Increasing Awareness of Lahu Culture through Solar Technology

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Abstract

Our team worked with the Mirror Art Group to install a solar electric unit in Ban Jalae, a rural hilltribe village in northern Thailand. The photovoltaic system provides electricity for educational equipment in a cultural center that showcases Lahu customs and traditions, as part of an effort to increase awareness and prevent their assimilation into mainstream Thai society. In addition, we analyzed the cultural and societal impacts of the technology.

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We would like to extend our gratitude to the Rockefeller Foundation for the funding they provided. In addition, we are appreciative of the assistance that Solartron provided in purchasing the photovoltaic equipment. Solartron's donation allowed us to provide more power for the Ban Jalae villagers.

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Executive Summary

Government regulations, technological development, and the overwhelming appeal of the mainstream Thai society are just some of the forces placing the culture of rural hilltribes in jeopardy. One tribe in particular, the Lahu, faces many internal and external pressures that threaten the existence of its culture. Recently, the government has forbidden the tribes to continue their traditional farming practices because the tribes' techniques contribute to the deforestation of Thailand's already largely depleted forests. While the government ordinances are intended to protect the environment, they have impeded the Lahu villagers from continuing their traditional lifestyles. In addition, the Lahu people are struggling to endure in a Thai society where technological advancement and societal conformity have become necessities for the villagers' survival. Fortunately, the Mirror Art Group (MAG), a non-profit, non-governmental organization, has recognized the need to assist the Lahu people in the preservation of their culture. The MAG is now making efforts to organize projects in northern Thailand to assist the Lahu and other hilltribes.

One of the projects the MAG promoted was the construction of the "Ban Jalae Hilltribe Life and Culture Center," a cultural museum and learning facility for the Lahu villagers. The Culture Center is located in Ban Jalae, a Lahu village situated in the Mae Yao sub-district of the Chiang Rai Province of Thailand. In order to preserve aspects of the tribe's traditional lifestyle, the Culture Center features a museum that highlights their tribal customs and ceremonies. The museum better enables the Lahu villagers to preserve their heritage and addresses some of the changes that are bound to come in an encroaching Thai society.

The Culture Center provides technological tools to aid the Ban Jalae inhabitants during this difficult period of transition. The equipment not only functions to document the culture and traditions of the tribe, but also provides educational services to the community and visitors. Since Ban Jalae is located in an isolated, mountainous region, the government has thus far not provided it with electricity. As a result, the MAG decided to have a self-sufficient and environmentally friendly method of powering the facility installed, using solar technology. It became our job to explore the feasibility of using a photovoltaic

(PV) system and determine its effectiveness and impact in the village. The goal of our project was to provide the Culture Center with electricity in order to assist in the preservation of Lahu culture.

To accomplish this goal successfully, our team completed four main objectives:

1) *Determining the expectations of the MAG and the Lahu tribe for the Culture Center*
2) *Evaluating the success of similar PV systems at a different Lahu village*
3) *Installing a sustainable solar power supply*
4) *Educating the Ban Jalae residents about the safety and maintenance of the PV technology.*

The first objective involved a study of both the Mirror Art Group and the villagers' expectations of what the Culture Center would provide. Individual interviews with the Hilltribe Life and Culture Center Council headman Khun Surachai, and MAG representative Jonathan Morris, allowed our project team to understand how the two groups expected the technological devices in the Culture Center to aid the villagers. It also gave us some insight as to the types of problems, both culturally and technically, that they expected would arise from the installation.

In general, the tribe members and the MAG had similar expectations for the Culture Center and its photovoltaic power supply. Khun Surachai minimized our fear that educational technology would adversely affect the village's culture by explaining that in order to preserve the Lahu way of life, the tribe needs to bridge the cultural communication gaps between generations. Khun Surachai made clear that this could only occur if the villagers maintained the will for their culture's existence.

We completed our second objective by analyzing previous PV system installations at Ban Yafu, also a Lahu hilltribe village, and conducting an interview with a villager, Khun Jamai, about the solar units' history and cultural impacts. The village's solar installations provided our team with an example of how a photovoltaic system withstands a rural hilltribe environment and what societal impacts the technology can have on a hilltribe community.

It was evident through both the interview and the observed condition of the solar installations in Ban Yafu that the villagers did not utilize these systems to their fullest. The solar components were in disarray and it seemed as if the villagers had not maintained the panels since their installation almost *seven years ago. Apparently, the villagers had received little training about how the system functioned or should be maintained.*

The third objective was the design and installation of our PV system in Ban Jalae. After we performed a load analysis and site surveys, our project team purchased, assembled, and installed the components with the assistance of Ban Jalae villagers.

The load analysis allowed us to estimate what size system was necessary to meet the electrical requirements of the Culture Center. Once we completed the load analysis, we purchased components that both met the budget and satisfied the power needs of the Culture Center. Before assembling the PV system, we conducted site surveys to determine the best placement and orientation of the solar panels, and decided that the construction of a separate building for the installation would best suit the villagers' needs.

Our final objective was to leave the villagers with the means for using and maintaining the PV system. For training purposes, we separated the tribe into two groups, those technically-inclined for maintenance purposes, and a larger group that we informed of the basic safety precautions of the system. We conducted a presentation to inform all villagers of the safety and operational issues with the PV system. Our team also provided a training session and technical demonstrations to four individuals in the village who volunteered to be in charge of the system's maintenance and repairs.

Although the installation of solar technology in Ban Jalae may seem primarily technical, the actual focus of our project was on what effects the technology will have on the people and their culture. The Lahu currently live in a society that is not dependent on technology, so having access to these new empowering devices will inevitably affect their day-to-day life. Achieving our goal of installing a photovoltaic system in a manner that does not harm the fragile cultural equilibrium that exists in Ban Jalae was essential to ensure the success of the village's Culture Center.

Through both the interview we conducted with Khun Surachai and our on site evaluations in the village, we have determined that the Lahu in Ban Jalae feel in no way culturally threatened by their newly acquired solar technology. This conclusion is extremely site specific, and projects teams working with similar hilltribe installations should analyze each tribe's cultural situation carefully on a case by case *basis. Our installation, however, should serve as a reference point for those future projects. We recommend that future project teams visit Ban Jalae and treat the village as a case study, taking into consideration where the project has succeeded and where improvements can be made.*

The Lahu tribal people in Ban Jalae face a difficult period of transition between their traditional way of life and a modernized form of existence. The Ban Jalae villagers realize that they must adapt to this new way of life in order to survive, but they also have a strong sense that they must take measures to preserve their culture, or it will inevitably be destroyed and the tribe will be culturally assimilated into mainstream Thai society. The solar technology that our team has installed in Ban Jalae is a means for preventing this assimilation, as it will aid in the villagers' efforts to preserve their culture.

Chapter 1: Introduction

The preservation of culture at first glance may seem as insignificant as it does futile. One may ask why preservation of cultural heritage in a dynamic society such as our own is a necessity when we perceive ambition as visions of the future. However, it is in man's best interest to cling to that which makes us unique; being able to look back and see what once existed is an inspiration that fuels ambition. Knowledge of the past can provide one with a deeper appreciation of one's origins. Unfortunately, not everyone has the luxury of being able to share his or her heritage with others. In some cases, it can be difficult for a group of people within the same culture to pass on the history of their heritage. Seeing that we all share the same planet, we should have respect for the many cultures of the world and take notice when one in particular is in danger of becoming extinct. Many cultures today face assimilation, especially those that have not kept up with the global technological revolution. Assimilation can occur when a majority group and a minority group co-exist in the same region. Over time, the culture of the majority can influence that of the minority, causing the minority to abandon its way of life, which ultimately becomes extinct.

Rural hilltribe villages in northern Thailand face an increasingly difficult struggle to maintain their culture, heritage, and traditions in an encroaching Thai society. In the past, the villagers in these tribes have passed on their culture orally. As a result, if a tribal generation fails to communicate its way of life to its children, that heritage is irretrievably lost. The tribal minorities in Thailand have not been able to organize themselves politically above the village level, causing additional erosion due to the lack of cultural authority in their homeland (Virtual Hilltribe Museum, 2003). As a result, the hilltribe villagers of northern Thailand have felt an increasing need to find new methods of preserving their culture and way of life.

The current erosion of the northern hilltribes' cultural identities is due to a few key factors. The hilltribes have encountered numerous economic and social problems due to the Thai government banning tribal agricultural practices and relocating the hilltribes to highland areas. Traditionally, most hilltribes *practice a slash and burn technique for the purpose of cultivation that can lay waste to large tracts of forest. Many Thai and foreign conservationists believe these techniques heavily damage the dwindling forests in Thailand. The government has banned these unsustainable farming techniques and has announced a program of "integration" of the hilltribes into Thai society, pushing them to become fully integrated Thai citizens. Yet obtaining Thai citizenship has proven to be extremely difficult, as the majority of the tribal people's time has been dedicated to adjusting to their surroundings and finding new ways to produce income. Without citizenship, it is impossible to vote, buy land, travel outside the district, work legally, or even own a vehicle in Thailand (Virtual Hilltribe Museum, 2003). A non-citizen effectively becomes a non-person.*

The Mirror Art Group (MAG), a non-profit, non-governmental organization (NGO), is working to assist hilltribes from the Mae Yao sub-district of the Chiang Rai Province in this difficult period of adaptation. The MAG, with support of the hilltribe villagers, felt that a creating a museum to showcase the tribal customs and ceremonies of the hilltribes would enable the villagers to preserve their heritage and address some of the changes that are bound to surface as a result of the impinging Thai society. In an attempt to document the hilltribes' vanishing cultures and to educate both tribal people and those interested in tribal culture, the MAG created a cultural learning center located in Ban Jalae, a village near the northern city of Chiang Rai (see Figure 2 in Chapter 2). This Culture Center, known fully as the "Ban Jalae Hilltribe Life and Culture Center," exists so that residents and visitors can learn about hilltribe culture within the environment of a tribal village. The MAG also planned a non-physical, internet-based, aspect of the project: the Virtual Hilltribe Museum (www.hilltribe.org). Through the multimedia presentations featured in the Culture Center and the online version of the museum, the villagers of Ban Jalae should have adequate tools to record and propagate their culture.

There was, however, a problem with the MAG's solution: the Thai government has not provided the Ban Jalae village with the electricity necessary to power such a facility. Ban Jalae is located in an isolated, mountainous region, which has thus far prevented the Thai government from connecting it *to the existing power grid. To ensure successful operation of the Culture Center's equipment, such as the multimedia devices, our team formulated a plan for electrification.*

To compensate for the lack of electrical grid connections, we explored the option of installing a solar electric unit in the Culture Center, where a computer and other educational equipment resides. The Lahu people who inhabit Ban Jalae will primarily utilize and maintain the center. Working alongside the Mirror Art Group, our project team has implemented this maintainable and sustainable technology with the financial support of the Rockefeller Foundation. *To guarantee the long-term viability of the Culture Center, we also developed a maintenance training program for the solar apparatus in order to educate local villagers who will ensure the upkeep of the system. The training program included instructions for preserving the unit as well as safety procedures to use when handling the equipment and its various electrical components.*

Chapter 2: Background

Our team conducted extensive background research on the Lahu hilltribe and the cultural issues they face, the Mirror Art Group and its mission to improve the conditions of the hilltribes in northern Thailand, case studies relevant to cultural assimilation, and information on solar technology. This research allowed us to make better-informed decisions while we worked with the Lahu hilltribe. By studying and observing the tribe's culture, we were able to construct a training program about the maintenance of the new solar unit for the tribe members. The villagers' use of this technology will have a crucial effect on how it influences their culture.

The first part of this chapter introduces the hilltribe people of northern Thailand and concentrates on the sociological factors that have led to their need for cultural preservation. The second section provides background information on the Mirror Art Group, which was responsible for the creation and successful deployment of the Culture Center. In the third section, we present a variety of case studies that describe what can occur when two cultures collide, and explain how communities can use technology to assist in the preservation of a threatened culture. The last section of this chapter focuses on some of the maintenance issues related to the solar electric units in rural Thailand.

2.1 The Hilltribes of Northern Thailand

In Southeast Asia, there are dozens of mountain-dwelling peoples collectively known as hilltribes. Hilltribes are linguistically and culturally distinct semi-nomadic peoples who have migrated through the mountains into Thailand over the last century. Most hilltribes are originally from Tibet, while more recently migrants have come from Myanmar (Burma), Laos, and the Yunnan province in China, after fleeing military conflict and oppression (Figure 1). Due to their origins, none of the hilltribe peoples are related to ethnic Thais, either linguistically or culturally.

Figure 1: Immigration routes for the six main hilltribes in Thailand
Source: www.hilltribe.org/museum/images/map1.jpg

Among the six largest hilltribe groups in Thailand are the Akha, Hmong, Karen, Lahu, Lisu, and Mien (Yao). Only the Mien have a traditional system of writing, which leaves the migration histories of the other hilltribe peoples to be derived from oral histories, linguistic data, Han Chinese manuscripts, and guesswork (Virtual Hilltribe Museum, 2003). As we will see, possessing only an oral language can make the recording of cultural history difficult for some hilltribes. In particular, the Lahu tribes have concerns that they are losing their way of life due in part to a breakdown of communication. Before we discuss these issues, we will first introduce the Lahu people and provide some background information on their culture and origins.

