwidth users.

While the facilities and technical skills to use such a system are present, there is still a possibility of motivational problems for the use of the web application. One representative at the PEA indicated skepticism that the tambons would use the system based on the fact that they do not always follow the current system. However, seen in Finding 2, we found that this was primarily due to a lack of information and training on the part of the tambon rather than a lack of

willingness. It will be important, however, to ensure that the members of the tambon are properly trained in the use and advantages of the web application to submit warranty claims.

5.2.2 A long term maintenance program, funded by villages and the government, should be established in order to ensure regular maintenance and ongoing functionality of the systems.

Our second recommendation is to implement a long term maintenance program, managed by the tambons. It would be supported through monthly SHS user fees and subsidized by the Ministry of the Interior (MOI), to pay for a designated village technician in every village and cover the cost of spare parts and the technician's salary.

Leveraging the improved communications between the tambon and installation companies provided by the web application, this recommendation helps to replace the unaffordable incidental costs of replacement SHS parts with predictable and affordable monthly fees.

Specifically, we recommend the following:

- The tambons should initiate collection of monthly fees for the maintenance of systems from the villagers.
    - Collect fifty baht per month as specified by the MOI
    - Collect an additional fee if basic maintenance must be performed, such as cleaning the system or adding distilled water.
    - Collect substantial additional fees if villagers use the system improperly (i.e. large television or incandescent bulb) as this decreases the life of the system.
    - Allow flexible payment or provide credit
- Train one to two villagers per village, in basic SHS maintenance, as village technicians.
    - Pay the village technician to collect fees and perform monthly checkups on the systems in the village.
    - For any part failures, these technicians can fill out warranty claim forms and give them to the tambon.

- Tambon should collect fees from all villages and use the money to purchase replacement parts as necessary.
    - In addition they must add the SHS to their budget and request matching funds from the MOI.
    - If they do not have enough money they should request additional funds from the MOI.
- Train one to two employees per tambon in the administration of the program.

As we discussed in the background chapter, in programs using a donations model for system distribution, long term maintenance is often a problem. This also is supported by Herbert Wade's experience with similar programs around the world. In our interview with Mr. Wade, he stressed the importance of a regular maintenance schedule for the ongoing functionality of the systems. In addition, he emphasized the fact that end user maintenance only works for a small set of technically interested users and should not be relied upon for the majority of SHS. (Appendix R). In addition, regular maintenance addresses the issue of a lack of urgency on the part of the villagers (Finding 6). Having a monthy checkup will make sure any failed system is up and running again promptly regardeless of the possible hesitation of the villagers to request repairs.

This reccomendation also addresses the lack of knowledge among the villagers about proper care, maintenance and warranties of the system, seen in Finding 1. The villagers, in general, are not knowledgable of warranties and regular system maintenance. Therefore, allowing a trained technican to take care of it regularly would help solve many issues. Targeted training of one to two technicians per village, combined with monthly checkups, will eliminate the need for village-wide training and improve the lifetime of the systems, as well as the turn around time for repairs.

The maintenance program will reduce costs for villagers. Seen in Finding 11, we found that the villagers have very limited resources with which to purchase replacement parts for their

systems. The monthly fee and government funding we recommend will cover the cost of repairs and replacements. This is better than the current situation where villagers would be required to pay for replacement parts as they break. Very few of villagers that we interviewed would be able to afford such immediate costs. In addition, shorter SHS downtime, due to the monthly checkups, will result in villagers spending less money on other energy sources, such as candles or kerosene, for light. The money that the villagers save on additional forms of lighting can be put towards their monthly maitenence fee.

In interviews with the PEA and DLA in Bangkok we learned that such a fee structure is already supported in the MOI, where each system owner would pay fifty baht per month and the tambons could request additional fuding from the MOI if needed. In our interview with Herbert Wade, we learned that similar programs around the world are sustainable with fees of two to three dollars per month (Appendix R). To match this level of funding it will be important for the tambons to request additional funding from the MOI for their SHS. Professor Wattanapong of the School for Renewable Energy Technology (SERT) stressed that the government should provide the needed funding, as it is their responsibility to care for the basic needs of the people (Appendix U).

Seen in Finding 7, we discovered that villagers were concerned that, with someone being paid to take care of the SHS, some households might not care for their systems. Implementing a program that rewards the villagers for taking care of the situation may remedy this problem. If a villager's system is not properly taken care of when the tecnician performs a monthly check-up, the tecnician would then charge an extra fee to perform the basic maitenence such as cleaning the solar cell and refilling the battery with distilled water.

In order to have technicains in each village, an organization would need to provide training. Villager training has occurred previously, as seen in the Tak Province where BGET has held two trainings for tambon employees and villagers. In addition, SERT has trained many groups in Thailand in the field of solar technology, including technicains and end users. SERT also trained the PEA in solar technology when the program first began (Appendix T, Appendix L). Thus, they would be a resource for providing these trainings.

Overall, implementation of a long term maintenance program will ensure that SHS are repaired beyond their current warranties. Establishing a plan for maintenance past the warranties will be vital to the sustainability of SHS in rural Thailand.

5.2.3 Implementation of long term recommendations

Due to the complex nature of the immediate, nationwide implementation of our recommendations, we suggest a small scale pilot program to test their effectiveness. We recommend that BGET sponsor this program in the Tak Province to test both the long term maintenance plan and the web application. This program would be subsidized by carbon offsets instead of the Thai government until the program is proven effective. In our second interview with Jamal Gore we discussed the possibility of carbon offset funding for such a program. He was enthusiastic and was interested in finding a way to make it work (Appendix W). This pilot phase would serve as a model for other tambons throughout the country that are responsible for SHS within their villages. After the completion and evaluation of this project the recommendations may be implemented nationwide with funding from a combination of sources such as the government, and carbon offset funding. In addition, through this pilot program, funding requirements necessary to sustain the program may be reevaluated.

5.3 Recommendations for Future Study

In addition to our short and long term recommendations we have provided some recommendations for future research in SHS sustainability. These are areas where, due to various constraints, we were unable to fully explore all of the relevant issues.

5.3.1 A comprehensive survey of all the SHS in Thailand should be completed.

During our research we were unable to find a survey of all the SHS in the country, or even a central database of the installed systems. A comprehensive survey of all the SHS should be conducted in order to fully assess the current situation. This survey could collect other information in addition to basic SHS status. According to Dr. Wattanapong, of SERT, the SHS for each area should be based on the load demand, lifestyle, and economic conditions of the users. (Appendix U). A comprehensive survey could include this information in order to identify potential options for the future. In addition, the current practices for disposing of failed SHS components could be investigated. Through our project it was brought to our attention that unsafe disposal methods for hazardous materials, such as lead could be occurring.

While we commend the PEA for working with a university to conduct a small-scale study in the future, a comprehensive survey of all of the SHS in Thailand is the only real way to be able to define the scope of the problem. The PEA is currently working with a university to do an in depth analysis on roughly one thousand SHS in Thailand (Appendix P). This study would cover less 1% of the total SHS in Thailand and a more comprehensive survey should be conducted to fully understand the scope of the problem.

5.3.2 The training of refugees as SHS technicians should be investigated.

Our sponsor, Chris Grecean, mentioned in an interview (Appendix V) that the training of refugees in SHS maintenance is a possibility to increase the number of trained technicians and

provide a maintenance service to the SHS owners at a reasonable cost. This is an idea that BGET and the United Nations have been working on. Refugees have been taught skills needed to run their own micro-enterprises, including bakeries and Karen to English translation services. Having refugees trained in SHS maintenance would provide the technicians needed for the villages surrounding the refugee camps. We recommend that further research into the legality of the refugees leaving the refugee area and implementation of this idea.

5.4 Conclusion

The strategy for sustainability of Thailand's SHS program was comprised of three sets of recommendations. The first set is short term recommendations, where we emphasize the urgent need for additional training sessions for the tambons and the re-notification of villagers about the warranty. The second set is long term recommendations, including the use of a web application to facilitate warranty communication and a long term maintenance program to keep the SHS functioning. These long term recommendations should be implemented in a pilot program in the Tak Province, and, upon evaluation, be expanded to all provinces in Thailand. Finally we made recommendations for future research including a comprehensive survey of all SHS in Thailand, and the possible training of refugees as SHS technicians.

Chapter 6: Conclusion

In conclusion, we have identified several findings and overarching themes that describe the problems that are a threat to the sustainability of solar home systems (SHS) in Thailand. We have found that villagers would like their systems to work, but their lack of urgency and limited knowledge of the warranty process has had an effect on whether or not the systems get fixed. At the next level in communication above the villagers, the tambons would like the systems to continue functioning but have limited resources to help with the program. The original implementer of the program, the Provincial Electricity Authority, will be pulling out in December of 2008 and has no extra money to subsidize SHS maintenance.

Our strategy will facilitate the improvement of the sustainability of SHS in rural villages of Thailand. Our short and long term recommendations include:

- The national government should hold additional training sessions for the tambons.
- Tambons should contact villagers again to notify them of their warranty rights and procedures for filing claims.
- A web application should be used as a centralized location for warranty requests to expedite the process of repairing malfunctioning SHS
- A long term maintenance program, funded by villages and the government, should be established in order to ensure regular maintenance and ongoing functionality of the SHS.

Some of these recommendations are very ambitious, and we recommend that they be implemented initially in a limited pilot program. They can be implemented in the Tak Province, where the Border Green Energy Team is already working to improve the sustainability of the SHS. The carbon offset company Carbon Clear has already indicated their interest in this potential project, and should be looked to as a resource for the finding of the pilot program. After evaluation of this project, the next step will be to expand these changes to the entire country.

Furthermore, there are aspects of the SHS program that we recommend for further research. In the limited amount of time that we had to complete this project these topics were not researched as in depth as we would have liked, and we feel that further research into these topics might improve sustainability. First, a comprehensive survey of SHS throughout the country is needed. We were only able to examine the current situation of four villages out of thousands, and a comprehensive survey is the only way to be able to determine the true scope of the problem. In addition, there is a potential for refugees to be trained as SHS technicians, and the complexities involved with doing so should be explored.

In conclusion, we investigated the problem of threatened sustainability of Thailand's SHS program. We have seen what can occur when people do not consider the future management of technology and have provided recommendations for utilizing the technological and human resources currently available to resolve the issues at hand. Our final developed strategy took common practices in other SHS programs around the world and applied them to the specific situation in Thailand. We hope that this work will encourage future studies into the SHS in Thailand, and that, when implemented, these recommendations will ensure that Thailand's SHS function as intended for many years to come.

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Appendices

I. Interview questions

Appendix A Interviews with Experts

Border Green Energy Team (BGET)

- What are your plans for when the warranties run out?
- Why didn't the postcard plan go through?
- Is there any incentive for the trainees?
    - Are they paid by the villagers?
- Where are technicians getting replacement parts from?

Bruce Countryman

- What are the problems with solar home systems (SHS) in Chang Mai?
- What alternative energy sources do you think people would use instead of their SHS?
- Would you believe organizations such as the World Bank would be a possible funding source for increasing SHS sustainability?

Herbert Wade

- What is your understanding of the situation concerning the sustainability of SHS in the Tak Province?
- What is the most successful (in terms of sustainability) SHS program involving government donations that you know about?
    - What made this successful?
    - Mexican government's work with donation SHS?
- In the paper "Monitoring and Evaluation of Solar Home Systems", it is indicated that end user maintenance rarely works, is there any case in which this has worked?
    - What are the best alternatives?
- What alternative energy sources do you think people would use if their SHS was not working?
- Would you believe organizations such as the World Bank would be a possible funding source for SHS related stuff?

Jamal Gore

- What is Carbon Clear's interest in BGET's work in the Tak Province?
- What are the characteristics of a good carbon offset program?
- Are there any thresholds that need to be reached for each category of requirements? (emissions additionality, investment additionality, sustainable livelihood benefits)
- Have you sponsored any similar programs elsewhere in the developing world?
    - What are the specifics of some of these?
- Who would carry out the validation of the SHS?
- What is the process for getting carbon credits?

Jamal Gore, Second interview

- What information would you be interested in seeing in the web application?
- Would the routine checks by a technician and regular updates prove the functionality of the SHS?
- How is it possible to verify the number of emissions offset?
- Is there a possibility of a trial period? (trial in one province)
- What is the percentage of time does a SHS need to work over its lifetime in order to produce carbon offset funding?

School of Renewable Energy Technology (SERT)

Questions for Prapita Thanarak, PhD

- What are SERT's plans and what has already been done w/ regards to the SHS?
- What are the major problems that you believe could affect solar sustainability?
- Have you worked previously with solar home systems in rural villages? (besides your dissertation?)
- What about trainings with the PEA? They indicated that SERT trained their Technicians?
- In your opinion what needs to be changed to ensure the sustainability of the SHS?
- Is there anything else you would like to add?

Questions for Dr. Wattanapong

- What has your experience been with rural electrification in Thailand
    - Elsewhere in the world?
- What are the good / less than ideal practices used in this SHS program?
- Do you think that the Government would be willing to provide additional funding of the program?
    - MOI / PEA?
- What is your opinion of the SHS instillation throughout the country?
- In your opinion what needs to be changed to ensure the sustainability of the SHS?
- Is there anything else you would like to add?

Appendix B Interview Questions for Government Organizations, Private Companies and Villagers

Department of Local Administration (DLA)

- What is your role in the solar electrification program?
- How do you feel about the electrification program?
- Do you have any involvement with the SHS now?
- What do you know about the warranty and how it is requested?
- What is your relationship with the SHS companies?
- What you like to see happen with the SHS?
- How was ownership of the SHS transferred to the tambons?
- How do inform the tambons of new rules?
- How well was the SHS program implemented?
- What do you feel needs to be done to sustain SHS?
- Where will the money come from to support the SHS?
- Do you have any long term plans once the PEA stops running it?

Provincial Electricity Authority (PEA)

- Do you have any involvement with the SHS now?
- How was ownership transferred to the tambons?
- Has there been any contact with the tambons since then?
- How did you understand the contract with the Solartron?
    - Would the government would provide the systems and the villagers would maintain them independently?
    - Was there some maintenance plan in place?
    - Were the minimal checkups and maintenance combined with the thought to be warranties sufficient?
- Is there a database of all SHS?
- How has your relationship been with Solartron?
- Is there funding that could be provided for spare parts?
- What energy sources do you think people would use instead of their SHS? (alternative or otherwise)
- How much is average consumption for villages that are connected to the grid per month?
- How much does an average villager connected to grid pay for their service per month?
- How did the SHS program begin?
- What were the outlined goals of the program?
- What were other options that were considered in electrification of rural villages?
- What is the plan for electrification 5 years from now?
- What are the major problems that you believe could affect solar sustainability?
- Other contacts?
    - Tak / Chang Mai provinces

PEA, Second Interview

- How many training sessions have occurred in each province and are there any refresher courses?
- What do the SHS training programs consist of and who attends?
    - What happens after the trainings?
    - Do the trainees check on the systems?
- How do you communicate with the Tambon offices regarding warranty service?
- How do you contact the installation companies to initiate warranty service?
- What kind of maintenance or checkups on the systems by the PEA occur?
- What is the PEA's relationship with Solartron and other installation companies in other provinces?
- What will happen to the broken systems once the warranties run out?
- Could the PEA/MOI provide any funding for spare parts after the current stock has been used up?
- Could the PEA/MOI provide any funding to subsidize monthly/bimonthly/quarterly maintenance?
- Would a web-based application that to facilitate communication between the PEA, Solartron, Tambons (who contact the villagers), and technicians be beneficial to the long term sustainability of the SHS?

Solartron and Acumen (Installation Companies)

- What are your plans for when the warranties run out?
- Where have the warranties come from? And can we see data?
- What was provided for the ongoing functioning of systems?
- How many warranties have they received?
- Is there any plan for future work with the government?
- What is the cost for SHS replacement parts?
- How much would it cost for a representative to check SHS?
- Would it be possible to offer replacement parts for credit?
- What are the major problems that you believe could affect solar sustainability?
- What were the results of the follow-up checks on the SHS?
- Other contacts?
- What is the ideal schedule of maintenance for your systems?

Tambon Offices

- Do you communicate regularly with villagers?
    - How?
    - How often?
- Do the villagers contact you?
    - How?
    - How often?
- Are there computers available for the villagers to use?
    - How much does it cost to use them?
- Are there telephones available for villagers to use?
    - How much does it cost to use them?
- How often does the postal service come?
- How did the SHS program begin?
- What were the outlined goals of the SHS program?
- What is the extent of your involvement with the SHS now?
- How did the PEA transfer ownership of the SHS to you?
    - Has the PEA worked with you since them?
- Is there any money to purchase replacement parts or offer credit?
- Are there spare parts that could be used for replacements?
- Where can we find the income of an average villager?
- What is the average expenditure of villagers on energy (on grid / off grid)?

Villagers

- What do you use your system for?
- Is your system working now?
    - What is wrong with your system?
    - Would you like your system fixed?
- Has your system stopped working in the past?
    - What did you do?
    - Who did you contact?
        - Did you contact tambon / PEA?
    - Was it fixed?
    - Who fixed it?
- Have you ever tried to fix your system yourself?
    - Has someone in your family tried to fix it?
- Did someone tell you about the warranty?
    - Who told you?
    - Have you applied for the warranty?
        - How did you do this?
- Do you communicate with the tambon?
    - How?
    - How often?
- Does the tambon contact you?

    - How?
    - How often?
- Do you go to the tambon office?
    - Do you use the computers in the tambon office?
        - Do you use the Internet?
        - What else do you use the computers for?
    - Do you use the telephones in the tambon office?
- What would you use if you didn't have the SHS for lighting?
- If you had to pay someone to come and fix your SHS, would you?
- How much kerosene and other lighting did you use before you had the SHS?
- How much kerosene do you use at home when the SHS is working?
- How much do you pay for kerosene?
- If you had the option of buying electricity from the grid, would you use it?
- Would you pay a monthly fee to have someone take care of your SHS?
- Do you have any questions about your system?

II. Interview Summaries

Appendix C Tak Province Villager Interviews – General Information

January 18-19, 2007

Village 1: *Goudatah* (กู่เตอทะ)
Village 2: *Khun Huay Mae Thaw* (ขุนห้วยแม่ท้อ)

Village	House	Use SHS for?	SHS Status?	Know of warranty?	Communicate with tambon?	Use computer at tambon?	Would want grid?	Pay for fixing?	Pay Monthly Fee?
1	A	Lights, TV,CD, cassette	Never broken	Yes	Goes to office 2-3 times a month	No	Yes	Yes	Yes
1	B	Lights	Broken Now	No	No	-	Yes	Yes	Yes
1	C	Lights	Broken Now	No	No	-	Yes	Yes	Yes
1	D	Lights	Fixed Before	No	No	-	Yes	-	100฿ for everything; 50฿ for just maintaining
2	E	Lights, radio	Broken Now	No	No	No	-	Yes	200฿
2	F	Lights	Never Broken	No	No	-	-	Yes	300฿
2	G	Lights	Broken Now	No	No	-	-	Yes	20฿
2	H	Lights, TV	Fixed Before	Yes	Goes to office once a month	No	-	Yes	100฿
2	I	Lights	Broken Now	No	No	-	-	Yes, 100-200฿	50฿

A) Male, Vice-Head of tambon

Questions:

- Can other types of power be produced?
- Can the PEA produce power from the waterfall 1 km from there?

Other Comments:

- Goes to tambon office for work, and is sometimes contacted by tambon.
- Doesn't know how to use a computer.
- If fixing the SHS is a low cost, then he can afford it, but believes most people can't afford it.
- Says that when villagers get power, they are happy, but then they want more power for more appliances. He would be happier if he had more power. If he had access to more power, he would like more power for a refrigerator and rice cooker.
- A problem is that for the first installations, some of the warranties for the battery have already expired and some people can't afford to replace it.

B) Female

Questions:

- How/what can she do to have her system working again?

Other Comments:

- If fixing cost less than now, then would pay, since sometimes she can't see with the candles
- She would like to try again, even though people didn't come the first time.
- Only asked for help once, sing thought once would be enough.

C) Female

Questions:

- Where did money that the government invested in program come from?

Other Comments:

- Uses light for gathering, reading at night, staying up with kids
- Was told by installer if something was broken to tell awbawtaw [synonym for tambon] people

D) Male

Questions:

- If grid comes to village, would they take the system back?
- If not, could he move it to the rice patty to use for a couple months? (for light to work by)

Other Comments:

- Heard of battery explosion in other villages and thought it occurred because of too much sunshine. He was afraid of that happening. His concern is safety, and if a person (coming to take care of the SHS) can make sure explosion won't happen, then would go for having the SHS maintained. As long as the SHS is not close to people, then not as worried.

E) Female

Questions:

- If she moves out of her family's home, would she be able to ask for another system?

Other Comments:

- A month ago, the staff at tambon office came and had meeting at the village and told all villagers if system broken to tell a tambon member

F) Female

Questions:

- None

Other Comments:

- Was told by tambon representatives to contact tambon representative if system broken

G) Male

Questions:

- None

Other Comments:

- Would pay for replacements if not too expensive.

H) Male, Head of Village

Questions:

- How much does one panel cost?
- How are micro-hydro systems distributed?

Other Comments:

- Was told by Solartron technician about warranty on the battery (2 years) and solar panel (5 years) when he came to fix the SHS
- Doesn't know how to use computers.
- Satellite phone system put in 24 years ago that just stopped working last year
- Village also has solar battery charging station, in addition to SHS

I) Female

Questions:

- How long can the SHS be used for in general?
- Is her SHS going to be fixed?
- What happens if something breaks for people with SHS that work?

Appendix D Tak Province Villager Interviews – Failed System
January 18-19, 2007

Notes: Rainy season refers to June/July months

House	SHS Broken Now?	SHS Ever Broken Before?	Want SHS working?	When Broken?	What was/is wrong?	What did he/she do to fix it?	Who was contacted?
A	No	No	-	-	-	-	-
B	Yes	-	Yes, wants it working, when not working gets frustrated	Last rainy season	assumed rain got into it, lights acted weird, now not working	- inverter broke first, charge controller works, - still charges battery, bought incandescent light and connected it to battery - charger not working now, tried to connect to DC (battery) now not doing anything	- employee of tambon took information (name and house number) - doesn't know if actually reported to office - reported soon after broken, has not asked again
C	Yes	-	would rather have system work all the time instead of intermitten tly working	- system installed a year ago - after a month the problem started	couple times a day system won't work, turns switch on and off to get it to work	Did not try to fix anything	- told the member of the tambon, he came and collected information, nothing happened after that - first time told them, Solartron came to fix other people's but did not come to her house - never attempted to inform anyone else
D	No	Yes	-	Last rainy season	Inverter damaged and one light wasn't working	-	- informed tambon member once, guy took information - took a month before fixed by company
E	No	-	-	-	-	-	-
F	No	No	-	-	-	-	-
G	Yes	-	Yes	1-2 weeks ago []	One light doesn't work	-	Haven't contacted anyone but plans to contact tambon representative
H	No	Yes	-	October	Light and inverter broken	- Purchased fluorescent light - BGET trained person couldn't fix it	- Contacted tambon representative - SHS fixed in a month
I	Yes	-	-	2-3 months ago []	Something sparked behind the panel and in	- Battery was disconnected - Did not try to fix anything	- Contacted tambon representative - Tambon representative did not

	the house near light	collect any information

A) –
B) **Diagnosed problem:** Battery rewired wrong and solar panel diode had failed
Solution for problem: Since the system was already not under warranty because it had been modified, the failed diode was removed and an alarm muted to allow lights to be used
C) **Diagnosed problem:** Intermittent switch problem
Solution for problem: Warranty already voided
Other comments: Wants system working, when not working gets frustrated
D) **Diagnosed problem:** Inverter was damaged and one light was not working
Solution for problem: Repaired but now warranty voided
E) **Diagnosed problem:** New, purchased light not working
Solution for problem: New battery not compatible
Other comments: Used a second battery, DC light, and controller from another program a year ago that requires her to charge the battery
F) **Other comments:** No problems experienced.
G) **Diagnosed problem:** Light bulb/ballast incorrect
Solution for problem: -
Other comments: Would like system working.
H) **Other comments:** Technician from company came last year and fixed 8 houses (including his), and the 9th house was not fixed since no one was home
I) **Diagnosed problem:** Polarity had been reversed on battery
Solution for problem: -
Other comments: Would like system working.

Appendix E Tak Province Villager Interviews – Energy Use
January 18-19, 2007

Notes: Cost of kerosene estimated by Salinee is 30฿ per can (1 liter = 3 cans)
Candles used are paraffin, 5฿/candle, 10cm long

Interview	Use without SHS	Amount used without SHS	Stated Cost (baht)	Amount used with SHS	Stated Cost without SHS (baht)
A	kerosene lamp	1 can every 1-2 wks	-	none	-
B	candle	-	10 ฿/ night, but sometimes only 5฿	none	-
C	kerosene lamp	5 liters per month	-	none	-
D	kerosene lamp	10 liters for 4-5 months	-	none	-
E	candle	3-4 a night	-	Less than 1 candle a night	-
F	Candles (kerosene rarely)	1 pack candles every 2 weeks	-	-	-
G	candle	1 pack every 3-4 days	10฿ per pack	-	-
H	kerosene lamp	5 liters every 2-3 months	-	none	-
I	candles	1 pack every 2 days	10฿ per pack	-	-

Appendix F Tak Province Energy Calculation

January 18-19, 2007

Interview	Use without SHS	Amount used before SHS per month	Cost per month (baht)	Amount used after SHS per month	Cost per month (baht)	Cost Difference (baht)	Pay to fix?	Monthly fee (baht)
A	kerosene lamp	1 liter	30	none	-	30	yes	-
B	candle	22.5 packs	225	none	-	225	yes	-
C	kerosene lamp	5 liters	150	none	-	150	yes	-
D	kerosene lamp	2 liters	60	none	-	60	-	100
E	candle	3 packs	30	1 pack	10	20	yes	200
F	kerosene lamp and candle	2 packs	60	-	-	60	yes	300
G	candle	10 packs	100	-	-	100	yes	20
H	kerosene lamp	2.08 liters	62.4	none	-	62.4	yes	100
I	candles	15 packs	150	-	-	150	yes, 100-200B	50
		Average:	96		**Average**:	95	**Average**:	128

Appendix G Chiang Mai Province Villager Interviews – General Information
February 5-6, 2007

Village 1: Hoi Som Poi 1
Village 2: Hoi Som Poi 2

Village	House	Use SHS for?	SHS Status?	Know of warranty?	Communicate with tambon Representative?	Go to tambon office?	Use computer at tambon?	Would want grid?	Pay for fixing?	Pay Monthly Fee?
1	J	Lights, TV	Never Broken	Yes	-	Yes	-	Yes	Yes, 200-300฿	Yes
2	K	Lights	Broken Now	-	-	-	-	-	-	-
2	L	Lights, TV	Broken Now	Limited Knowledge	Yes	No	No	-	Yes, 200-300฿	Yes
2	M	-	Broken Now	-	-	-	-	-	-	-
2	N	Lights	Broken Now	No	Yes	No	-	-	Doesn't know	Yes, 50฿ ok
2	O	Lights, TV, radio	Broken Now	Limited Knowledge	Yes	No	No	-	Yes, 100-200฿	Yes
1	P	Lights, TV	Broken Now	-	-	-	-	-	-	-
-	Q	Lights, TV, radio, CD	Never Broken	Yes	Yes	Yes	Yes	-	-	Yes
-	R	Lights, TV	Never Broken	No	Yes	Yes	-	-	Yes	Yes

J) Male, Noi

Other Comments:

- Some houses can't use TV, but the lights are fine
- People in village are happy they received the SHS for free
- Some know and some don't know what to do if system breaks. They don't know who to talk to. The people come to Noi because he understands the micro-hydro, but he can't really do much.
- Tries to tell people micro-hydro cost 20฿ is less than the 30฿ they pay in candles, but people don't always understand.
- Understands that the cost of the grid depends on how much it is used (TV, stereo, laundry cost more) Some houses wouldn't be able to use it because they are too poor, and they need to be told to use less, which they understand.
- Heard grid is coming to village, since another village in an adjacent national forest is getting the grid. There is hope for the grid, even though one national forest department won't allow, since they could potentially come a different way.