2.1.1 Demographics of the Lahu

Today roughly 25,000 Lahu occupy areas spread out over northern Thailand divided into four major groups: the Red Lahu, Black Lahu, Yellow Lahu, and Lahu Sheleh (Thaipro, 2003). The *particular tribe that our project team was involved with is known as the Laba Lahu, who are closely related to the Red Lahu. There are only two Laba Lahu villages in Thailand, one of which is Ban Jalae, located in the Mae Yao sub-district in the capital district of the northern Thai province of Chiang Rai (Figure 2).*

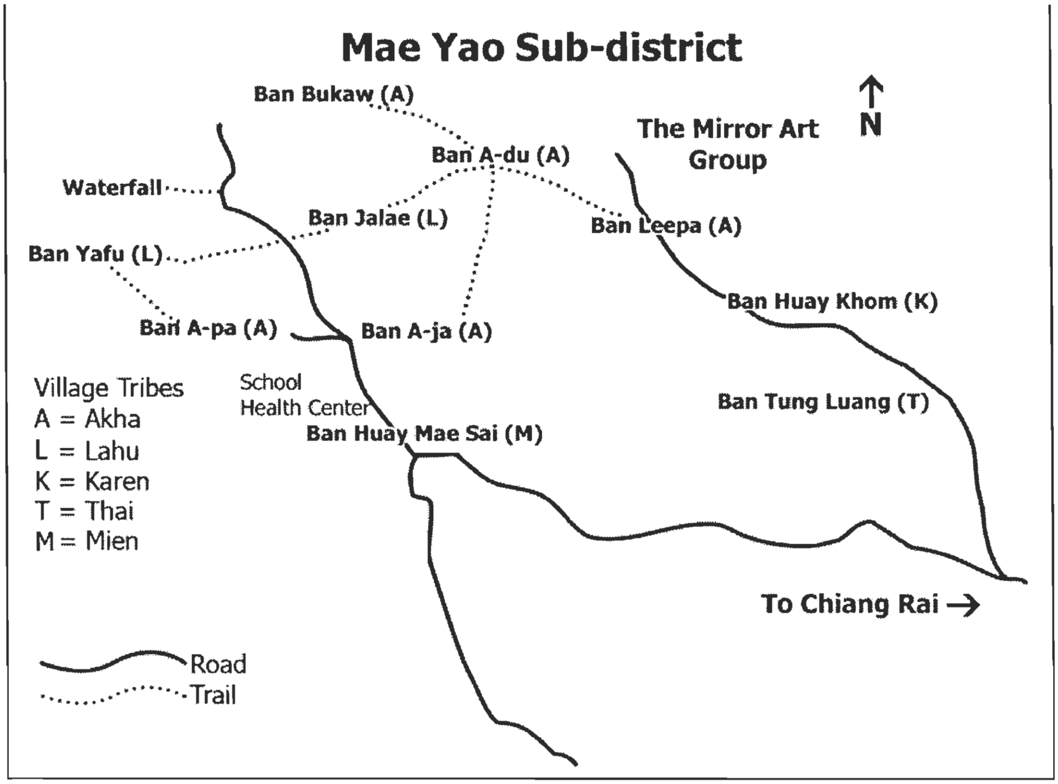

Figure 2: Map depicting the location of Ban Jalae
Source: www.mirrorartgroup.org

Ban Jalae consists of about 60 homes. The Lahu villagers settled in Ban Jalae as the government forced them to leave government-protected forestland in the mountains to "reservations" set aside in the foothills. Ban Jalae is at the site of a former government logging concession of the Royal Thai Government. A number of Akha families who worked for the logging concession also live in the Ban Jalae community (Mirror Art Group, 2003).

Since the Lahu villages are located far into the mountains, without paved roads and other aspects of city development, the tribes operate mostly independently of urban society. The villagers have made their living by hunting, trapping, and harvesting, and although they are some of the most skilled hunters and trappers in Thailand, a lack of game has required them to resort to harvesting crops as their *main source of income. They grow rice for consumption as well as corn and ginger for sale. Many people consider the Lahu ginger to be the best on the market and it is, therefore, a good source of income In addition to growing crops, the Lahu villagers raise cows, chickens, and pigs, both for consumption and for religious sacrifice. Although agriculture has become increasingly essential for the tribe, hunting remains a vital part of the villager's way of life, and tribes still judge their members by their tracking and trapping skills (Mirror Art Group, 2003).*

2.1.2 Lahu culture and traditions

The Lahu are extremely proud of their cultural identity. As a result, the villagers are notably unified in their communal and religious interactions. As important as the concept of unity is the respect the Lahu people have for their elderly; the village elders are the most respected members of the tribe and it is common for households to follow their rules and wishes. Although the decisions of the village elders can sometimes create a divided society, households that act against the elders' wishes are encouraged to leave. However tragic this occurrence, it attests to the strong social and political bonds that the Lahu people expect and their desire for unanimity. In general, the villagers anticipate that everyone will agree with the decisions that the council makes, and in particular, respect the wishes of the village elders.

Another governing force for the Lahu people is their village priest, or paw hku The traditional Lahu religion is animistic and is based on the belief that a supreme ruler called G'eu sha governs the spiritual realm. The village priest holds a high position in the village because he acts as mediator between man and G'eu sha and is the main religious teacher. Lahu religion and its practices can vary among the many different tribal branches, with some following a more shamanistic tradition and others placing more emphasis on ancestor worship. Those ethnic subgroups that have converted to Christianity have made the transition with relatively little destruction of their way of life, and many maintain a degree of animistic worship, creating their own brand of Christianity (Mirror Art Group, 2003). Their easy acceptance of Christianity is due to the separation of their spirituality from the rituals of every-day life, and because several movements of Lahu religion are already messianic (Virtual Hilltribe Museum, 2003). The

Lahu religion itself is still vital, as demonstrated by the recent opening of a Laba Lahu temple in the village of Ban Jalae. The religion creates a strong focus for the local population and allows all faithful members of the community to unite and celebrate their continued traditions, including traditional costumes (Mirror Art Group, 2003).

A further aspect of Lahu culture that contributes to the tribe's strong sense of community is gender equality. Within the household, the husband and wife share chores and childcare equally. In fact, a good husband is valued for his caring nature, especially in times of sickness and childbirth. The Lahu husband and wife are typically quite devoted to each other. Although divorce is a common practice among the tribal families, a married couple will share a mutual respect that does not exist elsewhere. The extended family does not dominate the household, although family members will often live nearby. A husband may live with his wife's family for a period, but it is never a permanent arrangement since most households tend to consist of the parents and their unmarried children. The children who live in the village tend to be very young because most of them leave their homes at around age fifteen to seek employment elsewhere, often in the city (Mirror Art Group, 2003).

Overall, the Lahu people are proud of their religion, skills, customs, and independence. They are a people of strong conviction who do not easily bend to the will of others. Even though poverty and hardship plague many of them, they refuse to sacrifice their way of life. Today, the government plays a greater role in determining how the villagers conduct education and farming practices by enforcing farming ordinances and enrolling Lahu children in Thai schools. The level of modernization that has made its way into the Lahu culture is proof that the tribal people are willing to accept change to ensure their survival, but because of their strong willed nature, "they wish to make the transitions on their own terms" (Mirror Art Group, 2003).

2.1.3 Cultural issues confronting the Lahu people

Many villagers of the Mae Yao sub-district continue the traditions of their ancestors and continue to defy government regulations. They carry on their slash-and-burn agriculture in fields deep *within the mountains, far from government supervision. Recent movements, however, have brought many villages to adopt new, sustainable agricultural techniques. Two of the most pressing issues currently confronting the Lahu tribes are adjusting to these new techniques and obtaining Thai citizenship. Recently, though, due to the strong organization of their villages, 60% of Mae Yao Lahus have become citizens.*

Obtaining citizenship is important for a variety of reasons. It enables hilltribe people to buy land, travel outside their district, work legally, and even own a vehicle. The government awards an individual citizenship only if both parents were born in Thailand and only considers giving an individual citizenship if one of the individual's parents has been a Thai resident for over three years. The government denies those without citizenship access to any governmental welfare benefits. The school certificate awarded at age 15 is stamped "non-citizen," meaning that all further education must come at the individual's expense, far beyond the budget of an average hilltribe family. In addition, Thai citizens pay a standard flat rate of 30 baht for every treatment received at government hospitals, but people living in Thailand without proof of citizenship are obligated to pay the full price. Although recently the number of Lahu villagers who have gained citizenship has been increasing, there are still difficulties with the process. Many times, in an effort to achieve citizenship and earn a better social and economic standing, villagers will fall prey to corrupt local government officials and police. City employers will often take advantage of the fact that the hilltribe people lack citizenship and will exploit them financially, causing further setbacks (Mirror Art Group, 2003).

Even hilltribe people with Thai citizenship are exploited due to ignorance of their rights and distrust of the legal process. This lack of knowledge is a result of the limited education most non-Thais receive and can lead to demoralization and uninformed decision-making. In recent years, for example, the drug trade has been influencing hilltribe communities. The result is that some hilltribe people have joined the infamous Golden Triangle drug trade in a search for income. Lack of knowledge about the dangers of newer drugs, such as methamphetamines, has led to their abuse among some of the rural villagers (Mirror Art Group, 2003).

In the face of these adversities, the distinct culture of the hilltribe people has begun to erode. Prejudice from the Thais, although never violent, is still prevalent in a mocking form. As an example, the Thai word for Akha, E-gaw, is pejorative, with undertones of backwardness, simplicity, and femininity. Since the majority of Lahu children now enroll in state-run or missionary-funded boarding schools after completing the sixth grade, it is not uncommon for Thai teachers to belittle a tribal child's ethnic identity (Mirror Art Group, 2003). Gradually this constant low-grade barrage of intolerance and cultural misunderstanding causes many members of the hilltribes to become ashamed of their own cultural heritages, thinking of them as backward and basic. Instead of returning home after schooling, hilltribe youths will often travel to the cities in search of employment, stepping directly back into this cycle of exploitation.

The villagers themselves are not blind to the erosive processes occurring; they just feel powerless to stop them. The following section describes the Mirror Art Group and its efforts to aid the hilltribe people in their difficult period of adjustment.

2.2 The Mirror Art Group's dedication to hilltribe communities

Our sponsor for this project, the Mirror Art Group, is a knowledgeable resource for the Lahu people about modernization and adaptation. This NGO has been working very closely with the hilltribe communities located in the Mae Yao sub-district, especially the Lahu tribe, for nearly five years. Thus, the organization has a great deal of information about the tribe's people and their culture. What follows is a description of how the Mirror Art Group established its connection with the hilltribes and what programs it is implementing to assist these communities.

2.2.1 History of the Mirror Art Group

Originally founded in 1991, the Mirror Art Group's (MAG) aim was to promote social change, human rights, and universal equality. Sombat Boongamanong, visionary and founding member (Figure 3), believed the best way to accomplish these goals was through cooperation, self-education, and *community activism. Sombat and his colleagues decided that art and drama performances could communicate their ideals to the widest audience. In addition, the MAG could avoid placing its organization in a dangerous political controversy by using entertainment to address potentially contentious issues like democracy, human rights, HIV, and sex education (Mirror Art Group, 2003).*

Figure 3: Photograph of Sombat Boongamanong (Nuling) , founder of the MAG
Source: www.mirrorartgroup.org

Despite performing over one hundred times per year, the Mirror Art Group eventually became disillusioned by the relatively small amount of time they were spending with rural target audiences. In 1998, the MAG decided to redirect its focus and moved from Bangkok to establish a grassroots multimedia center in Chiang Rai. The change in venue brought changes to the MAG's largely political website, www.thebangkok.com. The Mirror Art Group changed the name and general content of the website to www.bannok.com, bannok being a Thai term meaning rural (Mirror Art Group, 2003).

Upon arriving at their new location, the Mirror Art Group saw the high levels of poverty, unemployment, malnutrition, and drug abuse present in an adjacent village. It was the first time the MAG had considered the difficulties faced by Thailand's highland ethnic minority people (Mirror Art Group, 2003). The villagers were coping with the complete upheaval in their way of life brought on by their relocation from the mountaintops to the foothills. It was at this time that the Mirror Art Group found their new mission and began preparations to assist the tribes.

It was not long before the Mirror Art Group made friendships with the many neighboring tribes scattered throughout the Mae Yao sub-district. After learning the problems from the villagers' point of *view and seeing first hand that the modern world was slowly swallowing their culture, the MAG started projects to help the hilltribes regain their strong communities.*

2.2.2 Promoting cultural awareness through the Virtual Hilltribe Museum

One project the Mirror Art Group is working on is the completion of a Virtual Hilltribe Museum. This project's goal is to document and teach the public about the cultural shift of highland ethnic minorities in Southeast Asia, especially Thailand (Virtual Hilltribe Museum, 2003). The project aims at attracting an audience among hilltribe youths in urban environments who no longer have the time, access, or interest to receive the oral traditions of their cultures from elders. Tourists of the hilltribe villages and those interested in learning about the hilltribes will also find the website useful. The museum focuses on the traditional ways of life and the manner in which the hilltribe peoples have adapted and integrated with majority cultures, like the Thais. The project website is www.hilltribe.org and it has received funding from the Rockefeller Foundation's Mekong Sub-Region Project (Virtual Hilltribe Museum, 2003).

2.2.3 Development of the Ban Jalae Hilltribe Life and Culture Center

The Mirror Art Group, with support of the Ban Jalae villagers, believes that a museum highlighting the tribal customs and ceremonies of the Lahu hilltribe will enable the community to preserve its heritage and address some of the changes that are bound to come with an encroaching Thai society. The Culture Center provides the Ban Jalae villagers with some technological tools to aid in this endeavor. The equipment will not only document the culture and traditions of the tribe, but will provide educational services to the community and visitors. The equipment powered by the solar unit includes a large projector and one or more computers. In addition, the solar unit contains a battery charging station for the villagers.

A static version of the Virtual Hilltribe Museum website will be available to the villagers on the computers to exhibit their culture further. The computers will also serve to enhance the Lahu tribe's computer skills and may be linked to a satellite internet connection in the future. If an internet connection were to be present in the Culture Center, a new set of options would become available to the villagers: the Virtual Hilltribe Museum would no longer be static; through online research and instruction, the villagers could learn new languages and perform routine tasks, such as the checking of agricultural prices (Mirror Art Group, 2003). The remaining equipment would aid in the documentation of rituals and traditions by capturing video and still images of the tribe.

2.3 Case studies of cultural preservation

To gain a perspective on how cultures can be affected by assimilation, we have gathered a collection of case studies relating to the difficulties that face the Ban Jalae villagers. We used these case studies to anticipate possible social consequences that could occur with the installation of the solar unit, and understand why there is a need for the Culture Center. In this section, we use examples from different countries to show what can occur when two cultures collide, how people can use technology to assist in the preservation of a threatened culture, and how these examples relate directly to the Lahu tribe's situation.