- Don’t know if people would help pay for those unable. For micro-hydro, already pays for those who can’t afford it, keeps a bill, and receives payment within a week later. In the city, if you don’t pay, they stop the electricity. You have to help yourself. People can’t always work though. In the rainy season there is lots of work since people hire others to help, while in the dry season there is not much work.
- Last year left papers [referring to the BGET warranty papers that Bruce Countryman had filled out in a survey of the villages’ SHS] at tambon office, and thought maybe they had lost the papers. This was because previously he had given them papers to get paid for cooking at the school, but was called and told they didn't have them. They had to be resent.
- People only ask once because they "take it easy".
- Believes there are people like him, who would be willing to care for electric technology, but they would have to be trained first.
- Chief and tambon representative go to meetings at tambon office, then come back and have a village meetings. At village meetings they talk about important problems, such as to be careful of fires and that they're getting a new road. The SHS are not considered important now, although when micro-hydro stops it will be.
- Villagers spend approximately 1,000฿ per month on food
- There was a micro-hydro built nearby that the villagers use for electricity. Pays nothing because he cares for the system. Taught simple maintenance, and doesn’t understand how to fix the system. Contacts a mechanic in Chiang Mai when broken, and villagers only pay for parts. Checks meters in houses and people pay people pay 20-30฿ per month. Each month money is pooled; ½ goes to the hydro company [“Palang Naam”], ¼ goes to Noi and ¼ goes to Kham [another villager]. Once when it was broken, he advanced part of the money to pay for a part, and now takes a portion when he collects fees. Says the micro-hydro is the village’s; everyone uses it, and he is not concerned about repayment.
- Thinks maybe 20 SHS broken out of 123. Knows that SHS were put in and now there is no help.
- Tambon takes money from village to make up difference in community projects, such as making the roads. Villagers pay different amounts depending on their economic situation. They "just know" how much they should pay.
- If he had to pay to take care of system, he thinks it would help, but knows some people don't have enough and would pay less.
- Thinks people want SHS when micro-hydro not working.
- Villagers would pay certain amount per month for maintenance, but would need to talk with leader first.

K) Female

Other Comments:

- System installed 22/7/49; was identified by clearly written numbers on board
- Woman didn't know house number, and had to ask her son.

Note: Interview was incomplete

L) Male

Questions:

- Doesn't understand why SHS is broken.

Other Comments:

- SHS was installed 2-3 years ago.
- The installer told him the battery had a warranty for 2 years and that it was supposed to be filled with water.
- If everyone will pay monthly fee then he will.
- SHS was installed 2-3 years ago

M) Male

Other Comments:

- SHS was 1 year, 5 months old

Note: Interview was incomplete

N) Female

Questions:

- Doesn't know how to ask what is wrong.
- Doesn't know what the problem is.

Other Comments:

- Moved solar cell to under house because it didn't work and she was building a new home.
- SHS was 7 months old.
- When SHS was broken, it was used for one hour in the morning and none at night.
- Has SHS manual, but hadn't read it.
- If cost of replacement was too much, then couldn't pay.
- Had known to fill battery previously.
- [In response to monthly payment suggestion of 50฿] Some months could afford, but couldn't afford all months. Believes if good quality SHS then wouldn't have to pay much, but bad quality would need to pay more.
- Pays 30-50฿ per month for the micro-hydro. Keeps track of usage and pays accordingly.

O) Female

Questions:

- Doesn't know how to ask for system to be fixed.
- After warranty ends, then what happens?

Other Comments:

- Clothes had been left on battery and it needed to be cleaned.
- Doesn't want a small light; would prefer the larger ones.
- Doesn't know which parts are under warranty and how long they last.
- Was taught to put more water in the battery, but doesn't refill it.

P) Female

Other Comments:

- SHS was 2-3 years old.
- Every morning there is news on a loud speaker, where she heard she should tell her tambon representative if is broken, but still hasn't.

Note: Interview was incomplete

Q) Male, Vice President of Tambon

Questions:

- Doesn't know how to ask for system to be fixed.
- After warranty ends, then what happens?

Other Comments:

- Checks water in battery.
- Bulb broke once, but he bought a new one.
- All villagers can inform the tambon, where there is a mechanic. If SHS is broken, the tambon will tell mechanic and mechanic will tell PEA, who will send someone from the company.
- Four months ago the PEA and Solartron came to the village find which SHS work, collect warranties, and repair systems. No repairs have been done so far, since no one has sent in papers. Villagers can ask tambon representative and chief for help, and the tambon representative has the papers. There is one for each household to fill out. These are collected, and a cover letter is signed by chief and sent by the tambon representative on the 10^{th} of every month, and the tambon office keeps them until the 15^{th}.
- Knew about the warranty from government. A government official was sent to talk to him.
- The SHS are another tambon representative's job. They often have meetings . At tambon office they talk about collecting money, but wonder where they will collect the money. The tambon office hasn't told people yet, and they need to have the villagers understand there are only 5 years left.
- Afraid that some people will not take care of system. He wants every home to take care of SHS.
- When the installer comes, the tambon representative for the SHS came around with him to translate.
- Goes to tambon office 3 days a week.
- Uses computers to type reports. Doesn't use the internet. It is now broken at the office because they are fixing a room for 5 months. It should be done in a month. There was no problem before. Maybe people use it, and everyone can use the internet. He uses use telephones or fax.
- The warranty forms are sent to company by one man in main office who takes the forms. At the PEA, they sign that they've received the paper.
- Would pay monthly fee for maintenance, but first wants people to look after system for themselves.
- The PEA trained tambon members, one or two years, same person, then change people.

R) Male, Chief of Village

Questions:

- If finished warranty, is there a project that will help?

Other Comments:

- Never heard of how many years left in the warranty. Just knows if broken has to ask.
- [In response to the question, would people be willing to subsidize those not able to pay as much] It is not the same as micro-hydro, where entire village is responsible. SHS is per house, where every house is responsible. What if one house did not take care of it or look after it well?
- People only came to teach the second time when the SHS were installed.
- TV doesn't work with new systems.
- Uses SHS when micro-hydro doesn't work. SHS used more and important during the dry season when micro-dydro does not work.
- [In response to the questions, if there was a pay per month, would people care about their SHS?] If everyone pays in village than ok, 10฿/month.

Appendix H Chiang Mai Province Villager Interviews – Failed Systems

February 5-6, 2007

House	SHS Broken Now?	SHS Ever Broken Before?	Want SHS working?	When Broken?	What was/is wrong?	What did he/she do to fix it?	Who was contacted?
J	No	No	-	-	-	-	-
K	Yes	-	-	2 days ago	Light doesn't work	-	-
L	Yes	-	-	3 months ago	- noise problem - no lights	- didn't try to fix - just disconnected wires	- told tambon representative, who said needed to fill out form and give back - didn't fill out form because tambon representative didn't give him the paper - nothing else was said, even though they saw each other
M	Yes	-	-	2 months ago	Noise problem	- friends disconnected battery to stop noise	-
N	Yes	-	Yes	-	-	- moved it to under her house 2 weeks ago	- talked with tambon representative once, 3-4 months ago - he came to take paper to the office
O	Yes	-	Yes	A few months after installed	Switch broken	-	- told tambon member over a year ago - when asked a second time why system wasn't fixed, tambon member told her there was no warranty
P	Yes	-	-	Over a year ago	-	Bought a new ballast [at Bruce Countryman's suggestion] but it still didn't work	- Told Noi and Bruce, but no one else
Q	No	No	-	-	-	-	-
R	No	No	-	-	-	-	-

J) –

K) **Diagnosed problem:** light/ballast problem or switch problem

L) **Diagnosed problem:** battery and solar cell were disconnected to make noise stop; the battery was dead, since while the solar panel was giving current, it was not charging

M) -

N) -

O) -

P) **Diagnosed problem:** ballast not working

Q) –

R) –

Appendix I Chiang Mai Province Villager Interviews – Energy Use
February 5-6, 2007

Notes: Sap refers to pieces of wood soaked with pine sap that is found by the villagers and used for heating and light.

House	Used without SHS	Amount used without SHS	Stated Cost (baht)	Used with SHS	Stated Cost without SHS (baht)
J	candle and sap	?	30-40 per month, 1 per candle	-	-
K	-	-	-	-	-
L	candle and sap		20-30 per month	Micro-hydro	-
M	-	-	-	-	-
N	candle and sap	Mostly sap	0	-	-
O	candle and sap	-	30-40 per month	-	-
P	-	-	-	-	-
Q	candle and sap	-	100 per month	none	-
R	candle and sap	-	100 per month	-	-

Appendix J Chiang Mai Province, Tambon Representative Interview
6 February 2007

Location: *Hoi Som Poi 2*
Interviewee: *Tambon Representative*

- Knows if a household has broken SHS then the owner is to fill out a form and the form is to be given to the Tambon head
- Some villagers have told him that their SHS didn't work
    - Doesn't remember how many
    - He hasn't given them the appropriate forms
    - Tells villagers not to fix systems, just fill out forms and he will give them to Tambon head
    - He has sent some papers but no mechanic has come
- First time Solartron came to the village
    - Explained how warranty works
    - How many years the warranty is valid for
    - Now that warranty is finished, Solartron will not come again
- Second time Solartron came
    - Systems are breaking
    - Company is closed
    - Same type of warranty for new parts
- People might be willing to pay for maintenance, Doesn't know because it costs different costs to fix different broken parts
    - Might pay for monthly maintenance
    - Would pay for one time fixing of system if out of warranty
    - Payment would have to be subsidized, only 1500-3000฿ per owner per system is affordable
- Was told SHS would stay in their villages until the grid comes
- In rainy season uses micro-hydro
- Many villagers work making roads or dams
- No person in tambon in charge of SHS, everyone is very busy designing and constructing roads
- Mechanic doesn't understand SHS
    - Knows to send form to PEA
    - Uses internet

Appendix K Tak Province, Sam Muen Tambon Interview
January 18, 2007

Location: *Sam Muen* (อบต สามหมื่น) *Tambon offices*
Interviewee: *Rotchana Phanthip*

- There are currently about 785 SHS in this tambon and more are still being installed. The tambon manages these SHS.
- The tambon became first involved with the SHS when the Ministry of the Interior sent a letter transferring ownership of the SHS to the tambon.
- The PEA has worked to have more SHS installed since the transfer of ownership.
- A letter describing how to file the warranty claims was sent from the PEA to the tambon.
- Initially BGET informed the tambon of the warranty process.
- Using word of mouth, only the tambon informed the villagers of what to do in the case of a failure.
- The tambon has no long term goals for the SHS program and apparently higher level government doesn't as well.
- The tambon office employees go to the village whenever communication between the two is needed. Whenever the villagers need to contact the tambon they talk to the village tambon representative who travels to the tambon in person. Contact between the two occurs approximately 10-20 times per month. The traveling is due to the absence of postal service as well as the language gap. The office employees do no speak Karen, the villagers' language, so the tambon representative translates via word of mouth.
- There are village meetings once per month where general information can be distributed, such as what to do when the villagers' SHS fails.
- This tambon has regular contact with other tambons.
- There are freely available computers with internet access at the tambon. However, phone service is not provided.
- The income of an average villager within this tambon is approximately 20,000฿ per year per working person.

Appendix L Tak Province, PEA Engineer Interview
January 18, 2007

Location: *Sam Muen* (อบต สามหมื่น) *Tambon offices*
Interviewee: *PEA Engineer*

- Professors at SERT trained the PEA in the Tak Province in SHS maintenance and repair.
- The PEA is having meetings, trainings on how to use, and is maintaining systems.
- The PEA's first training occurred in September 2005 for tambon civil engineers and end users.
- Final training to conclude and refresh first trainings to occur in February 2007.
- What is covered in the trainings:
    - Overall system and how SHS works
    - How much power the SHS can supply
    - Simple checks / LED status light familiarity
- There are no regular visits to SHS by the PEA.
- Currently Solartron is fixing systems that are under warranty.
- In the future tambons should contact Solartron directly instead of the current practice of the tambon contacting the PEA, who relays it to Solartron, who performs the repairs.
- After the warranties expire the PEA has some spare parts. The exception is battery replacements.
- Villagers will have to pay for replacements after warranties and spare parts run out, if they can afford it.
- The PEA could allocate a budget for SHS at the tambon level.
- Currently the replacement parts aren't available locally for purchase, so villagers can't easily replace broken parts of the SHS.

Appendix M Tak Province, Sam Muen Sub-District Interview 2
February 15, 2007

Location: *Sam Muen* (อบต สามหมื่น) *Tambon offices*
Interviewee: *Rotchana Phanthip*

From phone interview in Thai then transcribed and translated to English by Salinee Tavaranan

Q: Has the tambon talked to Solartron directly?
A: No.

Q: After forwarding the warranty request to the PEA/Solartron, was the tambon notified when repairs were going to happen and/or after they occurred?
A: No.

Q: What other responsibilities does the person in charge of the SHS program have?
A: Administration, content, and responsible for the tambon Internet.

Q: What portion of her work is in the SHS program?
A: About 20-30% of her time.

Q: Computer and Internet usage and comfort of the person in charge of the SHS system: What computer programs does she use? Microsoft Word, Excel, etc?
A: MS Word, Excel, Power Point, and Photoshop.

Q: What websites does she go to? Google, Hotmail, etc?
A: Google for searching, Thai Local Administration website for data searching: http://www.thailocaladmin.go.th/index.jsp

Q: Does she use e-mail? If so, how often does she check it?
A: No, but she used to. The account was closed because she didn't use it.

Q: Would a website to submit a warranty or repair request to PEA and Solartron be helpful?
A: Yes, but the problem is the internet there is really slow. She said if the internet speed is faster it would be better to submit the warranty on the internet than to mail it.

Appendix N Chiang Mai Province, Doikeaw Tambon Interview
February 6, 2007

Location: *Doikeaw Tambon offices, near Chom Thong*

Interviewee: *Yonoyut, head of tambon*

- When the warranty expires the tambons are responsible for the SHS and their problems. The problem with the tambons' responsibility for the SHS is that there is not much money available to spend on maintenance and replacements. Hopes that we come up with a solution.
- The money will have to come from upper levels of government.
- If SHS mechanics come to maintain SHS, the tambon is willing to work together with them.
- The government sent SHS responsibilities to the tambon and now believes the tambon is entirely responsible.

Interviewee: *Chan Khasem, tambon civil engineer*

[Warranty forms from PEA presented]

- Process of warranty reclamation:
    - Owner fills out form, gives to tambon office
    - Tambon office gives to installation company
    - Installation company gives paper back to tambon
    - Tambon civil engineer and installation company technician go to the village to check the SHS and figure out what wrong and fix it
- Purpose of sending forms to PEA is to put pressure on Solartron.
- Before: villagers did not know where to contact.
- Now: villagers have papers, and talk with the tambon representative in village.
- Some houses still without or want SHS.
- About 350 out of 400 potential homes have SHS within the 9 villages in the tambon.
- Papers sent October 27th, 2006 and received November 2nd, 2006.
- There is now a problem he needs to solve: The first installation was in 2004, and the battery and inverter are now out of warranty.
- It is expensive for villagers and if many SHS fail, the tambon will not have enough money to fix them all.
- Accidents are not covered in the warranty.
- Contacted PEA office in Chom Thong and didn't receive contact back. He later got warranty information papers from PEA.
- Received some forms from villages, and now wants to receive more before sending to the company, waiting until the 15th of each month. This is because the company would not take forms until more arrived from villagers. He is waiting until every village has sent forms so he can go to Solartron with a large group of forms. On the 15th will send in whatever has come in each month.
- Didn't send them Jan 15th because had only 3 villages forms, but wants to send them in February no matter what.

- A problem is that he has to send forms to the installation company that installed them.
    - 1st company was Acumen
    - 2nd company was Solartron
    - so tambon has to figure out which company to send claims to
- Wants to find out more about the warranty claim then the tambon would talk to acumen, but they hasn't done so yet.
- Tambon only contacts Acumen by telephone.
- Tambon only got pamphlet from Acumen**.** Neither Acumen nor PEA came to train so had to study by himself.
- Tambon doesn't often contact other tambons since they are a far distance away
- Tambon uses the Internet, but now it is broken.
- Uses Excel, Word, Google, Hotmail (but not for work).
- Having a web application for the SHS coordinating communication and status would make it much easier and faster.
- This year no extra money in budget for SHS program because the small budget in general, many villages, and many projects needing funding.
- The tambon has no spare parts.
- He is also in charge of planning the roads, creating construction laws, and the digging of wells for farms.
- If we could have someone come in and look after system or train tambon employees to be able to do the maintenance, it would be better, since company is too slow.
- If only a little bit broken, perhaps someone else could fix the SHS.
- Civil engineer's opinion of SHS: helps villagers have light at night and renewable energy is good.
- Wants a small budget from the tambon for less expensive parts of the SHS, but batteries are expensive so would have to get external funding for them.

Appendix O Tak Province, Interview with the PEA and Solartron at Training
January 22, 2007

Location: *Conducted by Salinee Tavaranan on behalf of the WPI Solar Sustainability Team.*

PEA and Solartron training intended for one Tambon representative from each Tambon in Tak Province. This training happened once before. The training was from 9:00 am to 12:00 pm. It was the closing SHS program training.

- The trainings covered:
    - Purposes of the program
    - Program results from PEA
    - Installation and maintenance
    - And passing on the system possession to the Tambon offices

The Marketing Executive from Solartron covered the maintenance section including overall system components, how to use, maintain, trouble shoot the systems, what are under warranty, and what constitutes a voided warranty.

The information and answers from the training follow:

- Tambon responsibilities to SHS:
    - Collecting information from broken systems
    - Check the broken system and find what caused the problem
    - Provide the correct information on how to use and maintain the systems to the villagers
    - Ability to install a system in case that if the system needs to be moved they can move it

Q: What has PEA planned to help when the warranty expires, especially the earlier installation (2 years for battery) has expired already?
PEA: There is no plan in place yet. It depends on the new government's plan for SHS.

Q: What about the spared parts that PEA has? Can Tambons have access to use these as a replacement?
PEA: No. The PEA only has less than 0.25 % of the total of systems, not including the battery. They have to be exceptional cases that they will be able to use these parts as the replacement, such as the house burning down.

Q: What happened to the reported broken systems during rainy season. Solartron claimed that they can't reach those villages in 2-3 months because of the road condition. Some parts and systems warranty expired in the same period?
Solartron: If the systems have been reported before the expiration. Solartron will follow up and still fix them after the rainy season.

Q: According to the contract between the PEA and Solartron, the installers, if installers won't fix the reported broken systems in 7 business days after receive the information, installers will have to pay 200฿ fee/system/day to PEA. Has this been taken to action?

Solartron: Since the early contract, this part of the contract has been revised from 7 days to one month, which is a feasible time period for Solartron to fix the broken systems.

Q: What will happen if the area that has SHS later on also gets grid power?

PEA: The systems belong to tambon, so they can decide on what to do about them. They could remove it and use somewhere else, or combine them together to use for anything in the same village, or they can use it in the office for themselves... It's up to each Tambon to decide.

- Other general information:
    - If the villagers want to move systems that are under warranty, they have to inform the Tambon and Solartron so as not to void the warranty.
    - If the system has been stolen, they have to file the charge at a police station because it's government property.
    - After the program finishes, the tambon has to report the broken systems directly to Solartron, not through local PEA as previously done.
    - Solartron says that deep cycle batteries will be available in the market in March.
    - Anyone can buy the new inverter from Solartron for 4,500฿, after warranty expires.
    - Anyone can get an inverter fixed for 1,000฿/inverter for one time but no warranty after fixing it. For example if it's broken again after 2 weeks, you have to pay another 1,000฿ to get fixed.

According to Salinee it seems that the PEA doesn't have a plan for after the installations and warranties expire but Solartron does seem to have their marketing plan figured out.

Appendix P Interview with PEA
February 9, 2007

Location: *Bangkok PEA office*
Interviewee: *Narin*, *head of SHS program*

- Established communication
    - Since PEA transfer ownership to tambons the order of repair communications should go villagers to the tambon to the installation company.
    - The tambons should fax claims to the company and PEA as a record.
    - Local offices may not have fax, so may use telephone.
    - Tambon does not need to wait for sufficient forms to send them on like some have been told by the installation company.
    - By contract the company must visit the site within 7 days of receiving the forms.
    - This was a rushed program and PEA didn't train tambon on how to contact the company.
- Chiang Mai mechanic holding back forms
    - He should just send fax to company, and doesn't need to hold back from sending them out.
    - He should send them to PEA to keep as evidence in case they need to show that Solartron is not fixing.
    - PEA has transferred ownership to the tambons, so it is no longer their responsibility
    - Tambon is to send a fax to the company and a copy to PEA to claim the warranties.
- Trainings
    - Thai SHS was a 2 year program which didn't have training at first.
    - PEA trainings started a couple months ago.
    - Companies were responsible for training users.
    - PEA doesn't have record of what happened.
    - In PEA held trainings, 80% of area covered, but had to stop after coup and haven't done them since.
    - There are two phases, each with one training:
        1) 150,000 SHS; started 2 years ago
        2) 50,000 SHS
- SHS database
    - Each province will have a listing of which systems are in each tambon.
    - Once the second phase ends then PEA will have a complete list of the SHS each household owns.
    - Each company will receive a CD with their information.
    - Database is not publicly available.
    - Once the program is finished the PEA will distribute completed info on CD'S to tambons.
- Flexible payment rates
    - It is possible.
    - PEA is not responsible for management in the future, so there is a question of where the money would come from for a technician.

    - In a southern island there was a PEA run diesel generator where the villagers took ownership of after the PEA wanted to shut it down.
    - Charging extra money if the technician has to do basic maintenance is feasible, but it is up to the tambon.
- Tambon funding and the MOI
    - It is possible that the MOI will provide funding if the 50฿/month/household the tambon collects isn't enough.
    - The tambons could also use their money from other sources and put it towards the SHS program, but they would most likely spend money on projects such as road construction.
    - MOI might pay half if the villagers would pay half.
    - The 50฿ is not enough to buy new parts, but hopefully causes villagers to feel ownership of system.
    - This program was established in the previous government, and many people in the MOI who were the people to talk to are probably gone, and since a new election is coming soon so they might be replaced again.
    - There are different ways the tambon gets money, and there are many factors including: the number of villages, plans for the country, and plans for the roads.
    - The MOI has top-down management and any problems will go to top first and then down to a specific department.
- PEA dropping out of the program
    - PEA obligation ends when 2 year warranty ends.
    - They plan to pull out in December 2008.
    - Around 40,000 other households would like SHS, and that information has been passed to the MOI.
    - There may be a 3rd phase if the MOI provides more money.
- Contracts
    - Company must do checkup between 6 months and 2 years to receive final 10% of bond.
    - Solartron has completed 2 contracts: 1 in the South and 1 in North (including Tak).
    - If they do not complete it within the allotted time then PEA can hire a 3rd party to perform the work and charge the company (Solartron, Acumen).
- Communication now
    - There is a communication problem between groups.
    - When PEA meets the tambon, the PEA emphasizes that a full set of data must be provided when contracting the PEA.
    - The sheet sent to the tambons contains all the information needed, and when sent to Solartron it is sufficient as well.
    - There are posters which have a company fax number on them, which are posted in the villages.
    - The tambons were notified by the Department of Local Administration, who issued the regulation of a 50฿ fee (not the PEA).
- Web application
    - Cautions that the other routes of communication have already failed and the data changes quite a bit. The more avenues there are the better, but 10% of the tambons use computers.

    - PEA has a prototype, not ready for web yet, and will be updating it till the end of 2008. After the PEA is finished, it is up to the tambons to figure out what they want to do with the systems. The prototype will be updatable by the districts only for their section, while the main office could do it all.
    - CDs will be distributed to the tambons, in addition to the web application.
- Attitudes
    - Attitudes of local PEA offices are important in the sustainability of SHS.
    - PEA has met with tambons that have had no complaints.
    - Believes if the SHS work in 7 years then that is was successful program.
    - Over time the PEA attempts to extend the grid throughout Thailand.
- Other related programs
    - Has hired a university to do a detailed independent study of the SHS program including equipment.
    - They will be looking at about 1,000 out of 100,000 SHS in a database provided by PEA.

Appendix Q Department of Local Administration Interview
February 16, 2007

Location: *Department of Local Administration Bangkok Office*
Interviewees: *Mr. Oi Chai, Piraya, Wilisak, Adirake*

- The DLA helps provide support and standards to the local administrations to improve their quality of work.
- Presented manual of SHS related information to be distributed to tambons.
- Currently preparing a manual of standards.
    - By April, 7,855 copies will be distributed to the tambons, amphurs, and municipal governments. It will be also be put on the Internet.
    - The book is a guideline for the tambons, to help them take care of the SHS. In the book there is information about what an SHS is and how it works, basic knowledge of how to take care of the SHS, along with engineering and technical terms.
    - There is no information about the warranties, as that was contained in another set of documents provided when ownership was transferred by the PEA. Specifications and installation information are also not in there, as it was the PEA's responsibility.
    - There will be no training when they are given to the tambons. The group within the tambon office that works with the SHS will be responsible for instructing the village committee.
    - One of the purposes of the manual is to strengthen the capacity of the tambon and user groups to manage the systems.
    - There are other manuals like this that are created in order to transfer knowledge about many subjects, such as roads and waste disposal.
    - There will be future revisions, and the recommendations of the WPI project could go in them.
- There was a meeting towards the end of last year that the tambons, PEA, and solar companies attended.
- Two years ago the PEA started a survey of places where the grid couldn't go. They listed homes that couldn't use power. The funding for this program had to go through the DLA to get to the tambon.
- In 2004 153,000 SHS were installed, and in 2005 137,716 SHS were installed.
- It is the DLA's responsibility to provide maintenance information and make sure the tambons collect the recommended fee.
- The tambons should also set up committees of at least 3 people at the village level, with members responsible for maintaining and collecting payments from villagers with SHS. Any villages with at least 5 SHS need a committee.
    - The fee amount is not mandated. The committee is to collect and manage the fee money themselves. If more funds are needed, then they could ask the tambon. It is at the tambon's discretion to provide the money.
    - If villagers do not have SHS now, then they can ask for a SHS from the tambon. It is the tambon's discretion who gets the new equipment. The tambon will get the

equipment from the installation company, through the PEA. Money will come from the tambon budget.

- The DLA typically doesn't contact the installation companies.
- The tambons should contact the PEA if equipment is broken, and they will contact the solar installation companies. This is because the PEA is an expert and started the program.
- Tambon ownership began after the PEA had installed the SHS and held their trainings.
- There is a policy of decentralization of the government, and this is part of it. Control is at the local level, with the responsibility on the committee to go to the tambon for help, who will then contact the PEA for technical help.
- The SHS are for families to use, and the users need to take care of it themselves.
- If users do not want to pay, it is up to the local groups to manage it themselves.
- The tambons contact the amphur government, who then contact the central administration.
- At the tambon level they use the Internet, but don't use email as much.
- [In response to whether a web application would be beneficial] Yes, it would be useful. Solar energy is useful for all of Thailand, not just the border areas. NGO's and academic groups are interested in solar information, and the DLA would want to pass on this knowledge to other groups as it would be good for the country.
- Problems with implementation of SHS program:
    - The budget for the SHS was 25,000฿, which was an insufficient amount. The quality of the SHS wasn't that good. The solar installation companies did earnestly try to provide electricity to the villagers because they hadn't had it before.
    - There were two issues in the distribution:
        - High tech equipment was being distributed to people with little knowledge
        - The local capacity for management was limited
    - From what Mr. Oi-Chai has seen, this was to be expected. If people had better local knowledge, it would be a good investment.
- SHS are expensive compared to the electric line [grid]. Left as it is now, the SHS will last 2-3 years. It they are maintained then they will last longer. The solar panels themselves are fine.
- There is a plan to have big trainings where employees from the tambons would come to Bangkok to an existing institute where the technicians would learn. The institute is made up of classes and seminars taught by DLA personnel.
- Since this program was a pilot, there needs to be an evaluation in two years to see what needs to be done.
- It would be nice if groups like BGET helped more. Because of the decentralization, information is not being passed down from the central government. The DLA tries to improve the local capacity, and wonders to what extent it could do?
- What should be done?
    - Knowledge should have been instilled before the SHS were installed. There is a real lack of knowledge. For example, in another province, there was basic training by the company with pamphlets at the house and tambons, but there wasn't enough information. Batteries were corroded and didn't have basic information.

- Things to consider: The people who were the targets of the SHS program were poor people without education. The grid is cheaper than the SHS to install and maintain, which is a problem. This program was done from the top down, so there is a problem with sustainability.
- [In response to Chris saying that Thailand is unique in giving SHS to the villagers, since in other countries the governments provide electricity through subsidization, and there are advantages and disadvantages] It is a security issue, since part of the objective was to integrate people into Thai culture, since they are not culturally Thai.
- [In response to Chris's comments about VCD being used to show people how to use the SHS, that they are more likely to know how to use it] Agree, and that is why they use pictures in manual.

Appendix R Interview with Herbert Wade
January 16, 2007

Location: *Phone correspondence*

Herbert Wade has been on SERT's advisory committee for many years, he is coming back to work with them again but is not sure exactly what he will be doing with the group now. He is also the author of photovoltaic policy and thinks that the program in Thailand violates all of the rules for photovoltaic deployments.

Two issues with sustainability in the Tak Province and elsewhere:

- MAIN ISSUE: Equipment not suited for the location
    - The controller and inverter unit is together. If one breaks you need to replace both. In this case the inverter failure rate is quite high.
    - The solar panel and batteries are not bad.
    - OPTION: Replacements could be made. However, they must fit the situation.
- SECOND ISSUE: There has been no attempt to develop a maintenance structure
    - There needs to be an established process for replacement parts to be found. Currently there is nobody to develop them.