2.3.1 U. S. Indian School Chemawa

In an attempt to assimilate Indian tribes and meet the requirements of the Indian Act, the U.S. government, from the 1860s to the 1970s, established a Catholic-led system of residential schools. These schools targeted Indian children, with the goal of "civilizing" the children and making them more like their American "brothers and sisters" (U.S. Indian Commissioner, 1904, as cited in Carlisle Indian Industrial School, 2003). Government officials displaced Indian children from the ages five through eighteen from their homes and placed them under the care of nuns in the residential school system. The nuns were so anxious to "kill the Indian and save the man," that if a child spoke in his or her native language, he or she would be punished in order replace the children's native ways with the new "more civil" ways of the Americans (A Place at the Table, 2000). By subjecting them to constant brainwashing and punishment, the nuns were able to instill within the children's minds the belief that the

Indian way of life was wrong. The residential school system was a tragic attack on the Indian culture and it succeeded, to some extent, in diminishing the oral history and traditions of the native people, eliminating much of the Indian culture.

The residential school system serves as a warning of what could happen to a threatened culture. The Lahu villager's culture faces a similar threat as their children attend a Thai school just north of Chiang Rai. The emphasis is to assimilate the children into the Thai culture (Macan-Markar 3). The school is teaching them to be Thai and the children are allowed to speak their own language only outside the classroom. On Fridays, the school permits the Lahu children to wear their traditional clothes. While not as strict as the residential schools for the Indians, the Thai school teaches only Thai culture, which makes it difficult for the Lahu children to accept their own cultural background. These factors contributed to the Mirror Art Group's decision to implement the Culture Center, to help preserve the Lahu's cultural background by placing less emphasis on conformity within Thai-taught schools.

2.3.2 Four Directions Study

The Four Direction Study, conducted in the spring of 2001, involved four different Indian tribes across the US, and gave Indian children the opportunity to learn about their culture through interactions with their tribe and the creation of a virtual museum of Indian artifacts. A virtual museum is a museum located on the World Wide Web that contains images of artifacts, stories of past histories, and traditions of a culture. The tribal schools that these Indian children attended collaborated with local museums to allow the children access to artifacts. They selected objects from their own cultural background and used Quick Time Virtual Reality (QTVR) technology to build three-dimensional digital constructs of each artifact (Christal 436). With the aid of tribal community members, teachers, and museum staff, the students also conducted research to understand each artifact's cultural significance. This research combined information from the museum exhibit with valued cultural content provided by the tribal community. After the students completed the research and wrote text descriptions of the objects, they compiled all the data to a website where everyone could view it.

The virtual museum provided the tribal community with a resource to pass down cultural knowledge to the Indian tribe's younger generations. Many tribal members recognized that the student role in the virtual museum project contributed to the function of cultural reproduction. The students became "story-tellers for their grandparents" through their participation in the virtual museum project; story telling is an ancient tradition of the Indian tribes (Christal 441). Learning how to use the technology allowed the students to help preserve their culture for the future. The utilization of the technology also became an example to the Indian tribe members that they could intgrate technology into their culture to preserve their past, a valuable lesson that we applied to the Lahu tribe in Ban Jalae.

2.3.3 Museau da Pessoa (Museum of the Person)

With a mission to preserve the past of Brazilian history, Karen Worcman founded the Museau da Pessoa, a virtual museum that archives lifetime experiences of Brazilian individuals. The virtual museum uses the Brazilians' native language so that the people of Brazil can, themselves, access the museum and learn about others in their society. Although the museum is entirely in Portuguese, and is inaccessible to those who cannot speak or read that language, it has a strong social impact that reinforces the "individual and community identity and self-esteem" (Worcman 2). Brazilians have utilized the Museau da Pessoa to write books from their stories. Teachers have used these books in educational programs for workers to show the experiences of individuals who came before them. With the experiences of fellow countrymen before them, Brazilians draw on their history to shape their future. Karen Worcman established the virtual museum for the people and it remains an example of preserving culture and tradition by means of stories through the use of technology.

Using a virtual museum similar to the Museau da Pessoa, the inhabitants of Ban Jalae are now able to create a place where they can store knowledge of culture and tradition as well as preserve their native language. The Lahu language has no written script form, so the website of the virtual museum could be nonexclusive to the Lahu just as the Museau da Pessoa is nonexclusive to Brazilians. The website would have to be in another language, but could include an on-line talking dictionary that would *serve to physically preserve the oral Lahu language as well as provide a place for its study (Macan-Markar 2). The native language for any culture is important to uphold, as it is vital to its history and traditions.*

2.3.4 The Studio Museum in Harlem

Oral history and tradition is only one of many methods to preserve culture. At the Studio Museum in Harlem, artists of African descent portray their culture and history through sculptures, paintings, performances, and dialogues, among other artistic approaches. The museum allows people of all cultures to visit the exhibits and learn of the past and present struggles that the African American community has faced and currently faces. In addition to the art exhibits of the museum, the museum also functions as a studio. Artists of African descent can apply for an Artists-In-Residence Program, which admits three artists per year and gives them studio space as well as a fellowship (The Studio Museum in Harlem, 2003). These fellowships allow artists to explore their culture and experiences artistically. The studio displays their work to the public towards the end of their fellowship term. The fellowship permits the artists to surround themselves with their art.

The Museum in Harlem uses methods to display culture that are similar to those of the Culture Center in Ban Jalae, and both have a common goal of educating people who are a part of the culture as well as people who are not. The Culture Center serves as a place where the Lahu people can ensure that their culture endures. They are able to use the Culture Center to display their customs and ceremonies, which are very important as the younger generations do not "know the ceremonies, and this knowledge is being lost" (Macan-Markar 1). Using the Culture Center and the virtual museum, the Lahu people can teach their children their unique culture, which will keep their traditions from fading into the shadows.

2.3.5 PV Installation in Mae Wae

In 2001, a team of students from Worcester Polytechnic Institute conducted an Interactive Qualifying Project in Thailand that involved installing a photovoltaic system (PV) in a rural village in *order to provide electricity for a school. The students visited Sokaykla, Mae Wae, and Poe Kee, three villages in the northwest corner of Tak Province, and assessed the needs of the villages to decide where they would install the PV system. The team interviewed village leaders and schoolteachers to obtain information on how they would like to improve the children's education. Through these interviews, the team determined that by restructuring the villagers' Thai language classes, communications with people outside of the village could drastically be improved. The teachers in the village agreed that using a TV and video system would effectively meet the tribe's educational needs. In order to power this equipment, the team designed and successfully installed a photovoltaic system in Mae Wae. With the aim to keep the PV system running after the students left the village, they created a maintenance manual. The experience of that team provided a base of information for this project.*

2.4 Solar electric maintenance and safety

In order to ensure that the photovoltaic system would continue to function properly in its rural setting, we educated the local hilltribe on the system's operation and required maintenance. Three of the five major parts in a photovoltaic system--the solar module, inverter, and batteries (Figure 4)--have maintenance procedures and safety precautions to follow. Most of the information in the following sections derives from James Dunlop's useful article, "Stand Alone Photovoltaic Systems."

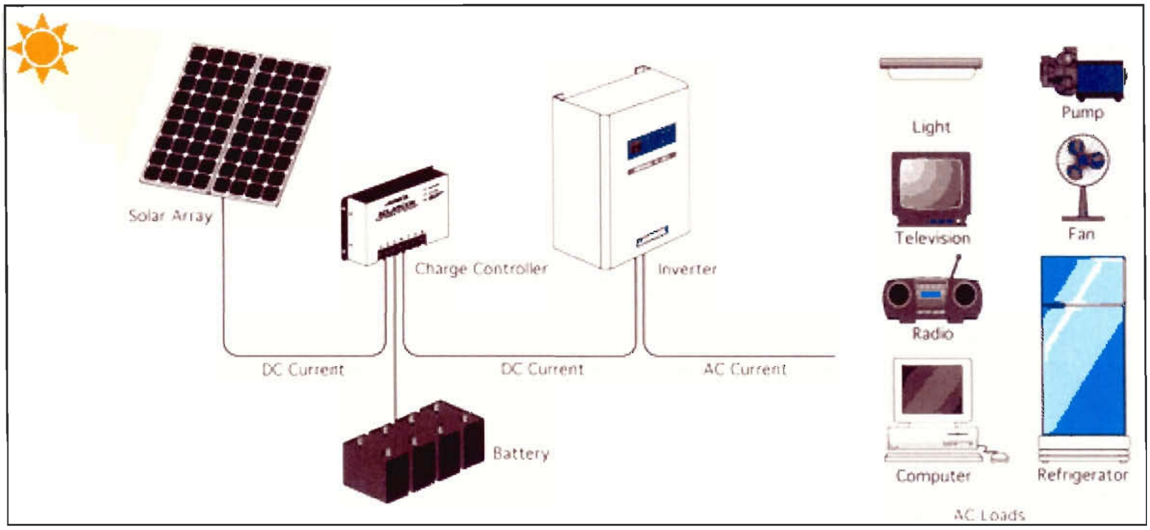

Figure 4: Diagram of a typical photovoltaic system
Source: www.solartron.com

2.4.1 Problems due to weather and debris

The solar module contains the solar panels and functions as the receptor of sunlight. The maintenance persons should wash the panels occasionally in order to remove dust or debris. If excessive debris collects under the module, air intake into the system could become blocked, which would result in system malfunction due to overheating. This is especially worrisome in Thailand where average daily temperatures often reach 90°F (Figure 5). There are two large trees located on either side of the Culture Center that are potential sources of natural debris. The villagers must check the solar module periodically for branches and leaves that may have fallen on the solar panels. These types of debris hinder the system's ability to collect solar rays and severely reduce energy output.

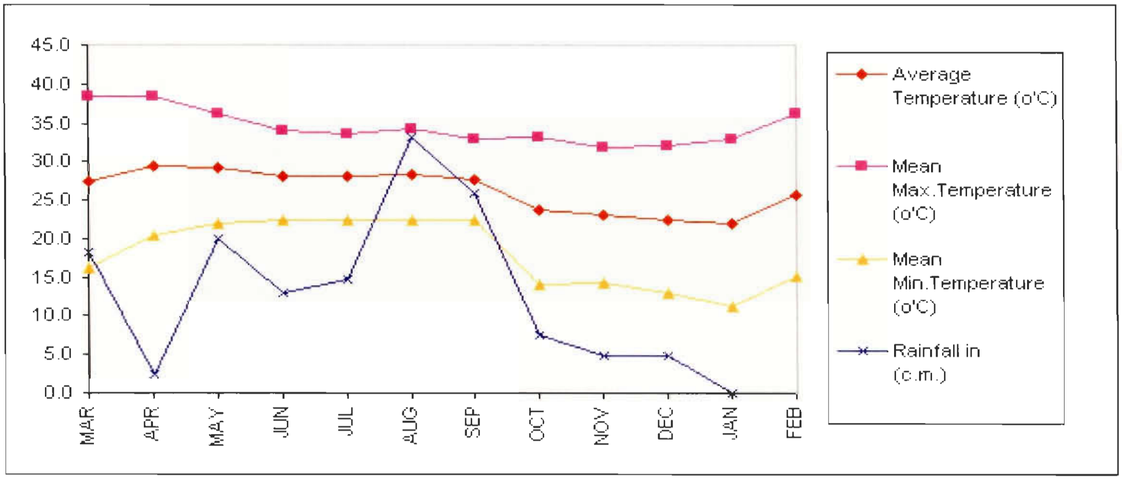

Figure 5: Graph of annual rainfall estimates (cm) and temperature (C°) in Thailand
Source: www.thaifocus.com/climate.htm

Rain will, over time, cause corrosion of the solar module's metal components. A protective coating of paint can help prevent this, but the Lahu villagers will need to apply a new coat about every two years to maintain the corrosion protection. When the cells in the solar console are manufactured, they are coated with a water proofing lamination, which may leak and cause the system to short circuit. If this should happen, the maintenance persons need to remove the solar receptor immediately from the sunlight to terminate their output. The solar cells should be replaced or the seal repaired after the maintenance persons have properly disconnected the panels from the system.

Leakage due to rainfall is particularly troublesome for the village's solar installation due to climatic changes in northern Thailand. Each year, around June or July, the climate shifts from warm and dry to relatively cool and rainy (Figure 5). During this rainy, or monsoon season, rainfall totals typically exceed 20 or even 30 cm a month (Northern Thai Climate and Weather, 2003). If the solar unit's housing does begin to leak during this season the villagers may need to disassemble sensitive electrical components and store them away from the damaging moisture. Another concern imposed by the monsoon season is that the production of solar electricity is nearly impossible as the cloud cover can block the sun for days at a time. The village owns a small generator that it uses to operate small power tools. If the villagers want to produce electricity during extended periods of cloudiness they may have to use the generator as an alternate power source.

An adjustable solar array mounting structure allows the solar modules to function at their highest level of efficiency by directly aligning them with the sun's rays. To obtain the appropriate angle towards the sun during various times throughout the year, solar installers typically raise the mounting structure using a series of stands or stilts. However, strong winds can cause the solar modules to twist slightly and become repositioned or even crack when this method is used. Selecting appropriate materials to resist the stresses imposed by strong winds and rain minimizes the effects of these deformations.

Other damaging deformations to the solar modules can result from excessive loading. The solar modules are designed to bear no more than the occasional weight of environmental debris. Therefore, it is imperative that the villagers place nothing on top of the modules, and that they do not walk on them during maintenance or repair. Any extra weight could cause the module to crack and it would need to be replaced. The solar panels in Ban Jalae are located in an area of relatively high recreational traffic. The children in the village often play soccer games nearby and throw around hard wooden tops which are both potentially hazardous to the installation.

2.4.2 Inverter overheating and fire risks

The location of the electric inverter determines its overall effectiveness and functionality. The main concern is that improper placement of the unit will cause overheating which will result in its malfunction. Direct exposure to the sun can cause overheating. The inverter, therefore, is located within the solar building where the protective roof will act as a shield against the sun's rays. The area around the inverter needs to be clear of debris, as any constriction of the airflow in or around the inverter could also cause the unit to overheat. Although the risk of overheating is unlikely since the inverter is located within the solar building, the threat of fire still exists.

Faulty wiring or connectors within the system are potential fire risks. To prevent shorts, the maintenance persons need to inspect the wire connections and the condition of the wires themselves. Any damaged connections or wires need replacement immediately, as they can also cause electric shocks or fires. If any of these shocks produce sparks around the system's batteries, human risk increases drastically as the sparks may induce an explosion.