In terms of sustainability, the most successful programs have used an external agency to provide maintenance of the systems.

In addition, decent components and affordable systems that are periodically checked are valuable.

The Mexican governments program used donations, but the program is faltering now.

End user maintenance does not work. An external agency is needed to provide periodic maintenance. People need to get equipment to provide services and then develop a fee structure for service. Installation companies could potentially support this as once the program is finished sales will drop. So they can do maintenance at the village level. In the end the majority of end users do not want to perform maintenance themselves.

In order to be successful you need regular maintenance schedule with money. One problem here is the lack of consistency in income. Fees cannot be forced monthly for some villages. In the end it is cheaper to do regular preventative maintenance on the systems.

When working correctly SHS offset approximately 70-90% of kerosene use.

PROBLEM: The lights on the current system are AC, not DC. This creates inefficiency. Using DC lights would use only 2/3 of the electricity of AC lights. DC is more expensive than AC. Leonics has a DC light for $9.

The World Bank/Global Environment Facility are not viable sources of funding. They would need at least 2 years just to get anything.

Carbon Offset companies are a possibility, but the money will not be substantial. Also, only electric lights offset carbon emissions, the use of TV offsets nothing.

In terms of funding and organizing a long-term maintenance program it is unlikely that the PEA will do it. If a private company were to do something they would probably only go to the most accessible villages whereas the PEA would go to all villages.

Appendix S Interview with Bruce Countryman
January 30, 2007

Location: *E-mail correspondence*

Q: What are your experiences with SHS in Chang Mai?
A: In June 2005 I visited a Karen village about 20K from Pai, Mae Hong Son. There where SHS installed in the village. Villagers did not know how take care of SHS and there was no village technician to perform SHS maintenance. Also, the villagers did know who to contact for technical assistance and SHS spare parts. In February 2006, working with the KNCE, I conducted a technical survey of 70 SHS in Huey Som Poi village outside of Chom Thong (35K South of Chiang Mai). I found about same percentage of SHS technical problems as BGET in the Tak Province. The KNCE filed warranty claims for SHS repair with the PEA in Chiang Mai. Also, the PEA office in Chiang Mai was not aware of the operational status of SHS in northern Thailand.

Q: Is communication a problem?
A: Yes, is very difficult to get messages out to the villages. The PEA has a database of tambon and local Solartron contractors contact information. The tambon has contact information for villages with cell phone systems. The KNCE does not have a complete database of contact information for tambon or village cell phone numbers for Northern Thailand.

Q: Have you worked with the tambon office in Chang Mai?
A: PEA? I have visited PEA office Chiang Mai regarding SHS warranty claims.

Q: Are you aware of PEA training sessions for new installations?
A: I am not aware of PEA training classes for SHS users.

Q: How much time have you spent in the villages? And how remote have they been?
A: Four days in Huey Som Poi village about 1 hour drive from Chom Thong and three days with BGET in a village (Tak) about 3 hour drive from Mae Sot.

Q: Are there any organizations like BGET that are trying to make a difference in Chiang Mai?
A: Not that I am aware of.

Q: What are the major problems that you believe could affect solar sustainability?
A: There is no structure in place at the village level to do maintenance, training, and collection of fees (capital replacement costs). Also, low quality SHS equipment i.e., controller/inverter and lighting ballasts will be continuous problem for the program.

Q: What alternative energy sources do you think people would use instead of their SHS?
A: There are Micro Hydro generators in a few villages. Average wind speed to low for wind generators. Maybe 5% of villages have potential for Micro Hydro power.

Q: Are you aware of how many repairs have been done in Chiang Mai?
A: Only Huey Som Poi village, about 30 repairs. (NOTE: After visiting Huey Som Poi it was found that these repairs were never actually carried out).

Q: Are you aware of how many warranties have been utilized?
A: About 30 warranty claims have been filed with PEA from Huey Som Poi village.

Appendix T ***Interview with Prapita Thanarak, PhD***
February 13, 2007

Location: *E-mail correspondence with The School of Renewable Energy Technology, Naresuan University*

Q: What are SERT's plans and what has already been done with regards to the SHS?

A: SERT always believed in quality in training, demonstration, installation and periodic onsite inspection of SHS regarding its operation, performance and maintenance for making SHS sustainable. SERT has installed demonstration units of SHS at its Energy Park and has been training technicians, policy makers, installers, teachers, students, end-users, PEA technicians, etc. regarding the SHS. Besides that SERT researchers as well as trainers are continuously visiting the real site of installation to check the system to find the problems of SHS installation, operation and maintenance and giving end-users onsite training regarding the SHS. Now, SERT is doing an assessment of SHS in lower Northern Region of Thailand and studying to develop a system to integrate farm-engine (tractors) to make SHS a hybrid type of system.

Q: What are the major problems that you believe could affect solar sustainability?

A: Reliable and long life services of any system make it sustainable. Poor system design, poor installation standard, poor wiring, sub-standard BOS [Balance of System] selection, insufficient training to end users about the BOS make any SHS unreliable and lead to poor operation life increasing the maintenance cost, hence adding extra unnecessary financial burden to end users making them feel that SHS is not a reliable system. Such sub-standard material selection, installation, wiring could often lead to dangerous accidents such as fire as most of the rural households are made of woods and having straw roofs. These are the major problems that could affect solar sustainability. To make solar a sustainable energy supplier, SERT continuously arranges its researcher and trainer to visit rural site to study about the system, if faulty wirings were found, its staffs fix them and teach the end users of danger of faulty wiring as well as consequences that could arise by miss handling of batteries as well as circuiting of solar wirings. SERT aims to make every solar system a reliable system, hence making them sustainable.

Q: Have you worked previously with SHS in rural villages? Besides your dissertation?

A: Well, I was not from technical background. I was studying my bachelor degree in Chiang Mai University taking agriculture economic as major. During that time I often had chance to visit to rural communities and used to see SHS and was excited about Solar system, and the way it functions which generated curiosity on me how these system works. After graduating bachelor degree, I decided to join Master of Science degree in Renewable Energy here at SERT, Naresuan University to gain more about solar and other renewable energy. During my master degree got more chances to visit and see the solar system in remote villages and found how it helps rural communities by providing clean pollution free light. I have also found problems and heard complaints from end users regarding the unreliable services of solar system. During my second year of Master Degree, I visited more of the rural villagers and had chance to work on solar energy system and know more about it and its impacts on socio-economy as well as life style of rural communities. That was the time; I started working with solar systems in the rural villages by visiting the site and helping them understand more

about SHS. Inspired by such frequent visit to rural sites to study and work on solar system, I have finally decided to join PhD degree after graduating MS degree in Renewable and finally decided to take SHS for my dissertation. During dissertation I have more chance to visit SHS sites and talk with end users, hear about views on SHS regarding benefits, problems, their thinking about the system, their happiness about the system as well as unhappiness, listen to their views how to make SHS beneficial for their community. The dissertation work was really inspiring and worthy to make me a RE professional at this time of my life.

Q: What about trainings with the PEA? They indicated that SERT trained their Technicians?

A: As I have already mentioned that SERT has been training and demonstrating to the people from different walks of life to make the solar system sustainable, PEA technicians were also the part of that too. The trainings which were conducted for PEA staffs were really fruitful to let them know all about solar systems use for rural electrification and we really hope that the training helped them to improve the reliability of solar system for rural community. SERT still welcomes different people from different walks of life for training, demonstration or consultations, testing of solar energy systems. You are welcome to if you wish.

Q: In your opinion what needs to be changed to ensure the sustainability of the SHS?

A: If you are asking my personal opinion what I think needs to be changed, I would say, the way of information dissemination in rural people as well as thinking of policy makers and other related people to change their perception towards solar energy and formulate the policy to make it sustainable. Government policy should be changed for disseminating SHS in rural communities, subsidies or tax incentives should be given to investors to make SHS commercialized and reduced the cost. In such a way SHS would be sustainable, that's what I think, then later on comes training, demonstration, R&D and so on, which are regular activities that is usually followed by the commercialization of products or systems in the market that makes them self sustainable.

Q: Is there anything else you would like to add?

A: Energy demand is growing up. There are wide differences in energy consumption pattern in urban and rural areas. People in urban areas, enjoying the full fruit of electricity and cannot imagine living without electricity. In the contrary, rural people are living without electricity and mostly dependent on traditional fuels such as fire wood or fossil fuels which contribute to green house gas emission. Do you think the world is getting warmer? Well, if your answer is yes, I guess you know the reason of the causes also. Besides that, lack of electricity in rural areas creates bigger gap between rich and poor as rich people in urban areas have all the modern access while rural people don't. So in my personal opinion, its time for government to think to change the policies, give incentives to private investors in solar energy sector. Today the investment may be high, economically unattractive but no government could trade reducing the knowledge and economic gaps between urban and rural people in the name of economic feasibility or benefits. It's time to act together give much needed electricity facilities to rural communities, let the rural people enjoy the facilities that could provide by electricity. They have right to have access to electricity as much as the people in urban areas. Promote solar energy, reduce dependency in fossil fuel, and small but importantly, reduce to help GHG emission. Need to act now before it's too late in reducing social and living standard gaps between rural and urban people. Don't you think so?

Appendix U Interview with Dr. Wattanapong, SERT

22 February 2007

Location: *E-mail correspondence*

Q: What has your experience been with rural electrification in Thailand?

A: Well, Because of Royal Thai Governments aggressive policy in 1974 to extensively electrify the country has resulted Thailand to be very successful example regarding the rural electrification programme. PEA aggressively extended its grid networks to electrify the rural areas of Thailand, which increased total number of electrified households from 20% in 1974 to 98.9% in 2002 and 99% at present. The Royal Thai Government made such very aggressive policy because, it knew, three forth of the countries population lives in rural areas. Without providing basic facilities to rural population, country cannot grow technically, no industrial development will take place hence there won't be any economical activities will take place and effect economy of country as whole. PEA could not extend grid electricity to remaining one percent of rural households because of isolated location of rural settlement, that's why the government made national policy to electrify by using renewable energy sources such as solar, wind, micro hydro, biomass, etc., which ever is available in rural areas.

Q: Elsewhere in the world?

A: Well, have you seen the night map of the world, which revealed how the electricity has been supplied in the world in different countries? If you have seen that night map of the world, you can surely notice that Asian continent, where half of the world's populations live, still lack of electricity. Three forth of the populations in Asia live in rural areas where electricity is not available. How do you think of living without electricity in this 21st century? There has been a good initiative that some government has taken to electrify rural areas like in Nepal, where 50% of the cost is subsidized. Subsidies are also being placed in Vietnam, Laos, etc. The main objectives of the government in the region should be giving the basic needs of human life such as electricity or information technology to rural people to be its people to be competitive with the urban people.

Q: What are the good / less than ideal practices used in this SHS program?

A: SHS system is very good for rural electrification in different countries based on load demand. It’s independent of the end users and supplies the power to meet the load demand of each and every individual end user. Many countries have developed standardized system to meet their local end users. In some countries, researches have been done since long to match the load profile and attitude of the local people. These practices, I certainly take as very good or less than I deal practices used in SHS program. Thai government has also standardized SHS system, but what I think is designing any SHS system, staying in Central area, may not suit to people living in rural areas, as different remote location may have different load profile, loads, and attitude of communities may vary depending upon the location of settlements and economic conditions as well as the life style the way how they live their lives. So, personally, I feel like practices of having single standardized SHS for whole remote area is not a good idea. People should go to communities and do the survey which will surely brings more than one standardized system to meet the each of the households demand. This kind of practices would be much better or close to ideal practices to be used in SHS program to electrify each

and every rural communities based on their load demand profile, living style and economic conditions.

Q: Do you think that the Government would be willing to provide additional funding of the program? For example the MOI or PEA?

A: In my personal opinion, it's not the question of Government's willingness to provide funding or not. In fact, the question should be "Isn't it the responsibility of government to treat or similar kind of facilities to its entire people not matter where do they live urban or rural areas?" If the government takes giving basic needs of life to each and every people of the country, and there is no choice of supplying by grid extension or other sources of energy, then government should be willing in fact must be willing to provide additional funding for the program. If not, there will be lack of electricity in rural communities. And in this modern century electricity means everything, as you know you cannot live without electricity even for few minutes without the facility that you get from the electricity. So think, how can we have rural people living in dark? By dark what I mean is, not only in the sense of light of visibility but in the sense of knowledge, information, technology, entertainment, economic development, etc., which creates a very big social, economical as well as knowledge gap between rural and urban people, which in fact, brings down whole country's economy level, literacy rate, GDP etc. So, if the government is really willing to reduce the gap between its rural and urban people, it should be willing to provide additional funding to people in rural communities, hence try to reduce the on going biggest gap between rural and urban communities as stated above. If PEA has limitation extending its grid based electricity to the rural areas, it should seek help from the Government or MOI to electrify the rural communities using the renewable energy based electricity supply to meet the rural demand where, whatever resources is available and I am confident that for where other resources are not available, the sun is always there to give an opportunity to utilize its abundant energy as Thailand is located in tropical area of the world.

Q: What is your opinion of the SHS instillation throughout the country?

A: The Royal Thai government has taken good initiative for promoting SHS for rural electrification in the country targeting to install more than 300,000 systems around the country in couple of years. This is very beneficial for the rural community and will certainly brings changes in life style of the rural community increasing more economic activities, media disseminations and creating the knowledge based society. This will reduce the economic as well as the knowledge gap between rural and urban people hence helping country to grow fast. But still, as I have mentioned before, the present standardized SHS system should be modified to meet different load profile and living style of the community based on their economic capabilities as well as living style.

Q: In your opinion what needs to be changed to ensure the sustainability of the SHS?

A: As I have already mentioned, the government should be committed to give basic needs of human life to rural communities to reduce the gap between the rural and urban people. A single standardized system would surely not be sustainable and economical depending upon the different demand load profile, living standard and economical conditions of the rural communities living in different parts of the country. There should be standardized installation and safety measures, good training to end users. Poor wiring and battery handling often lead

to serious accidents. There should be quality controlling body to check and balance the after installation and maintenance work done by the assigned company or contractor. There have been reports of serious accidents in Thailand due to poor wiring and rural people are not willing to use SHS anymore in the community. It's not because SHS is dangerous to use, it's because Training and wiring standards are not done properly. To make SHS sustainable, these simple but very important issues must be taken into consideration and lay down strict measurements of safety factor in installation and after sales service. Training end users about safety factors would surely make SHS sustainable.

Q: Is there anything else you would like to add?

A: Well I as I have already mentioned in previous queries what should be done. To summarize here, make different standard system to meet different load profile of the different communities. No single standardized system that was designed staying in office could be sustainable or economic as the load profile, living style and economic conditions of different rural communities vary depending upon where they live. Training and strict monitoring of installation standard must be followed to make SHS sustainable. Its duty of the government to provide basic needs of human life regardless of where its people are living, urban or rural if the government wants to decrease the gaps between the people living in urban and rural areas. Well, I've reviewed the web application already. It's very useful for all SHS stakeholder. I could share my information also in your web as we have a plan for SHS survey in next month.

Appendix V Interview with BGET
February 14, 2007

Location: *Bangkok Gardens, Bangkok*
Interviewee: *Chris Greacen, Ph.D., founder of BGET*

- Web application progress
    - Make sure there are fields for serial and inverter numbers
    - Andrew from BGET can tell us how to translate the site into Thai
    - Chris would also like to see all functions as we develop them
- Summary page
- Everyone have access to see data or have limitations based on account
- Statistics on data/ system query
    - Be able to export statistics as Excel or access file
- Edit records
    - Necessity of an undo function and have old data archived for safety, possibly like a wiki
- BGET will administer the site at first and then hand it over to MOI if they are interested
- Recommendations
    - Possibly make a price list for maintenance or recommend it for further research
    - BGET and UN idea:
        - Train refugees in nearby camps to do maintenance
        - Thai people are not going for these jobs so not taking jobs away from Thai people
        - Would maintain 1000 systems at most so not applicable for the entirety of Thailand but in those areas where they could reach it could make a difference
        - It would be a micro enterprise for the refugees, such as bakeries and English-Karen translation services.
    - Notifying people know our recommendations
        - Send invitations to our contacts for our presentation
        - Write up a letter that summarizes recommendations and the website
        - Department of Local Administration can distribute information

Appendix W Interview with Jamal Gore of Carbon Clear
February 19, 2007

Location: *Via phone to Carbon Clear offices.*
Interviewee: *Jamal Gore Director of Carbon Clear Ltd.*

The price on website (£9) includes cost of postage and is what their customers pay; the actual amount is roughly £5 per ton. Carbon Clear does not normally pay more than £3 per ton/ project

Regarding initial calculations:

- Buying only 1 DC battery per year is not useful.
- They have justified that kind of cost in the past by saying it paid a salary.

How long would the funding keep the program going? 7 years maximum

[We suggested looking over site and setting up a test account]

Every bit of funding that they can put in is good. Local team has to make sure that the funding is worth the hoops you have to jump through.

Web application makes tracking easier.

They can charge customers more for things that meet the gold standard, which means Carbon Clear can invest more in the project.

We need to think about not just how much can be provided, but also how much is needed?

Things to consider

- CDM rules
- Prevailing practice:
- Technology additionality

Customers push for proof of certainty that the SHS are working properly

Will downtime affect the project?

- 1 month downtime over 7 year project – not a big deal, only 1%
- 1 month downtime over 12 month project – then it is a big deal
- All depends on percentage of downtime.

Can't assume that everything will work perfectly of course. Make some estimates up front about how likely systems are to break down and factor them in.

Web application is a useful tool, and would allow the tambon to input data. It would also bring down the monitoring cost.

In a project from another organization, administration costs swamped the project and it ultimately failed due to high monitoring costs.

Ensure that a balance is struck between requirements and what Carbon Clear can provide.

Jamal will put as much money into these types of projects as he can but from a company standpoint he has to make his customers happy and prove that his projects are accomplishing something.

Appendix X Interview with Acumen
February 23, 2007

Location: *via e-mail with Acumen*

Q: What are the major problems that you believe could affect solar sustainability?
A: Inadequately tambon's budget could be the problem for maintenance cost after no warranty period. Lacking of system understanding for real users or even tambon 's staffs could be the reason for misuse and breaking warranty void. They are not realize for system limitation. Many user want to use a number of equipments that meet the overload system limitation and effect the inverter damage.

Q: What is the ideal schedule of maintenance for your systems?
A: According to service level agreement, we provide within 7 days onsite service after receiving each failure report and post preventive maintenance every sites 18 months after installation. The schedule of maintenance by user themselves that we had recommend is checking for battery liquid level every week and dusty cleaning for solarcell board and inverter every month.

Q: Have you preformed the post installation check of the systems? If so what were the results of the follow-up checks on the SHS?
A: Yes, we have. It's 18 months after installation. Now we are in that interval and doing on process. The result is we found many inverter damage and user's misuse like the answer above.

Q: What plan was provided for the ongoing functioning of systems?
A: We had provided some system training to user and tambons's staff for taking care and using the system, both components and solar system including basic system maintenance and first aid. In fact , solar home system maintenance by user do not need so much and not complicate. Just dusty clean and check battery acid level. Solar home in Thailand specification is only 150W and could be used only two 10w fluorescent and one 14" color TV.

Q: What process are the tambons supposed to use to contact you in case of a problem with the system?
A: The tambons supposed to report local PEA first then PEA contact to us at service center, Cheangmai and Cheangrai. Our staff take onsite services to solve the problem then report system recovery to tambons and local PEA. Most of the user directly report the problem to us then we coordinate with tambons and report to PEA. Because we can give some preliminary advices to them, the user, some problem that normally not cause by system itself can be solve on call. Most of this kind of problem that we solve on call is battery completely discharged from too much user consumption and frequently happen on rainy season.

Q: How many warranty claims have you received? And can we see your data?
A: We have received claims from tambons around 60 stations per month. Causes of the problem are inverter 99.5%, battery 0.4 % and others 0.1%.

Q: Where have the warranty claims come from?
A: Most of claims come from the user, PEA and tambons respectively.

Q: What is the cost for SHS replacement parts?
Solar board 25000-35000฿
Battery 3500-4500฿
Inverter 4000-5500฿
However that cost are approximately.

Q: Would it be possible to offer replacement parts for credit?
A: It would not be possible for credit. There are not services charge within warranty period, if there are any equipment without warranty the replacement or repairs depend on tambon decision because of the different condition between each tambons.

Appendix Y ***Interview with Solartron***
February 22, 2007

Location: *via e-mail with Solartron representative*

Q: What are the major problems that you believe could affect solar sustainability?
A: 1.User no have knowledge and technical.
2. Basic to maintain and take care system of household.

Q: What is the ideal schedule of maintenance for your systems?
A: 1. Maintenance under TOR up to 6 month/ trip.
2. My ideal to take service and maintenance up to 3 month/trip and transfer basic technical Solar Home Systems to communities and users.
3. Trainee Solar Power and maintenance to communities and households.

Q: Have you preformed the post installation check of the systems?
A: We have schedules plan for maintenance after installation under TOR of PEA up to 6 month / trip and take report to project office.

Q: What were the results of the follow-up checks on the SHS?
A: 1. Have maintain to be widespread.
2. The residents have the high quantity of lift.
3. User a little bit knowledge and obtain to systems.

Q: What plan was provided for the ongoing functioning of systems?
A: 1. Service and maintenance under warranty of TOR.
2. After warranty PEA take systems to tambons take care and maintenance.
3. Trainee and relation to tambons overall for increase and develop systems.

Q: What process are the tambons supposed to use to contact you in case of a problem with the system?
A: In case of all problem direct contact from customers take care and service to checking systems.

Q: Would you be willing to communicate with the tambons using a web application?*
A: 1. No contact pass website.
2. Direct call to office Sub district.

**Possible miss-translation as "do you currently" instead of the intended "would you be willing to".*

Q: How many warranty claims have you received?
A: Service claims sheet about 400 - 500 households per month.

Q: Where have the warranty claims come from?
A: 1. PEA of Provincial, Province and Head office.

2. Sub District to direct advise call center office.
3. Household to direct advise call center office.

Q: Can we see your data?
A: Copy document file PDF attach.

Q: What is the cost for SHS replacement parts?
A: Cost to expense of service teams up to value household and area zone about 500 - 700฿ per household.

Q: Would it be possible to offer replacement parts for credit?
A: 1. Spare Part have commit under contract to supplier and have stock for fast track after sales service to household in tender.
2. No have credit or extra purchases replacement part.

III. Project Deliverables

Appendix Z Manual for Prototype Web Application

Thailand Solar Home Systems
Web Application Manual

Created By: WPI Solar Sustainability Team
Gabriel Baldwin
Benjamin Childs
Carolyn Hunter
Victoria Urrea

Getting Started

To use the Thailand Solar Home Systems Web Application first enter the following url into your web browser.

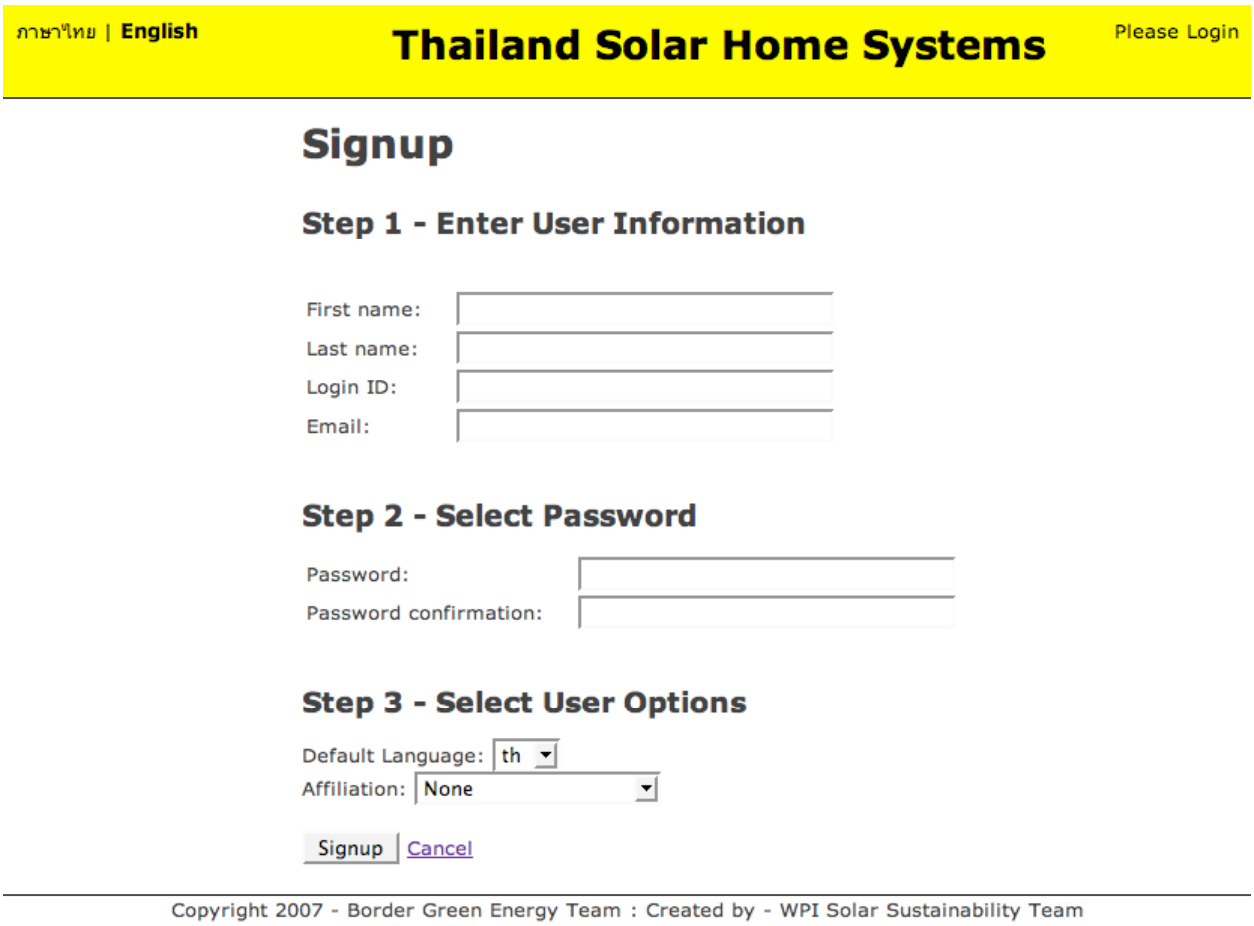
http://www.thaisolarhome.com

When you first arrive at the site you will see the following screen. You may select your preferred language at the top left and login to the site in the center of the page.

If you do not have an account you will need to register for an account. For instructions see the next step.

Register for an Account

To register for an account click the ‘Register for an account’ link on the main login page. This will take you to the first signup page:



First enter your first name, last name, login ID and email address.

NOTE: Please ensure that you enter the correct e-mail address, as it will be used to verify your account.

Next enter your password in both the Password and Password confirmation boxes.

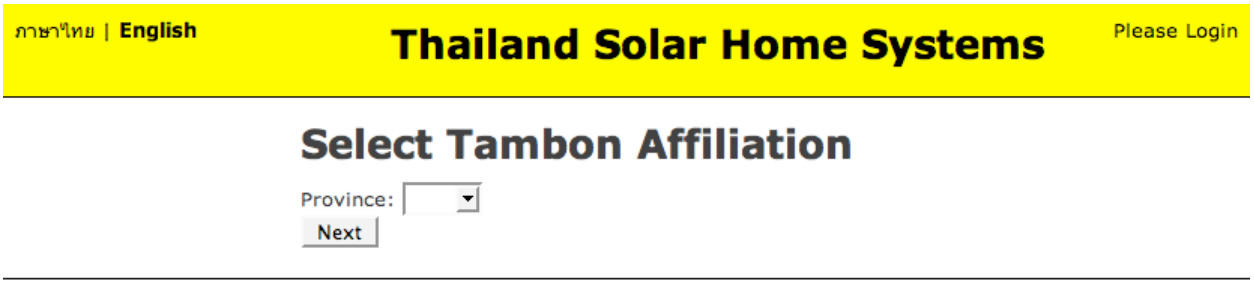
Next select your default language, Thai or English.

Finally you must select your affiliation. This determines your role in the Thailand Solar Home Systems application. When selected click the Signup button.