2.4.3 Maintenance and safety issues with lead-acid batteries

The most common types of batteries used in photovoltaic systems are lead-acid. It is essential that the maintenance persons monitor these batteries through either routine checks or continual readings from meters on the battery charge controller. These readings will indicate whether the batteries are functioning properly. It is imperative that the maintenance persons be able to understand the system readings in order to perform the proper maintenance or repairs. Routine cleaning of the battery and battery terminals will ensure conductive connections and help prevent corrosion and battery acid leakage. Routine maintenance will also minimize the occurrences of shorts within the system.

Due to the potential production and mixing of gases within lead-acid batteries, they are extremely prone to explosions. Improper charging or overcharging of the batteries can also have the same result. Suitable ventilation will allow these gases to escape and will greatly reduce this risk. Production of sparks or flames by power tools or other objects near the battery storage area can cause the gases to *ignite. The maintenance persons need to disconnect the batteries from the system in order to avoid electrical sparks that could result in an explosion.*

The potential toxicity of the batteries in a photovoltaic system prevents them from being disposed of conventionally. There are typically strict regulations on where disposal of batteries can occur in order to prevent environmental pollution. Oftentimes the companies that produce the batteries will also provide methods of disposal. Ultimately, the Ban Jalae villagers are responsible for the proper disposal of old or damaged batteries.

Chapter 3: Methodology

This project aims to increase awareness of the Lahu tribal culture by assisting with the implementation of a Culture Center in the Ban Jalae village. Sponsored by the Mirror Art Group (MAG), our team has investigated the option of installing a photovoltaic (PV) system to power the Culture Center, while taking into consideration the societal impacts of the technology.

To accomplish this goal successfully, our team completed these four main objectives:

5) *Determining the expectations of the MAG and the Lahu tribe for the Culture Center .*
6) *Evaluating the success of similar PV systems at a second Lahu village*
7) *Installing a sustainable solar power supply*
8) *Educating the Jalae villagers about the safety and maintenance of the PV technology.*

The first objective involved a study of both the Mirror Art Group and the Lahu tribe's expectations of what the Culture Center would provide. Individual interviews with a selected villager and MAG representative allowed our project team to understand how the two expected the technological devices in the Culture Center to aid the Lahu villagers in their struggle to preserve their cultural identity. The results from the second objective provided our team with an example of how a photovoltaic system fares in a rural hilltribe village and what societal impacts the technology can have on the community. We achieved this objective by analyzing two previous PV system installations and conducting an interview with a Ban Yafu villager about the history and impacts of the PV systems. The third objective was the actual design and installation of our PV system in Ban Jalae. After we performed a load analysis and site surveys, our project team purchased, assembled, and installed the system with the assistance of villagers. Finally, once the PV system was fully functional, our last objective was to leave the Lahu villagers with the means for using and maintaining the PV system. We conducted a presentation for the villagers to inform them of the safety and operational issues with the PV system. We also provided a training session to the individuals in the village who are in charge of the system's maintenance and repairs.

3.1 Determining the expectations for the Culture Center

Our first main goal was to assess whether the Ban Jalae residents had realistic expectations of the Culture Center and its deliverables. We drew comparisons between the expectations obtained from the interviews with a Lahu villager and a MAG representative in order to predict the success of the Culture Center and the solar installation.

3.1.1 Interviewing the chief member of the Culture Center Board

Our team initially chose to conduct a census of the Ban Jalae Lahu rather than interviews and focus groups. A census would have provided a statistically better picture of how the villagers viewed this project. However, when we consulted members of the MAG, they brought to our attention that these results may not be entirely accurate, as some villagers would respond to our questions with the answers they thought we wanted to hear. We decided that in place of a census we would interview a respected member of the tribe who could represent the views of the entire tribe. We interviewed Khun Surachai, the head of the council the villagers created to oversee construction of the Culture Center. Khun Surachai was able to give us a clear overall perspective of the villagers' expectations of the Culture Center. The interview covered three main issues: how the Lahu people felt about tourism and the increase of traffic through their village due to the Culture Center's presence; how the Culture Center and the technology powering it would affect the lives of the villagers; and what the tribe members expect to gain from the facility. A transcript of the interview is in Appendix A.

3.1.2 Interviewing a MAG representative

The second part of the project's initial assessment of expectations involved conducting an interview with a Mirror Art Group representative. Our project team used an interview instead of questionnaire. This was largely due to our inability to anticipate the range of possible answers. An interview allowed us to collect specific answers to our questions and to redirect the conversation towards material that we did not consider prior to the interview. The interview with the MAG representative ensured that we obtained the most accurate information in the most direct manner possible (Berg 114).

Since the MAG was responsible for the creation of the Culture Center, its representatives had the clearest idea of its goals and also a firm understanding of what equipment would aid in its functionality. The questions in the interview centered on how the Mirror Art Group envisioned the Culture Center benefiting the Lahu people. We questioned Jonathan Morris, our main contact in the organization, about the Culture Center and its role in providing cultural education and preservation. A record of the interview is in Appendix A.

3.2 Observing PV installations at a different Lahu village

While visiting Ban Jalae our team learned of another Lahu village within walking distance, Ban Yafu, which contained two previously installed solar units. An analysis of their current condition and operating history was vital for predicting the success of our team's PV system. Since the village was also Lahu, we were able to investigate the cultural impacts associated with the unit's installation as well.

3.2.1 Examining the condition of the PV systems

In order to obtain information about Ban Yafu's PV systems, we interviewed a villager that was familiar with the PV systems' operation and history. It seemed that the villager that we consulted had the most accurate knowledge of how the PV systems had been performing and what issues had arisen since their installation. We made observations and asked questions pertaining to the types of maintenance and repairs that the villagers performed on the system, how often problems had arisen, and during what time of year or under what kind of meteorological conditions the PV systems had encountered difficulties. Answers to these questions along with resolutions to the problems, if they were in fact resolved, provided us with a clear understanding of what procedures we would need to take to avoid similar problems with the solar installation in Ban Jalae.

3.2.2 Determining the installations' cultural and societal impacts

The ways in which the introduction of solar technology socially and culturally affected the Lahu in Ban Yafu, contributed to our understanding of how the Ban Jalae villagers may also be affected.

While observing the physical condition of the system, the project team also asked the Ban Yafu villager what types of impacts they felt that the photovoltaic system has had on the tribe. The questions we asked were similar to those addressed when interviewing the Ban Jalae villagers regarding electrification of the Culture Center: whether the Ban Yafu tribe was accepting of having electricity brought to their village, how the installations affected the tribe, and whether the electrically powered equipment had taken away from their culture or heritage. A detailed description of the questions and responses from the interview is in Appendix A.

3.3 Installing a sustainable solar power supply

The main technical element of our team's project involved powering the Culture Center's educational equipment. For the Ban Jalae installation, a well-designed and environmentally appropriate photovoltaic system was necessary, not only to meet the requirements of the equipment being run but also to be accessible, maintainable, and resistant to Thailand's climate and weather. The following three sections detail the main tasks in providing the Culture Center with an appropriate solar power solution.

3.3.1 Performing a load analysis

To meet the power requirements of the equipment used in the Culture Center, we performed a load analysis to determine the exact system requirements. The load refers to the total amount of power required on a daily basis. Although it was impossible with our budget to install a photovoltaic system that could supply all the power the Lahu tribe desired, determining the power requirements afforded us the opportunity to inform the Lahu tribe and the Mirror Art Group of what power limitations they had. We identified the hourly power requirements of all appliances in the Culture Center, along with their likely hourly usage, to calculate the overall system requirements. Once we obtained this information, we were able to estimate the maximum power output that our budget would allow.

3.3.2 Conducting site surveys

In order to select the most appropriate location for the installation in Ban Jalae, our team conducted a site survey of the village. To assess the strengths and weaknesses of different locations around the Culture Center, we created a Site Survey Analysis Sheet (see Appendix B). The analysis sheet helped us evaluate the conditions at each site, including the amount of sunlight, safety, location of other components, and distance from the Culture Center. We then evaluated this data in order to determine which location in the village would be best for the system installation.

To assess the amount of sunlight each location receives during different times of the year, our team used NASA's surface meteorology and solar energy data tables. This webpage is a tool consisting of data that NASA has gathered dealing with solar geometry and meteorology around the world (Barkstrom, 2004). By entering the latitude and longitude of an area, our team could determine the average percentage of a full day of sun that a specific site receives during any time of year.

Keeping the system safe and from injuring villagers was another important criterion our team used in comparing the different system installation sites. Our team conducted a visual evaluation at each of the locations to seek for potential threats to the Ban Jalae villagers and the system components. To ensure the safety of the components from damage by people or animals and vice versa, we further evaluated the sites based upon their proximity to heavily accessed areas of the village. We also took into consideration methods for preventing the electronic devices from being rained on or exposed to extreme temperatures and humidity. Finally, by considering all these factors, we determined the safety criterion for each potential system installation site.

Our team also evaluated possible locations for each of the individual components of the PV system. The solar panel's proximity to the batteries, charge controller, and inverter can greatly affect power loss. As described in the inverter section of Appendix C, the power produced by the solar panels comes in the form of direct current (DC). Unfortunately, this DC is applied with a very low voltage, which means that long wires lead to power losses. To minimize the power loss, we tried to situate the components as close to the solar panels as possible, eliminating the need for larger, more expensive panels.

Our last measurement was the distance between the PV system and the Culture Center. Distance directly affects the PV system's cost and maintainability. The wiring used to connect the PV system to the load devices powered by it is expensive, so minimizing the length of the wires can reduce the overall system cost. In addition, longer wires are more prone to damage, which would increase the amount of maintenance and likelihood of premature system failure. We logged the distances between the components and the Culture Center in the Site Survey Analysis Sheet. We used the summation of all the information we gathered to discover the most appropriate location of the PV system installation in Ban Jalae.

3.3.3 Assembling the PV system

In order to obtain a PV system, we identified companies that sold PV system components and arranged meetings with their sales representatives. We presented the PV system design parameters that we determined for the Culture Center to the PV distributors who delivered price quotes and system specifications of the PV system components to us. We evaluated each of these systems and compared components according to cost and appropriateness for the Culture Center implementation, and selected the most cost-effective and appropriate design.

Using funding from a Rockefeller Foundation grant, we purchased and delivered the PV system to Chiang Rai. Appendix E includes price quotes of the main PV components and Appendix F contains the parts list. To ensure none of the components were damaged or defective, we thoroughly examined and tested them individually. After we verified that all the components were functioning properly, we proceeded with the installation of the system.

The installation involved constructing an adjustable mounting structure, wiring the solar panels and the remaining components, and testing the completed system to ensure proper performance. We constructed the mounting structure to ensure that we oriented the solar panels correctly to receive the greatest amount of sunlight throughout the year. Once we wired the solar panels into the electronic components of the solar power system, we tested the panels' functionality on the mounting structure. After *wiring the batteries, charge controller, and inverter together, we could finally verify that the PV system met the power requirements of the educational equipment in the Culture Center.*

3.4 Educating the Lahu villagers on PV Maintenance and Safety

The Ban Jalae hilltribe has experience with electricity and had an understanding of its benefits prior to our solar installation. However, now that we have installed the solar unit in the village, the tribe will be solely responsibly for the system's upkeep and regulation. It is possible that the solar unit could cease to operate or cause injury if the village residents do not maintain and monitor the unit's usage. To prevent such problems, we implemented a training program for the villagers.

3.4.1 Presenting general PV safety information to the Ban Jalae villagers

The safety of the Ban Jalae villagers was the most important aspect of our training program. Our main concern was that village inhabitants could injure themselves while operating or maintaining the system. Although we did not find it necessary to instruct the entire village about the system's maintenance and operation, we tried to ensure that each member was aware of the dangers that a photovoltaic system poses. We discussed safety and maintenance issues and created a poster, currently displayed next to the photovoltaic system, explaining proper safety procedures (see Figure 15 in Chapter 4). Since a language barrier existed between the villagers and our team, we made use of pictures in our informational posters that were able to show systematically, with minimal use of words, the safety precautions for the system. The poster shown in Figure 15 will contain additional Thai text describing in more detail the pictures illustrated. We gave the residents a brief overview of the technical aspects of the photovoltaic system as well. This overview included information about the amount of electricity that the PV system can produce daily and a short introduction to how the system functions. We made every effort to stress that the solar energy output has limitations and that the villagers should use the electricity only for its planned purposes.

Although the group discuss ion and posters were helpful in conveying general safety precautions, our team also decided that a more technical description of the maintenance and repair of the system was necessary for select individuals of the tribe.

3.4.2 Developing a training program for maintenance and repair

The Mirror Art Group made it clear that there were technologically inclined villagers in the tribe. With this in mind, we created a separate training program concerning the maintenance and repair of the photovoltaic system for these villagers. We designed this program to cover the photovoltaic system and each of the components in detail. Section 4.4.2 contains a more thorough description of the training program. In addition to our team's physical and verbal instruction, we created a poster that showed the selected tribe members the methods for operating the PV system's battery charging station (see Figure 14 in Chapter 4). The finalized version of the poster will also contain Thai text describing the process of charging 12-volt batteries.

Chapter 4: Results and Analysis

In the following sections, we discuss the results from our four main objectives. The first section covers the expectations of both the Ban Jalae villagers and MAG concerning the Culture Center and PV technology. By analyzing the responses given in the two interviews, our team was able to determine if the two groups had similar outlooks, which assisted in predicting of the success of our solar installation in Ban Jalae. Next, our team assessed the solar installations in Ban Yafu. By observing its physical condition and interviewing a villager, we were able to avoid similar problems during our installation of the solar equipment. In addition, the interview with the Ban Yafu villager allowed our team to draw further connections between technology and its influence on a rural hilltribe village. Our third section focuses on the actual installation of the photovoltaic system in Ban Jalae and the complications our team experienced. The last issue discussed focuses on the results of our maintenance and safety training programs, and the problems that surfaced during each of them.

4.1 Evaluation of the expectations of the Lahu villagers and the MAG

One of our team's first steps towards the completion of this project was determining if the MAG was providing the Ban Jalae villagers with what they expected to receive from the Culture Center, and in turn, if the community had realistic expectations of the Culture Center and its technology. We wanted to ensure that we designed our solar electric system to meet its intended purposes. The interviews with both groups provided information concerning how the MAG and the villagers felt the Culture Center's technology might affect the culture of the tribe.

4.1.1 Interview with the head Culture Center Board member

While in Ban Jalae, we had the opportunity to interview Khun Surachai who, in addition to being a member of the Lahu tribe, is the head of the Ban Jalae Hilltribe Life and Culture Center Board. We chose to interview Khun Surachai because he holds a high position in the village and could represent the majority opinion of the villagers with respect to the Culture Center. He also speaks fluent Thai, *which allowed us to use only a single translator during the interview and reduced the possibility of miscommunication. We divided the content of the interview with Khun Surachai into two main sections: the villagers' expectations for the Culture Center, and technology's influence on the tribe's way of life. A transcript of the interview is in Appendix A.*

Since the Culture Center would be open to visitors and provide multimedia presentations about hilltribes, it is likely that tourism in Ban Jalae would increase once the facility was finished. Improved tourism would provide the financially burdened community with a source of outside income. Before visiting Ban Jalae, we believed that the number of non-Lahu visitors in the village also would disrupt the villagers' traditional lifestyles. However, Khun Surachai informed us that the Lahu villagers are delighted about this increase in tourism. One of the main reasons the villagers agreed to the creation of the Culture Center was to increase tourism and thus increase their income. Due to the lack of suitable farmland, the Lahu villagers are desperate for new sources of income. Khun Surachai assured us that tourism would in no way degrade the quality of the tribe's culture, as the community has always had the will to remain strongly unified.

The Ban Jalae villagers possessed a very open mind as to how they could benefit from the Culture Center. They anticipated that it would provide better education for younger generations about the tribe's sacred traditions and practices, but as Khun Surachai told us, the villagers were unfamiliar with the actual solar technology and electrical equipment. The Lahu villagers were excited about the prospect of being able to charge batteries and have computer access, but they did not have a full understanding of how the technology operated, and so did not entirely know what to expect. They were still confident that the Culture Center would exceed any expectations they might have.

Overall, Khun Surachai believed that the Culture Center was going to have an enormously positive effect on the Ban Jalae community's culture. It had already served to unify the village, as each villager had a hand in its creation. Furthermore, the role of the Culture Center is to preserve important Lahu traditions and practices by making it possible for older generations to pass them on to their *offspring. Khun Surachai told us that cultural communication between generations is very important to the Lahu. The villagers considered the Culture Center and the PV installation to be a blessing.*

Our team was concerned that the Culture Center's technology could have a negative affect on the way the villagers live. The community has thus far lived with extremely limited amounts of electricity and we suspected that introducing such technology might cause the village to become dependent on it and lose sight of what makes their tribe unique. This concern prompted us to discuss these issues with Khun Surachai in the second section of our interview.

Contrary to what we expected, the Ban Jalae villagers' attitude towards the solar electric unit and the electronic equipment in the Culture Center were equally positive. We asked Khun Surachai questions about the effect modernization would have on the tribe, such as, "Do you see any conflicts between modernization and the preservation of tradition?" and "Could electricity accelerate the process of cultural erosion?" His responses gave us a clear understanding of how the Ban Jalae residents perceive their assimilation into mainstream society through modernization. The goal of the villagers has never been to oppose modernization, but to use aspects of Thai society and technology to their advantage. 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. In addition to being a means for education, technology itself is necessary for the tribe because without some level of modernization it could not survive. The conflict is not between Lahu culture and modernization but rather stems from a lack of cultural continuity amid the generations. The technology we have given the villagers not only enables the Culture Center to function; it provides a degree of modernization that allows the tribe to endure.

The results of the interview with Khun Surachai were quite different from what we expected. Our first impression was that tourism, although economically stimulating, would impose on the tribe and their traditional way of life. To our relief we found that the local people were optimistic and supportive of the Culture Center and its electrification.

4.1.2 Interview with the MAG representative

One of our motives for conducting interviews was to determine how the views and expectations of both the Lahu tribe and the MAG could be compared to make sure that the two groups did not have contrasting ideas of how the Culture Center was to be used and how it would benefit the tribe. Our other motive was to gain some insight into what types of problems might arise both during and after the installation process. We interviewed our liaison, Jonathan Morris, from the MAG in hopes that he could provide answers to these questions. The interview contained the same types of questions as the interview with Khun Surachai and retained the two basic sections: MAG's expectations for the Culture Center and technology's influence on the tribe's way of life. Appendix A contains a transcript of this interview.

Like the first interview with Khun Surchai, we asked questions to address the relationship between the introduction of the photovoltaic technology and the rising levels of tourism. We asked Jonathan what some of the pros and cons associated with the increased tourism due to the completion of the Culture Center. Similarly to Khun Surachai, the MAG recognizes that the Lahu villagers receive a large portion of their income from tourists. Although, tourism has introduced things like candy and rubbish into village, the Lahu are still struggling to survive economically. For the time being, the MAG believes tourism will need to remain a part of their daily lives.

One part of our discussion about the expectations for the Culture Center that we did not mention in our interview with Khun Surachai dealt with neighboring tribes sharing resources. Since both Ahka and Lahu villagers occupy Ban Jalae, we asked Jonathan if there was a possibility of conflict between the tribes over the new technology. He said that there had been conflicts between the two tribes over minor issues, but he felt that the installation would present no such problems. A member of the Lahu tribe had already been appointed to regulate the power supply to ensure that the two tribes, or villagers within the same tribe, would not come into conflict over the use of electricity. Jonathan told us that both Ahka and Lahu would be able to use the battery charging station.

The second section of our interview discussed the issue of technology's influence on the Lahu way of life. We asked Jonathan whether the MAG was concerned about the solar installation having a potentially negative effect on the villagers' culture. He believed that to some degree, the tribe would further integrate into Thai society, but it would only occur for survival purposes. Jonathan shared the same belief as Khun Surachai that the introduction of technology and preservation of tradition can coexist. Both interviewees believe that the electrically powered educational equipment will help the Ban Jalae inhabitants with their struggle for survival and the only way that the villagers can preserve their culture is to maintain the will for its continued existence.

Through the information obtained in our interviews with both Khun Surachai and Jonathan, we determined that the two individuals have a similar understanding of what to expect of the Culture Center and what impacts the new technology will have on the tribe's culture and way of life.

4.2 Assessment of the solar installations in Ban Yafu

In order to make further educated predictions as to how the solar installation in Ban Jalae would affect the Lahu villagers in the future, our group traveled to Ban Yafu to assess similar solar installations. Our trip to Ban Yafu served two purposes: to observe the physical condition of the solar units in order to see what actions we could take to avoid hazards, and to observe effects the new technology had had on the villager's society and culture.

4.2.1 The physical condition of the PV systems in Ban Yafu

The village of Ban Yafu had two different photovoltaic systems. The first consisted of two small solar panels and was intended as a power supply for the village schoolhouse. The second unit consisted of fifteen different panels subdivided into five arrays and serving as five battery-charging stations that were intended for use by all houses in the village.

4.2.1.1 Ban Yafu schoolhouse PV system

The PV system for the school originally had two solar panels mounted on two separate poles about two meters from the school building. One of the panels was resting on the bathroom roof just outside of the schoolhouse as it had fallen from the pole mount. Based on this observation, we noted that we should secure our solar panels to a substantially sturdier structure. There was no apparatus for adjusting the angle of the panels towards the sun nor were the panels facing towards the south. During different seasons of the year, failure to adjust the panels would result in a reduction of maximum energy output from the system. We also noticed that the solar modules had a thick layer of dust that had collected on the solar cells. To prevent dust build-up on the Ban Jalae panels, we planned to provide details on how to wash the cells in our maintenance program.

After observing the solar panels, we studied the rest of the PV system. The charge controller had been installed inside a plastic box. We thought that we should also use some kind of box to keep wiring connection from collecting dust and corroding. The inverter sat on the shelf above the batteries, which were lying on the floor with their wiring exposed. This is a dangerous arrangement for system components. We knew that there should not be any objects above the batteries that could fall onto the battery terminals. The exposed wires convinced us that we needed to use electrical tape to cover connections that could wear from use.

4.2.1.2 Ban Yafu battery charging stations

The Ban Yafu battery charging stations were in a grassy area just south of the village center. A metal frame supported the solar array and the area was fenced in with barbed wire to keep animals out. The vegetation around the modules had grown tall and a layer of dust coated the panels. We determined that either there was no one in the village responsible for the upkeep of the PV system, or that no one had informed the villagers of the steps necessary to keep the system operating at its maximum performance.

We reaffirmed our suspicions that no one was in charge of the upkeep of the solar unit after entering a metal structure that contained the rest of the components. Although the structure protected the *system from environmental damage, the components were in poor condition. Only two out of the five charging stations were still functional. Attempts to repair the non-functional stations revealed exposed wiring and misplaced components. One Ban Yafu villager st ated that there were no restrictions placed on the charging stations, which most likely led to their abuse. We saw evidence of this, as a villager had connected a wire from one of the stations that was missing its charge controller to a house that was over ten meters away. These observations led us to propose that the Lahu in Ban Jalae appoint at least two people to be in charge of their PV system.*

4.2.2 Cultural and societal impacts of the projects in Ban Yafu

Since Ban Yafu is also a Lahu village, we were able to investigate the cultural impacts associated with the unit's installation. The Ban Yafu inst allations were constructed for Lahu villagers very similar to those of Ban Jalae, which means that we were able to use interview data to predict similar problems that could result from Ban Jalae's installation.

We interviewed Khun Jamai, a Ban Yafu villager, near one of the solar arrays. The interview covered two topics: PV installations and technology's influence on the tribe's way of life. The first section of the interview gave us a better understanding of the history of the PV systems and their operating status. We structured the second section of the interview to be comparable to the previous Ban Jalae villager and MAG interviews. In this manner, we could draw better conclusions on how the solar installation in Ban Jalae could affect the villagers.

Our team was not surprised to discover that a dedicated technician did not maintain or repair Ban Yafu's solar installations; the village carpenter only repaired the system occasionally. It was interesting to note, however, that despite the shortcomings of the PV system's current electrical output, the tribe remained generally content with the installation. It was useful to have the battery charging station available to all the villagers and the school children and teacher greatly enjoyed their access to a television.

In terms of the technology's influence on the tribe's way of life, the Ban Yafu villager believed that little change has occurred. The fact that the villagers use the solar installation to enhance everyday *activities as opposed to promoting cultural awareness, as the Culture Center installation intends, may explain Khun Jamai's outlook on the technology's impact.*

While observing the Ban Yafu village, our team did not detect that the technology had any negative effects on their culture. Since we only made observations in Ban Yafu for two days, we cannot state definitively that the villagers experienced no negative change. However, our observations and Khun Jamai's responses seem to indicate that the solar installations have not harmed the villagers' culture.

4.3 Installation of the Photovoltaic system

The technical part of our project consisted of designing and installing a photovoltaic system to meet the needs of the Lahu villagers. In the following sections, we describe the process by which we arrived at the finished product of the PV system. The first section contains the design of our solar unit. In the second section, we explain how we chose the PV system equipment. The third section presents our site placement analysis, which describes where we decided to place the PV system in Ban Jalae. In the final section, we describe the installation and testing process of the completed PV system.

4.3.1 System Design

The solar unit consists of two main parts, the photovoltaic system, and the mounting frame for the solar panels. In the following sections, we discuss how we arrived at our final system design.

4.3.1.1 PV system design

In order to determine what components were necessary for the PV system, we performed a load analysis on the Culture Center's educational equipment. We used a system design worksheet from "Improving Hill-Tribe Education with Solar Power". Appendix D contains a completed form with our calculations. Our results from the calculations appear in Table 1.

Parameter	Value
Total Load (in W)	1185
Number of 24 Volt Batteries	5
Battery capacity (in A-hr)	132
Solar Modules Required	5
Peak Wattage of Solar Panels	75

Inverter Size (in W)	*1185*

Table 1: Summary of minimal design requirements for the Ban Jalae PV system

We calculated the total load by assuming that the Lahu villagers would use only a computer and a projector as their main loads. It is very likely, however, that the villagers will use other appliances along with the computer and projector. Since the total load of the system affects most of the PV components, we decided to design the system to allow for future expansion. The battery capacity and peak wattage of the solar panels were our limiting factors since these were the highest rated equipment in terms of output that the PV companies had in stock. We chose a 2kW inverter to allow the villagers to add more appliances to the system, ten 12V batteries that we wired to create a 24V battery array, eight 75W solar panels, and a 30A charge controller. With these main components, we designed the PV system shown in Figure 6.