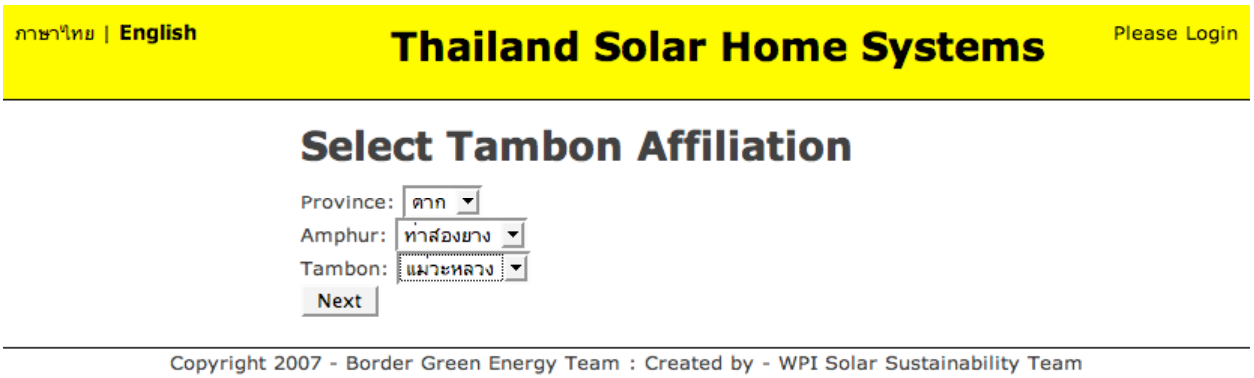
- **None:** Select this affiliation if you are not affiliated with a tambon or installation company. Skip to Finish Signup
- **Tambon:** Select this affiliation if you are a member of a tambon government office. Tambon members can request repairs and verify their completion. Go to the next step.
- **Installation Company:** Select this affiliation if you are a member of one of the installation companies. Installation company members can schedule repairs. Skip to Select Installation Company Affiliation.

Select Tambon Affiliation

If you select affiliation with a tambon you must select which tambon you are affiliated with. You will see the following page:



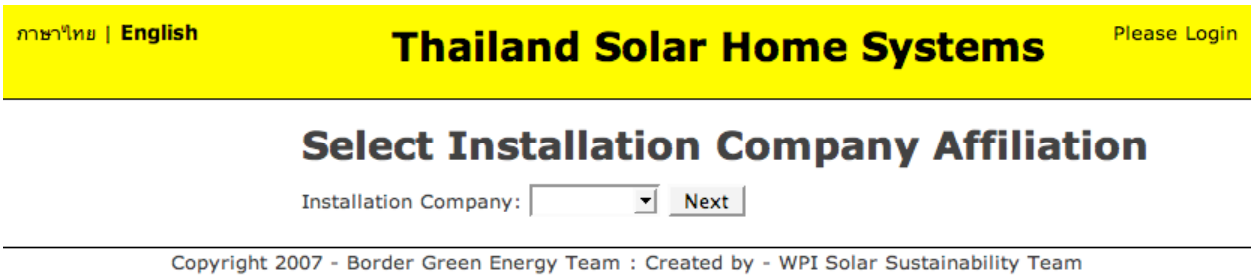
Select the province, amphur, and then your tambon:



Then click the 'Next' button and skip to Finish Signup.

Select Installation Company Affiliation

If you select affiliation with an installation company you must select the installation company that you are a member of. You will see the following page:



Select the installation company and click next.

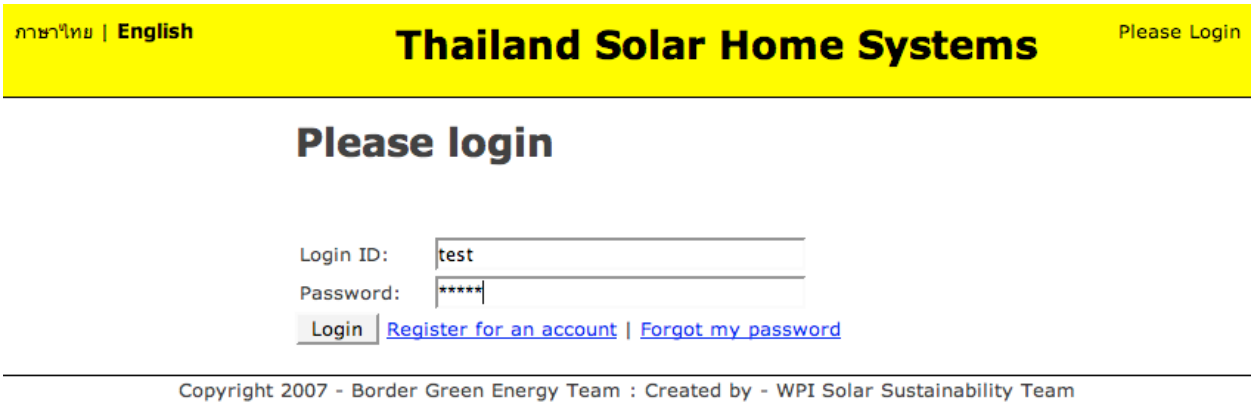
Finish Signup

After completing the signup you will see the following message.

You now need to check your e-mail and click the confirmation link to activate your account.

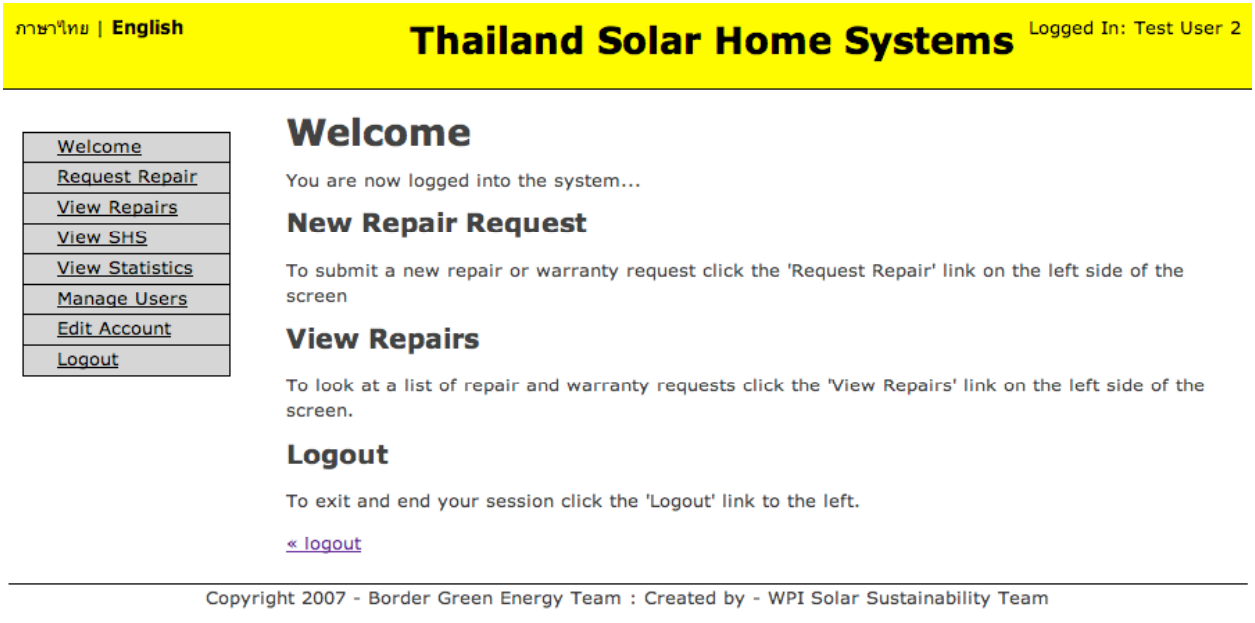
Login

To login from the main login page enter your login ID and password and then click the login button.



Requesting and Verifying Repairs

If you are a member of a tambon you may request and verify repairs. After logging in you will see the following page:



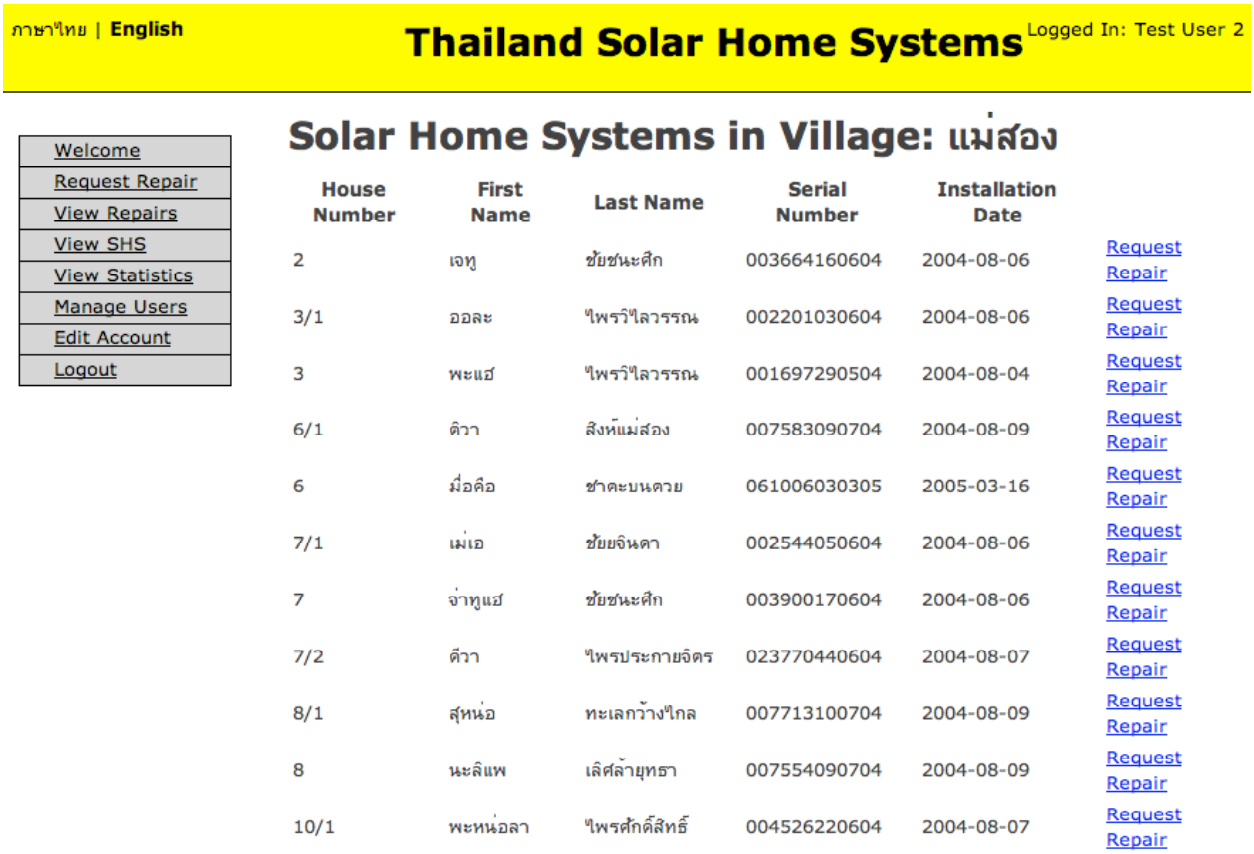
Submit A Repair Request

To start a new repair request, click the ‘Request Repair’ link on the left side of the screen.

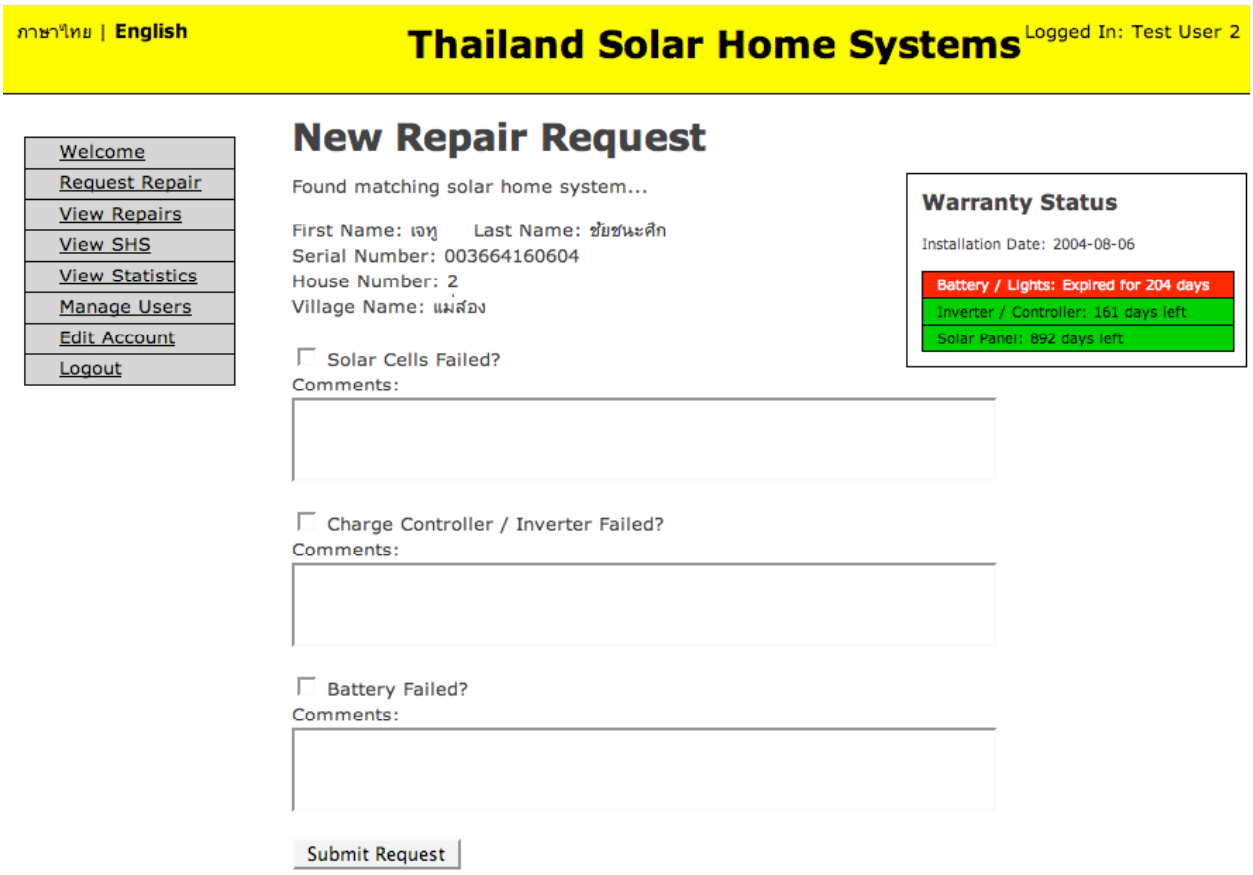
The next page allows you to search by serial number or village.

If you know the serial number of panel for the SHS, you may enter it here and go directly to the repair request form. Otherwise you can select the village for the repair from the drop down box.