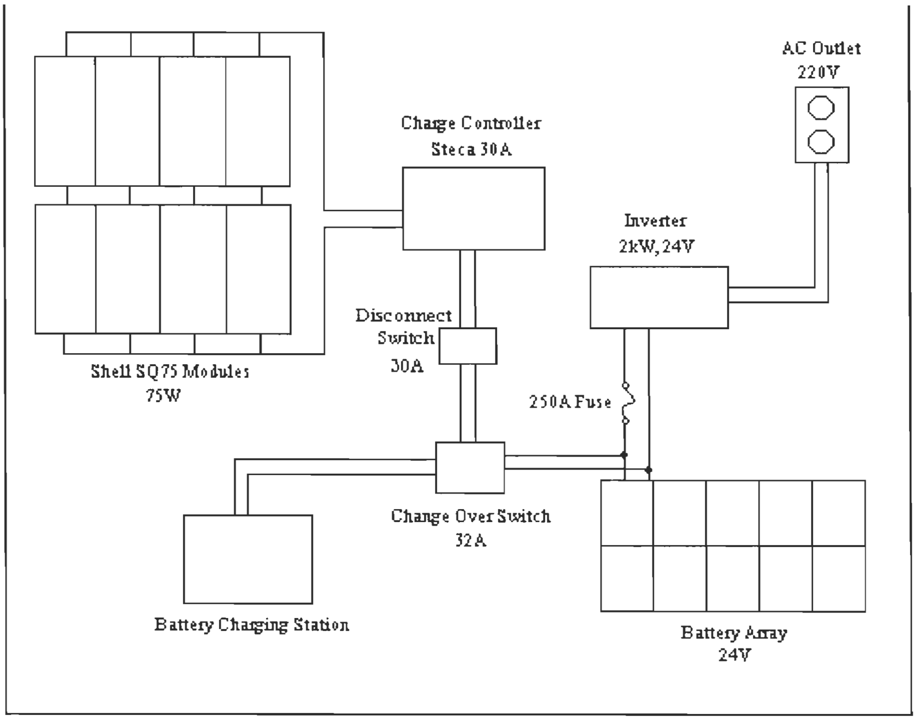

Figure 6: Diagram of the PV system design

The PV system consists of eight solar panels wired in series and parallel, which connect to the charge controller. The charge controller output runs to a disconnect switch, which serves as a safety feature to shut off the power coming from the solar array to the battery array. The disconnect switch connects to *the change over switch, which controls the two features of the system. When one turns the change over switch to the battery charging position, the villagers can charge two batteries in series. When one turns the switch to the AC load position, the solar panels will supply power to the battery array. The positive wire from the battery array connects to a fuse and then the inverter. We used the fuse to prevent a power surge from damaging the inverter. The inverter then changes the DC from the batteries into AC, which then connects to the AC outlet where the villagers can plug in appliances.*

4.3.1.2 Frame design

Just as important as the electrical design of the system was the design of a suitable mounting structure for the solar modules. We decided to build a mounting structure from scratch rather than purchase one from a solar distributor for two reasons: we estimated that the building materials would be less expensive than purchasing a pre-built unit, and that the unit provided by our solar distributor, Solartron, only provided mounting structures to accommodate PV systems in excess of 15 modules. Four major considerations went into designing the support structure: weight, angle adjustability, exposure to weather, and cost of materials. Our team was able to formulate an optimal design for the mounting structure to accommodate these four parameters.

The entire support structure consisted of two parts, a rack to maintain the eight panels in a specified rigid formation, and a linkage system that would aid the roof in supporting the rack and allow the villagers to adjust it seasonally. We drafted three final designs to choose among for the actual installation. The first consisted of an arm supporting a rotatable module rack that could be positioned on different rack notches to alter the angle. The major problem with this system was that the arm would not be able to support the heavy load of the panels for particular adjustments intervals. The second design was much simpler because it avoided any type of linkage. The rack design remained the same as above, for the modules, except that the angle adjustments would be made by adding or removing blocks from underneath the rack. A crucial problem with this is that the blocks would not be stable enough and could easily buckle.

In the end, we implemented our third design for the adjustable mount, which utilizes legs that extend from the front of the roof to the ground. This is a key feature of the design because it means that the roof only has to support half the weight of the rack. The unit consists of a four bar linkage in which the legs can extend to adjust the angle of the module rack, which hinges towards the top of the roof (Figure 7). We constructed the rack itself using bolted L-braces as cradles for the modules and the remaining adjustment apparatus is entirely of steel and painted to protect against corrosion.

Figure 7: The completed solar module rack design

4.3.2 Purchase of the PV components

With the design of the photovoltaic system complete, we contacted three PV companies and gave company representatives our load analysis results, to obtain a list of suitable components. In order to determine which PV parts would be useful, we collected the specifications of the equipment, shipping time, and cost. Appendix E contains price quotes from the PV companies. Our compilation of data appears in Table 2.

Supplier	Component	Specifications	Shipping Time	Cost (in Baht)	Notes
BP Solar	Solar Panel	75W	5-7 days	15,000	
	Charge Controller	20A		5,500	
	Battery	200A-hr		4,000	
	Inverter	2kW, 12V		45,000	Pure sine wave
Solartron	Solar Panel	75W	2-4 days	14,000	
	Charge Controller	30A		10,100	LCD included
	Battery	132A-hr		3,500	
	Inverter	2kW, 24V		31,500	modified sine wave
Siam Solar	Solar Panel	60W	1-2 months	18,000	BP solar product
	Charge Controller	30A		12,000	
	Battery	NA		NA	
	Inverter	1kW, 24V		55,000	cannot handle load

Table 2: PV component information

Our criteria for choosing which company to buy from were availability of parts, price, and rapidity of shipping. All of the PV components that the companies offered in the price quotes were in stock with the exception of Siam Solar's products. Our budget had been extended to 240,000 baht for the entire PV system; we needed to maximize the power output while keeping within budget. A prompt shipping time was also important so we could complete the solar unit during our stay in Thailand.

After comparing the data in Table 2 with our criteria, we decided to buy the PV components from Solartron. We eliminated Siam Solar as an option since the parts would take at least a month to arrive and their cost was the highest. We rejected BP Solar, as their prices and shipping time were not as good as Solartron's. We considered buying the batteries from BP Solar because they offered greater storage capacity, but we could not reach the sale representative in time for our return to Ban Jalae. Solartron's equipment fit our design requirements as well as our purchasing criteria.

None of the three companies had all the parts needed to construct a complete PV system. We went to Win Chance Industries outside of Bangkok to buy two switches and a fuse. The remaining equipment we purchased from electrical supply stores in Chiang Rai. Appendix F contains a full parts list.

4.3.3 Site Placement Analysis

In order to determine the best location for the photovoltaic system, our team performed a site survey of the village and analyzed a number of factors at each of three chosen locations. Appendix B contains a completed site survey form and a diagram showing the three surveyed locations. Location one was situated by the northeast wall of the Presentation Hall. Location two was positioned atop a villager's house about ten meters to the east of the Culture Center. Location three was situated two meters from the south wall of the Cultural Museum. We ran the wire for the system from the modules to the charge controller, from the charge controller to the batteries, from the batteries to the inverter, and finally from the inverter to the AC loads. The AC loads are located in the Presentation Hall; however, the location of the other components was dependent on where we chose to mount the panels.

After completing our site placement analysis, the team decided that the best location for the solar modules was next to the Cultural Museum's southern wall. At this site there were no trees to obstruct the solar arrays as there were with locations one and two. The distance from the Culture Center to location one and two, was much closer than if we were to mount an array on the roof of a villager's hut. Since there were no roofs in our chosen location that were suitable to support the weight of the modules, we had initially planned to mount the solar array on stilts. However, this was a dangerous approach as the wind could cause the mounting poles to break. Another issue that we also needed to address was where to place the charge controller, inverter, and batteries. The builders constructed the Culture Center without allowing extra space for this vital equipment. Our team concluded that it would be beneficial in this specific case to build a separate housing unit solely for the PV system.

By having the villagers erect a separate building, we were able to meet the exact specifications for our photovoltaic system. The villagers built the roof at such an angle that when the sun was at its lowest point of the year, the solar panel could rest flat against its slope. We also designed a metal frame for the top of the building that allowed for quarterly adjustments of the angle of the panels. The housing unit also provided a space for the charge controller, inverter and batteries to reside that was waterproof to prevent electrical malfunction and corrosion. The villagers were able to install a locking door on the building, which made it possible to restrict access to these components. The building would protect the equipment from weather, people, and animals, as well as prevent unnecessary injury to villagers not trained in handling the equipment. The villagers made the building high enough so that people and animals could not tamper with the solar modules. In addition to safety, the solar housing building allowed more space to be available in the Presentation Hall for extra equipment, furniture, or community space.

4.3.4 PV system installation and testing

The PV system installation consisted of two main parts: building the frame to support the solar panels, and wiring the electrical equipment. The first step was to assemble the module frame. We had the village carpenter, Loong Luat, cut the braces to the appropriate lengths and then we bolted the frame together. We placed a panel in the frame to test the dimensions and double-check our measurements. Loong Luat and some of the villagers made the hinges and the bars that would attach to the frame, as well as the adjustable legs. Once we painted the metal components with multiple rust protective coats, Loong Luat welded the additional support bars to the frame. At this point, the frame was complete and we could mount the solar modules (Figure 8).

Figure 8: Bolting of solar panels into the frame

Once we had all eight solar panels secured in the frame, we wired them in series and in parallel (Figure 9). While the panels were facing the sun, we tested them to see if they were producing the correct voltage and if the bypass diodes functioned properly. We checked each panel's output voltage to see if it was approximately 21.7VDC. Every panel produced voltages between 20.5VDC and 21.3VDC. These were acceptable values, as the panels were not optimally aligned with the sun. We then tested the output of the solar array, which was 41.1VDC. This value was within the acceptable range; the maximum output was 43.4VDC.

Figure 9: The solar array wired in parallel and series

After finding that the voltage outputs were correct, we tested the functionality of the bypass diodes. The diodes serve as a safety feature so that if a panel in series fails, the second panel in that series can still deliver current to the charge controller. To mimic broken panels, we covered the four panels that we connected in parallel from the positive terminals as shown in Figure 10. We measured the voltage output to be 20.7Vdc, showing us that the bypass diodes were operational.

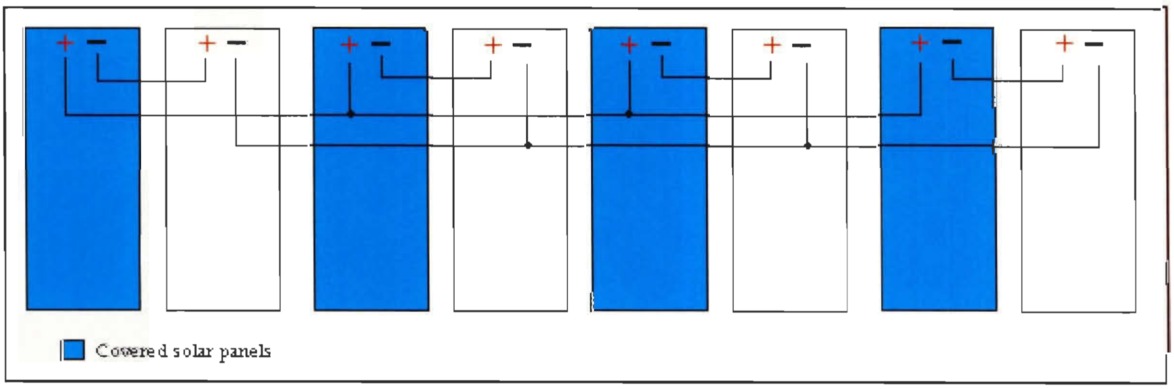

Figure 10: Diagram of bypass diode test setup

After testing the mounted solar panels, we constructed a control box that housed the charge controller, the disconnect switch, and the change over switch (Figure 11). In order to test the connections between these components, we used the multimeter to determine when the switches created a completed path for current. We checked all combinations of the switch positions to ensure that we had connected the internal wiring correctly.

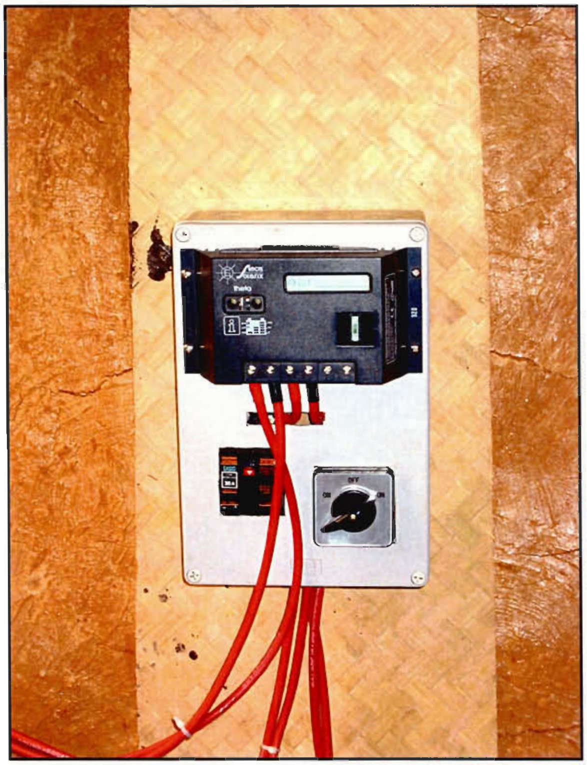

Figure 11: The completed control box

With the control box connections all made correctly, we connected the battery array by wiring the series connections, then wiring the positive parallel connections, and finally the negative parallel connections (Figure 12). We connected the inverter to the battery array and we tested the functionality of the inverter by plugging an AC operated lamp into the inverter outlet. The lighting of the lamp demonstrated that the inverter operated properly.

Figure 12: Wiring of the battery array

The final step for installing the PV system was to mount the frame on the roof of the solar housing building. Twenty villagers assisted in hoisting the frame onto the roof (Figure 13). Once the rack was in the correct position, Loong Luat secured the frame using bolts through hinges on the roof.

Figure 13: The roof mount

Finally, we checked to see if the solar array charged the battery array by measuring the voltage level of the batteries while the disconnect switch was off and comparing it to the voltage level of the batteries while the disconnect switch was on. When the disconnect switch was on we recorded the voltage level across the batteries to be 1.2VDC higher than when it was off. The success of this final test meant that the photovoltaic system was completely functional.

4.4 Results of the training sessions

The following sections describe the material we presented in our training sessions. We examine the effectiveness of the deliverables, such as the poster boards, that we presented to the villagers. We also discuss issues that arose during the training session, including the concepts that were difficult for the villagers to understand and how we rectified the problems that surfaced.

4.4.1 Maintenance training session

Initially, our team planned to conduct a formal training session for the technically-inclined villagers that the Hilltribe Life and Culture Center Council identified. However, since these villagers were present throughout the solar unit's installation process, we decided to train them while we installed it. By using the solar equipment as a hands-on visual aid, it was easier to convey our training and maintenance instructions to the villagers. Jonathan Morris was also present during this training period and served as an invaluable resource as he translated our instructions into Thai.

We provided a poster, which is now hanging above the charge controller, to show the villagers how to charge individual batteries at the battery charging station (Figure 14). The connections at the charging station are intended to connect and charge two twelve volt batteries in series simultaneously, since the installation produces twenty-four volts. The villagers also use six-volt batteries, which they should charge four at a time to maximize each of their battery's life spans. We made the wiring of the batteries in series very clear to the villagers and made sure to inform them of the types of connections that they would need to purchase if they wanted to charge their six-volt batteries.

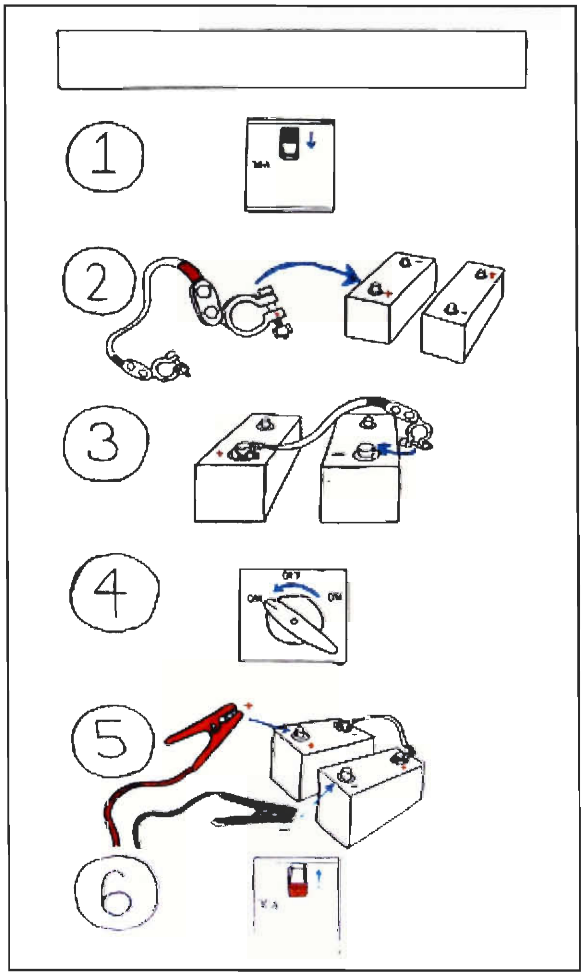

Figure 14: Poster describing the 12-volt battery charging process

Another important piece of information that we conveyed to the technically-inclined villagers was the importance of covering the solar panels with an opaque material before any type of electrical work was to begin. Although the system may appear to be off, the panels still produce enough electricity to cause shock. We noticed that the villagers did not take seemingly common safety precautions during the system's installation. For example, while welding the frame for the solar panels the welder only wore a pair of sunglasses to protect his eyes from the radiation instead of a welding mask. The safety of the villagers as they work with the PV system remains a major concern.

4.4.2 General training session for the villagers

After the installation was completed, we began our planned training session for the entire village. Our intention had been to discuss photovoltaic safety issues to the villagers inside the Presentation Hall, *but instead we proceeded less formally. Much like our training session for the technically-inclined, we conducted the general training session while the villagers were gathered around the solar installation. We created a poster with pictorial instructions displaying the types of precautions the villagers should take when they are close in proximity to the solar unit.*

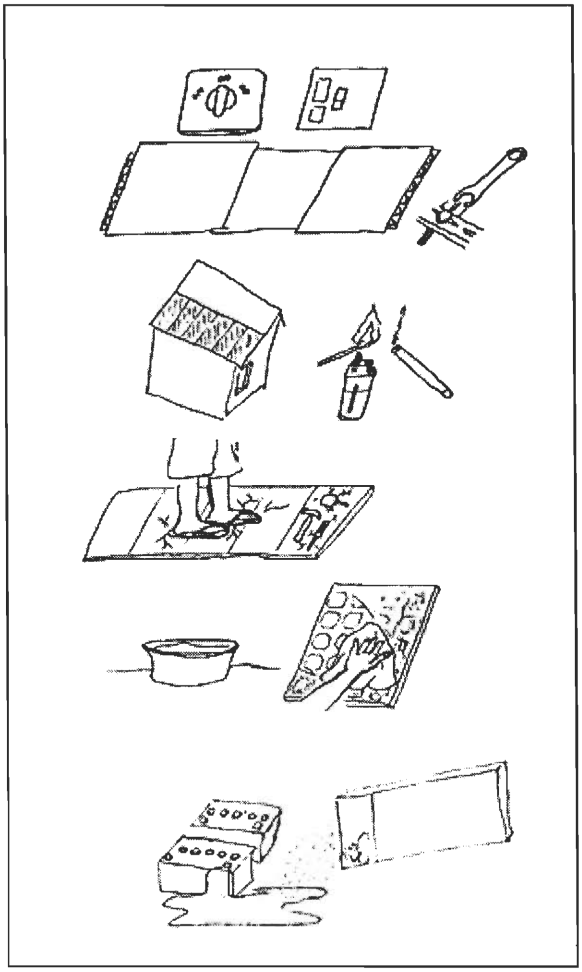

Figure 15: PV safety information poster

It was slightly more difficult for us to convey information to the entire tribe than it was to the technically-inclined villagers. Although some of the villagers spoke fluent Thai, the majority could only speak the tribal language. Jonathan Morris was also our translator during this time, but on occasion, we needed a second translator who was both fluent in Thai and Lahu in order to explain certain complex *instructions. Having two translators was essential to explaining successfully the technologically rich aspects of the project.*

While staying in the Ban Jalae village, we noted that the villagers participated in sporting activities almost every night near the site of the solar installation. We tried to have the elders explain to the children that if a ball or other object were to hit the solar panels, it could damage the entire PV system. The children seemed to take the warning lightly, and the issue still concerns us.

Chapter 5: Conclusions and Recommendations

Our main focus in this project was not the installation of the PV system but rather ensuring that its completion would help preserve the culture of the Lahu villagers. In our interview with Khun Surachai and our own observations, we concluded that the technology would not damage the traditions and heritage of the villagers. However, the new solar technology would have an immediate impact on the village's ability to accommodate rising levels of tourism. Potentially, the tribe members could focus so intently on the tourist market that unique cultural aspects of their lifestyle could start to diminish. The Ban Jalae villagers, however, are confident that the Culture Center will prevent further cultural erosion and are glad to increase visitors' awareness of the Lahu way of life.

Our project team left Thailand shortly after the project was completed, so we could not analyze the long-term effects of the solar electric installation in Ban Jalae. We recommended that the MAG document any changes that occur in the villagers' traditions or daily routines that could be due to the solar technology. The MAG could then evaluate the cultural changes associated with the PV installation to decide if future projects along the same line would be beneficial.

We also recommend that before a similar installation is completed in a rural hilltribe village, our project be used as a case study. The successes and failures of the PV system in Ban Jalae, and their cultural effects can serve as a reference point for future project teams. However, the results of our project are site specific. Other hilltribe villages may not face similar cultural preservation issues like the Ban Jalae villagers; therefore, the implementation of a PV powered culture center may not be the most appropriate choice. We suggest that in addition to using our project as a case study, future project groups should also conduct interviews to determine potential site-specific problems.

The installation in the village of Ban Yafu provided our project team with great insight as to what can result from an installation where the residents receive little to no training about its operation and upkeep. Based on the condition of the solar unit in Ban Yafu, and the likely success of our training *program in Ban Jalae, we recommend that future projects highly consider presenting a training session to ensure that the villagers understand and respect the full potential of a photovoltaic system.*

Ban Jalae will eventually be connected to the national power grid. When this occurs, they will no longer need their PV unit. Our final recommendation to the MAG was that if Ban Jalae does receive electricity from the grid, they either donate or sell the unit to another village that is in need of electricity. The installation came at no cost to Ban Jalae and thus a donation or sale at an inexpensive price would allow them to help another village that is also facing cultural assimilation.

The Lahu tribe in Ban Jalae faces a difficult period of transition between their traditional way of life and a new modernized form of existence. The tribe members realize they must adapt in order to survive in a changing world, but they also have a clear sense that they must remain strong and united to keep the spirit of the Lahu alive in their hearts and minds. The solar technology that our team has installed in Ban Jalae will work with this assimilation and aid in the villagers' efforts to preserve their culture.

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Appendices

Appendix A: MAG and Lahu interviews

Listed below are the questions we asked during our interviews with a Mirror Art Group representative, the head of the Culture Center council, and a Ban Yafu villager. The responses that we received are italicized. In the case of the interviews with the Lahu tribe members, translators were necessary and therefore the responses are in a third-person perspective. We added the comments, in brackets, after the interviews were completed.

Interview with the head Culture Center Board member

Interviewee: Khun Surachai – Head of the Ban Jalae Hilltribe Life and Culture Center Council

When: Monday, January 19, 2004

Location of interview: Campfire area outside the Culture Center in Ban Jalae

Description:
Sitting in a circle around the campfire with our translator, Jon Morris, Ben Mar acted as the main interviewer, and Chris Treat as the response transcriber. The respondent, Khun Surachai, answered the questions after Jon translated them into Thai. Our translator then translated Khun Surchai's responses into English, with some elaboration as needed for Chris to record in note form.

Session Introduction:
We would like to talk to you about the Culture Center and solar cell technology in order to understand how they will affect your village. We also want to identify the expectations that the tribe has for the Culture Center and the solar cell technology.

Section 1: Expectations for the Culture Center
How do you see the Culture Center helping the Lahu in the future?

> *Good, tourism generates income so the villagers do not have to move. With farmlands being restricted, the villages are desperate for all the income they can get. The Culture Center is one thing all the villagers agree on, it unifies everyone because everyone pitched in. Also, the elders are very happy to pass on their knowledge.*

What equipment do you see as the most important or beneficial for the solar unit to power in the Culture Center and why?

> *The computer is important because it will eventually have access to the internet. In addition, the villagers want to charge batteries. However, there will need to be a system to ration the power.*

For what do you want the Culture Center to be used?

The Culture Center will be a place of reference; it will immortalize aspects of the culture that would otherwise be lost.

For what do you want the solar unit to be used?

This is something new to them, they do not really know what it is capable of, and therefore they do not know what to expect.

Section 2: Technology's influence on the tribe's way of life

Is the tribe generally accepting of having electricity brought to their village?

Yes, the tribe likes to be able to power lights at night and looks forward to having a computer in the village.

How will having a solar unit change the village/villagers?

The villagers are not going to be able to live the way they normally do, but this is good because they could not survive if they did. Modernization is necessary for the village to survive, the villagers need to be educated, it all comes back to restricted farmland preventing them from living the way they are used to.

Do you see any conflicts between modernization and the preservation of tradition?

There is no conflict between modernization and preservation of tradition, the only conflict that exists is between generations. It is getting harder for older generations to pass on information because of the different lifestyles of the younger generations. The Culture Center makes the passing on of important cultural traditions possible.

Could electricity accelerate the process of cultural erosion?

This is not an issue, electricity will not degrade the culture in any way because it in no way affects what is essential to the culture. The Lahu will still be Lahu whether they have electricity or not. What is essential about the culture requires the aid of technology to preserve it; electricity will do nothing except help the Lahu. It is up to each person to make good use of it.

Interview with Mirror Art Group representative

Interviewee: Jonathan Morris – Member of the Mirror Art Group

When: Monday, January 19, 2004

Location of interview: Sitting area in front of the Culture Center in Ban Jalae

Description:

We conducted the main portion of the interview while seated in front of the Culture Center. Justin acted as the interviewer and both Chris and Ben performed the transcription. Although we asked most questions during this period, Jon answered some questions in Section 2 later that day.

Session Introduction:

We would like to gain an understanding of how the MAG envisions the Culture Center and the solar installation benefiting the Lahu people. The effects that the technology will have on the tribe are also of main concern.

Section 1: Expectations for the Culture Center

What services will the Culture Center provide to tribe members and visitors?

The Culture Center will be an interactive museum where visitors can learn about hilltribe culture and rituals through presentations and self-observation. The Lahu villagers will be able to use the Culture Center to learn about aspects of their culture that may otherwise not be communicated to them. The computers will provide language instruction and in the future will provide internet access for research purposes.

How will the Lahu benefit from the Culture Center?

[The above response was sufficient in answering this question]

What are some of the pros and cons associated with the increased tourism due to the completion of the Culture Center?

The Lahu receive a large portion of their income from tourists. Although, tourism has introduced things like candy into village, the Lahu are still struggling to survive. For the time being, tourism will need to remain a part of their lives.

Will both the Lahu and the Akha make use of the Culture Center?

Yes. The Culture Center will showcase the Lahu's culture, however both tribes will be able to use the equipment powered by the PV system

Do you foresee any cultural/political conflicts between tribes resulting from the solar technology?

No, their has already been group discussion amongst the tribes and they have made arrangements with each other. Someone within the Lahu tribe will monitor the use of electricity so that neither group can abuse the system.

Section 2: Technology's influence on the tribe's way of life

Was the tribe generally accepting of having electricity brought to their village?

Yes, our discussion with the Culture Center Council has shown that they are anxious for the PV installation.

Do you see any conflicts between modernization and the preservation of tradition?

The Lahu have sustained their way of life thus far by adapting to their environment and the tools they have available. They are not ashamed of using technology to aid in their advancement or to make tasks easier. Therefore, the conflict is really a non-issue.

Could the introduction of the newly powered equipment accelerate the tribe's integration into Thai society?

Not in the sense that people would abandon their Lahu roots. A certain level of mainstreaming is desired for survival. The technology itself will not have a negative effect on the culture, how they use it will determine its impact.

Interview with Yafu villager

Interviewee: Khun Jamai – Lahu tribesman living in Ban Yafu

When: Thursday, February 19, 2004

Location of interview: Sitting area near the second PV system installation

Description:
We conducted the interview with Khun Jamai while seated on the benches across from one of the solar arrays. Ben acted as the interviewer and Colin performed the transcription. Khun Laak, a member of the Mirror Art Group, acted as our translator.

Session Introduction:
We would like to ask you some questions regarding the two solar installations. The effects that the technology has had on the tribe are also of main concern.

Section 1: The PV installations

When were the PV systems installed?

[Khun Jamai pointed to the nearby 15-panel array]

This one is about 6 years old. The PV system that the school uses is about 10 years old.

How much did each PV system cost?

[After some discussion amongst villagers on pricing, rough figures were given. Our translator informed us however that these prices would not be comparable with today's prices because of economical changes that have taken place]

Who designed and installed the PV systems?

[Khun Jamai could not recall the organization's name]

For what purposes were the PV systems installed?

The villagers use the newer PV system to charge their 12-volt batteries. The PV system powering the school is used for satellite television.