If you search by village you will see all of the SHS in the village organized by house number. Find the appropriate SHS and click the 'Request Repair' link to the right:



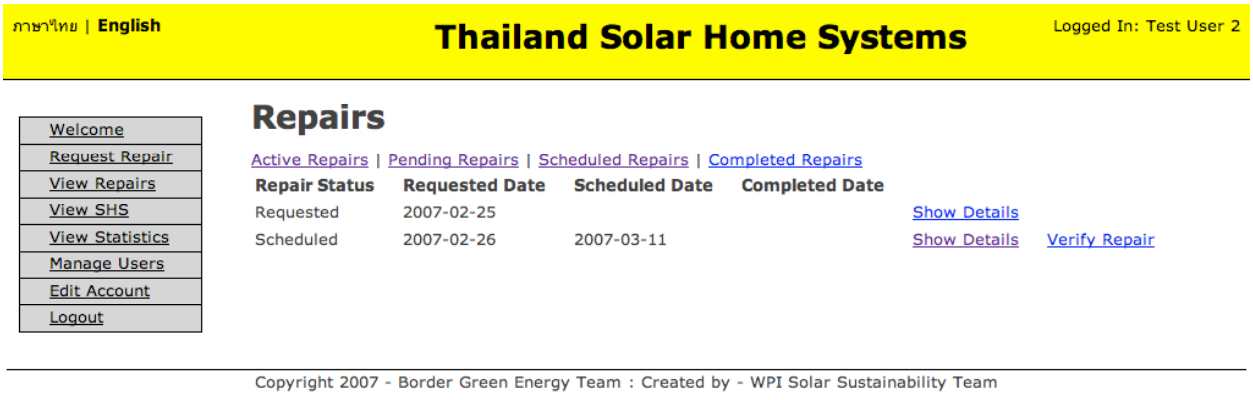
After selecting the SHS through the village or serial number search you will be taken to the request form. Enter the information on the paper request form into this page. You can also see the status of the warranty on the system on the right hand side of the page.



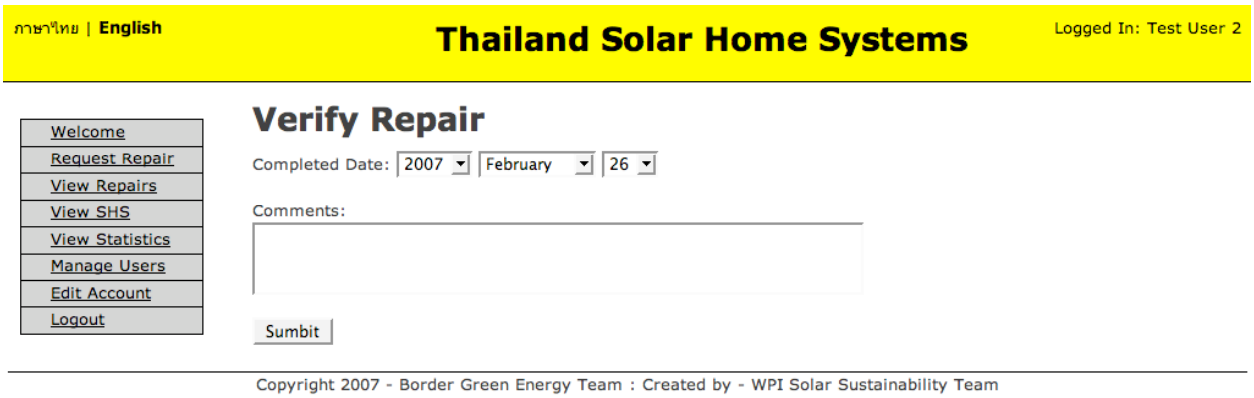
Click submit request to finish the request. The installation company will be notified of the request.

View and Verify Repairs

To view all repairs for your repairs click the 'View Repairs' link on the left hand side of the page. This will take you to the main view repairs page:



The default view shows all Requested and Scheduled repairs. If a repair has been completed you may click ‘Verify Repair’ to record the repair in the system.



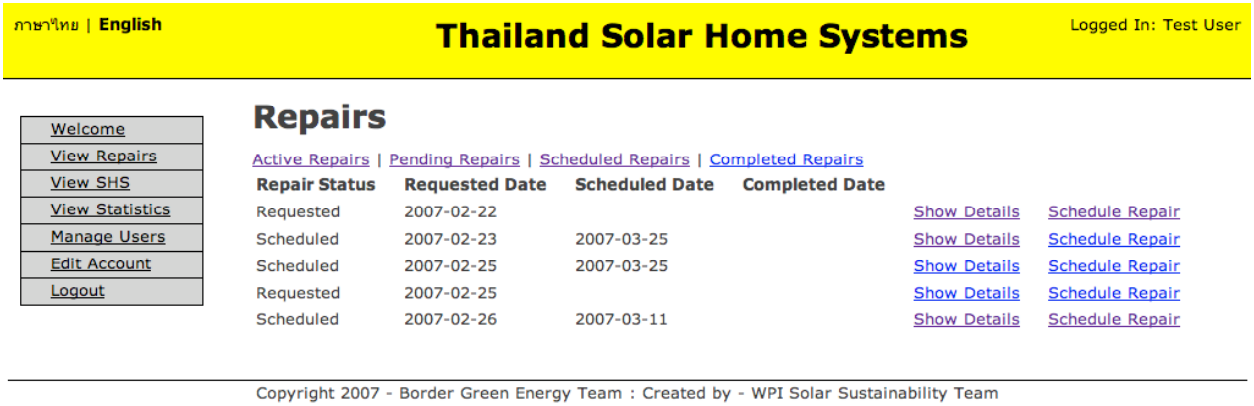
Record the date of completion and write any comments on the repair. Then click submit to record the repair as completed.

Scheduling Service

If you are a member of an installation company, you can schedule requested repairs.

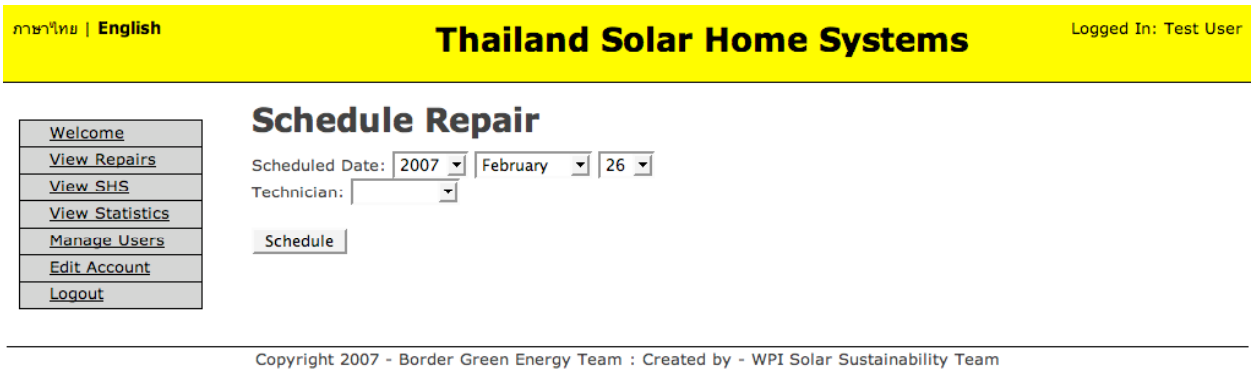
View and Schedule Repairs

To view repairs that need to be scheduled click ‘View Repairs’. This will bring you to the following page:



You can filter the repairs to just those that have not been scheduled by clicking the ‘Pending Repairs’ link:

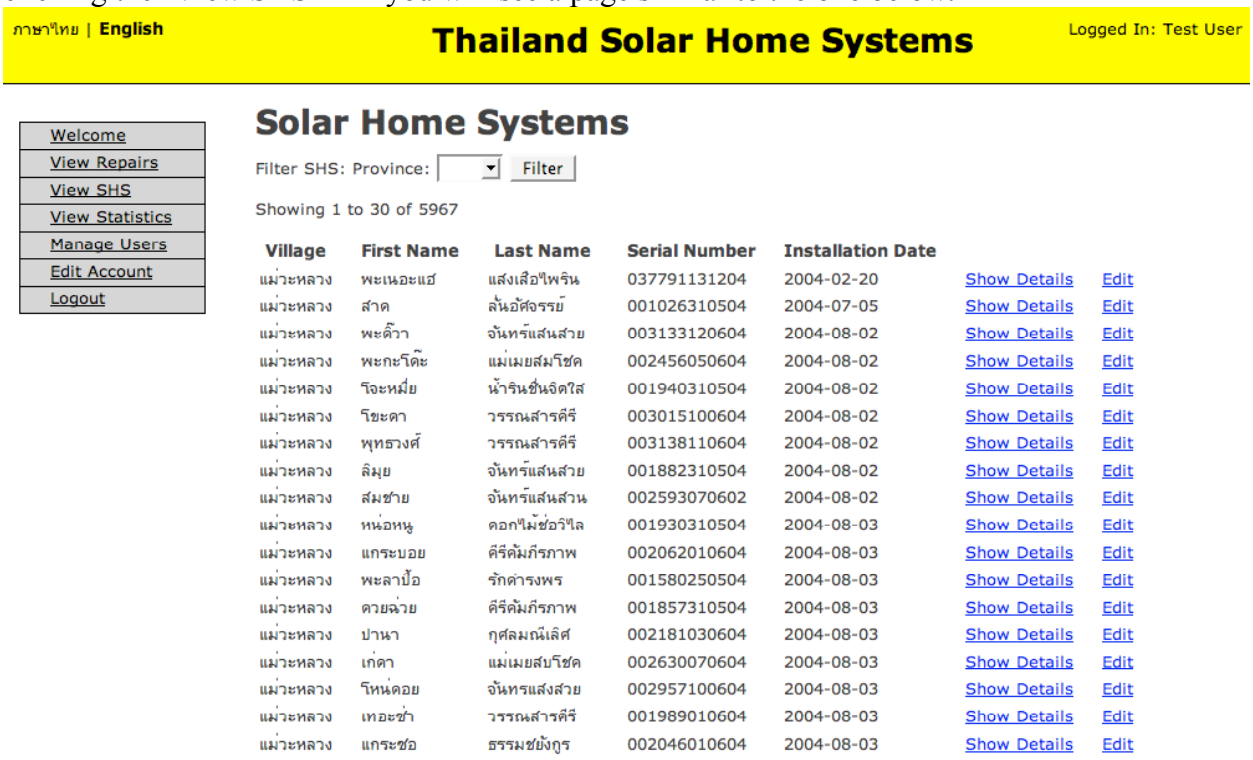
To view a repair’s details click the ‘Show Details’ link. You can also just click ‘Schedule Repair’ to go to the schedule page:



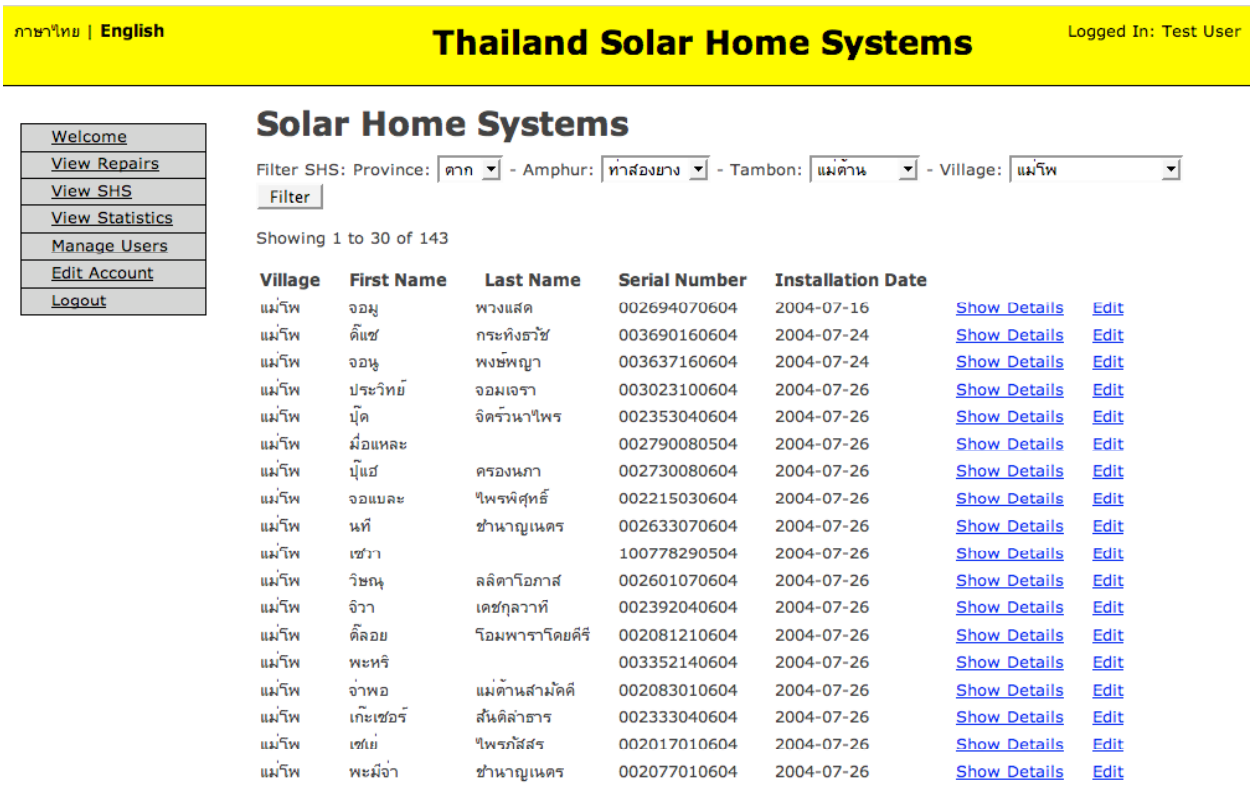
Select the date and technician to schedule the repair and click the ‘Schedule’ button. You can reschedule repairs at any time until they have been completed.

Viewing SHS

Any user can view the installed SHS. To View SHS click the ‘View SHS’ link on the left. After clicking the ‘View SHS’ link you will see a page similar to the one below.



You can filter the viewed solar home systems by Province, Amphur, Tambon and Village. First select a Province from the Filter SHS, Province drop down box. Then select an amphur, tambon and village.



To clear the filters just click the ‘View SHS’ link on the left again.

You can see more details about any SHS using the ‘Show Details’ link. If you are a member of the tambon or installation company responsible for the SHS you can also Edit the information.