Who is in charge of the systems' maintenance and repairs?

Currently, nobody is designated in charge. When some thing needs repair, the local carpenter is usually the one that works on the system.

Have there been problems with either system's operation?

Wiring has been damaged and PV equipment, like voltage indicators, have gone missing.

Have there been problems with how the systems' have been used?

Yes, the lack of maintenance has been a problem. Also, some villagers have been using the power for their personal equipment.

If something could have been done differently or improved, what would that be?

The villagers wish they were better informed on how to maintain and repair the systems so that they would work better.

Were the villagers originally content with the PV installations?

Yes, the school children and teacher were happy to have a television in the classroom.

[Follow up question]
Are they still content?

Yes, they are still content but wish the systems could be repaired to work better and produce more electricity.

<u>Section 2: Technology's influence on the tribe's way of life</u>

Was the tribe generally accepting of having electricity brought to their village?

Yes, charging batteries usually would take a few days, but now they could do it much quicker.

How has the system changed the village / villagers?

They haven't noticed a change in their village. Electric generators were used for lighting long before the solar installation.

Do the villagers feel that having greater access to electrically powered equipment has taken away from their culture or heritage?

No, they still celebrate their traditional holidays and continue to dress and speak Lahu. Being able to use electricity for education and lighting has only improved their living.

Do you see any conflicts between modernization and the preservation of tradition?

[This question was difficult for Khun Jamai to understand at first. Khun Laak needed to rephrase the question so that it was easier to answer.]

No, the Lahu will always stay Lahu. Technology, such as the PV installations, has made it easier for the tribe to accomplish their everyday tasks.

Appendix B: Site survey analysis

Shown below is a diagram representing an aerial view of the Culture Center area. The three locations labeled were possible sites for the PV installation. The tables that follow contain information about the parameters our team used to decide the final location of the PV installation.

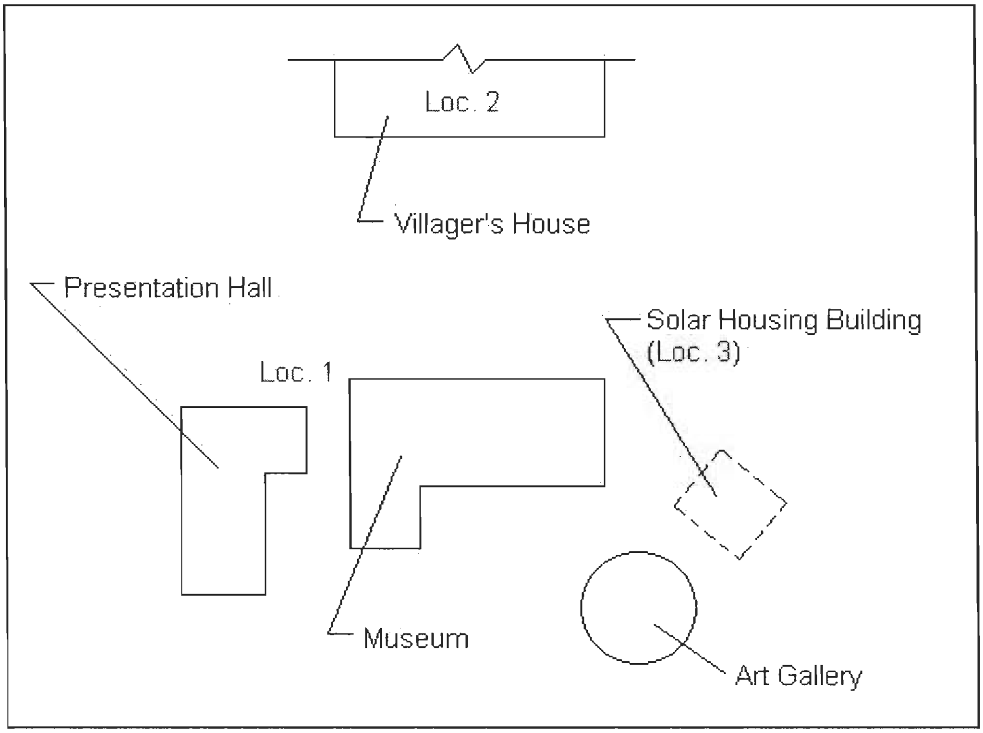

Diagram depicting the three possible locations for the PV i nstallation

Site	*Description*	*Battery Location*	*Distance from Presentation Hall*	*Safety Factors*	*Maintenance Factors*
Presentation Hall	*Small area adjacent to two buildings on the south and west sides with a large tree on the east side*	*Inside the Presentation Hall next to the computer*	*1 to 2 meters east*	*Very safe location due to the low level of traffic and close proximity to the Presentation Hall, however batteries would be unsafely exposed*	*Physical maintenance would be difficult due to small amount of space, debris from the adjacent tree would demand more frequent cleaning of modules*
Village house	*On the roof of a villager's house 10 meters east of the culture center*	*Inside the Presentation Hall next to the computer*	*10 meters east*	*Low level of safety, wire would run through a villager's home across an area of high traffic, batteries would be unsafely exposed*	*Module maintenance would require technicians to frequently access someone's home, however debris and moisture would be minimal. Large amount of AC wire would be more likely to suffer damage.*
**Solar housing building*	*Solar housing building located in an open area 2 meters east of the cultural museum*	*Inside the solar housing building*	*20 meters south*	*Very high level of safety, all components of the PV unit are contained in the solar housing building which protects against traffic and tampering*	*Optimal position for maintenance, technicians will be able to perform maintenance procedures free from disturbance. All components will be free of potentially dam aging effects.*

(Indicates chosen site)*

Distances with respect to the solar housing building

Distance from solar panels to charge controller	*1 to 2 meters*
Distance from charge controller to batteries	*1 meter*
Distance from charge controller to inverter	*1 meter*
Distance from inverter to load	*20 meters*
Type of Installation (Roof, Ground, or Pole Mount)	*Roof mount*

Appendix C: Information on photovoltaic systems

The photovoltaic method directly converts solar energy to electrical energy. A photovoltaic system is composed of five main parts, which include solar panels, an inverter, conductors, a system charge controller, and batteries. In order for our team to be able to assemble such a system, it is necessary to understand the functions of each of these parts, what will be required to maintain them, and the parameters that they collectively impose on the system.

Solar panels

A photovoltaic solar panel is composed of two layers of semiconductor material, a reflective film, a glass cover, and insulating material. The majority of the photovoltaic activity takes place between the two semiconductors. The reflective film functions simply as a barrier to keep the sun's rays trapped in the panel, and the glass serves as a transparent protective covering.

The most widely used semiconductor for solar panels is silicon. It accounts for about 95% of all solar panel semiconductors in the world. This is partially because silicon has a high level of conductivity, but more importantly, silicon is the second most abundant element on the earth's crust and therefore is inexpensive.

Inverter

A main power grid supplies alternating current (AC) power. However, a photovoltaic system supplies direct current (DC) power. Direct current flows in a single direction whereas alternating current changes directions many times a second. Direct current is the more powerful of the two, but it tends to decrease in magnitude over long distances. Therefore, alternating current is more practical for power grid usage. The purpose of an inverter is to enable the electric energy in a photovoltaic system to be converted from direct current to alternating current in order to support AC appliances. The inverter, also known as the power adapter, changes the voltage between the two states as well.

There are two main types of inverters that are used today: true sine wave inverters and modified sine wave inverters. True sine wave inverters produce the ideal form of AC power. They have a smooth *wave pattern and deliver a very stable connection. Modified sine waves on the other hand, produce a square waveform, which can be detrimental to certain systems. The modified sine waves can drastically reduce efficiency and reliability of motors. It can also interfere with digital clocks, and render them useless. The modified sine wave is the less expensive of the two inverters, but the true sine wave produces a more exact power connection.*

Conductors

The conductors in a photovoltaic system are the wires that run between each component of the system. It is important to utilize conductors that allow for maximum energy transfer in order to increase the efficiency of the system. There are two different factors to take into consideration when trying to determine which conductor will be used: wire type and wire size.

Wire type can differ in conductor material within the wire, and insulation surrounding the wire. The conductor material can be made out of either aluminum or copper, and can be composed of a single thread or many smaller threads twisted together. Aluminum is not nearly as durable as copper and upon insulation may even weaken to the point of failure. Copper also is a better conductor than aluminum and is able to carry current in larger quantities. The conductor wires may also be coated with many different protective coatings. Depending upon the location of the system, the conductors may need to resist heat, moisture, chemicals, abrasion, or ultraviolet light. The wires that are designated to resist sunlight must be marked clearly. Each conductor wire is designed for a unique purpose in the system and is color coded accordingly. Both alternating and direct current systems use a color coding system, so it is imperative that the person installing and maintaining the unit is familiar with the system and the color coding method he or she is dealing with.

Wire size is determined by line losses and the amount of current flow. Line losses, or decreases in electricity flowing through the conductors, are measured as voltage drops and result from resistance in the conductor lines. Line losses can be attributed to many things: the gauge of the wire, the amount of current flowing through the wire, and the length of the wire. The greater the length of a conductor wire, *the greater the resistance in the system. Also, a functional photovoltaic system requires a balance between wire size and current flowing through the wire. If the current flow exceeds the current flow capability of the wire, voltage drops will increase. Voltage drops are not only very expensive, but they can also lower the life expectancy of the equipment powered by the system.*

System charge controller

The system charge controller has many functions. The most important task that the charge controller has is to ensure that the battery's charge is kept at the highest possible levels. It is also responsible for preventing battery overcharge, providing load control functions, and performing temperature compensations.

Any system that may have unpredicted power surges should contain a charge controller. The effectiveness of charge on a battery is directly linked to how well the system's power is controlled. The charge controller will prevent overcharging by ceasing to supply energy to a battery after the battery has been fully ch arged. Over discharge will also be prevented; if the controller senses that the charge is low in the battery, it will disconnect the battery from the appliance it is powering.

Another function of a charge converter is to perform temperature compensations. The controller measures the temperature of the system and if it is lower than the ideal design temperature it will increase voltage flowing to the battery in order to charge the battery fully. If the temperature is greater than that of the ideal design temperature, then the voltage is decreased so that the battery does not overheat.

The system change controller is one of the most expensive parts of a photovoltaic system. It is important that the controller used is sized according to maximum surge voltages and currents. There is a possibility that reflections from clouds and other atmospheric water may magnify the intensity of the sun rays. Therefore, there should be a factor of safety (125%) so that the possibility of overload is at a minimum. Even though it may seem as if the extremes of the controller's capabilities are unrealistic, the charge controller is worth the investment. If the controller is undersized and fails, it will be more expensive to replace it than it would have been to buy a better controller with which to begin.

Batteries

In order for a photovoltaic power system to create a power reserve, the system needs to include batteries for energy storage. There are two possible types of batteries that can be used: shallow cycle batteries, and deep cycle batteries. Shallow cycle batteries do not have the ability to store energy for long periods of time or in mass quantities. However, they are an inexpensive source for short-term power storage. Deep cycle batteries have a longer life span than shallow cycle batteries and can store a considerably larger amount of energy. Deep cycle batteries are more expensive.

Appendix D: Completed system design worksheet

We produced a preliminary design for the PV system using the data we collected fr om Ban Jalae. We used the system design worksheet from Improving Hill-Tribe Education with Solar Power. The WPI IQP team, Andrew Keefe, Charles McAuley, Gregory Milette, and Justin Schneiderman designed the layout of the worksheet in 2001. We entered our data to obtain the summary of design parameters.

Section I: Information Gathering

This information needs to be determined before the calculation begins.

Average Sun Hours per day (kWh/m²)	*1) 5.2*
Peak Watt Rating of Solar Panels	*2) 75*
Number of Days of Backup Storage for Cloudy Days	*3) 4*
Amp-Hour Rating of Battery	*4) 132*

1. *This data can be obtained from meteorological services or from Appendix G.*
2. *The peak watt rating of the solar panel is the maximum amount of power the array can produce. This value can be modified once the needed peak watt rating of the modules are determined. This information comes from the PV supplier. Typically it is 50 to 120 Watts.*
3. *Time, in number of days, for backup storage. How many days of storage do you want the battery to hold? Typically 5 days are needed in Thailand. This data can be obtained from meteorological services or from Appendix G.*
4. *Each battery has an amp-hour rating, the amount of charge the batteries can store. Most conventional PV batteries are rated at 220 ah. An industrial PV battery can be rated as high as 350ah. Golf cart batteries are rated at 50ah. The PV supplier provides this information.*

Section II: Load Analysis

This section will determine how much power is required.

Device	Watts	X	Hours per Day	=	Watt Hours per Day
Computer	600	X	5	=	3000
Projector	585	X	1	=	585
5) Total Device Load:	1185				3585

Each AC device that will be used on the PV system is rated for a certain amount of watts. This can also be found by multiplying the input voltage (V) by the input current (A).

Total Device Load per Day	X	Inverter Loss	=	Total Load (Watt-Hours)
5) 1185	X	1.15	=	6) 1363

Section III: Battery Size

This section will determine how many batteries are needed.

Total Load (Watt-Hours)	X	Battery Loss	X	Battery Discharge Reserve	=	Total Adjusted Load (Watt-Hours)
6) 1363	X	1.2	X	2	=	7) 3270

Total Adjusted Load (Watt-Hours)	/	System Voltage (Volts)	=	Total Load (Amp-Hours)
7) 3270	/	24	=	8) 136

Total Load (Amp-Hours)	X	Days of Storage	=	Battery Bank Capacity Needed (Amp-Hours)
8) 136	X	3) 4	=	9) 545

Battery Bank Capacity (Amp-Hours)	/	24 Volt Battery Rating (Amp-Hour)	=	Number of 24 volt Battery Strings
9) 545	/	4) 132	=	10) 5

Section IV: Solar Panels

This section will determine how many solar panels are needed at what peak wattage.

Total Load (Watt-Hours)	X	Battery Loss	=	Required Watt-Hours per Day
6) 1363	X	1.2	=	12) 1635

Required Watt-Hours per Day	/	Average Sun Hours per Day	=	Solar Array Watts Required
12) 1635	/	1) 5.2	=	13) 315

Solar Array Watts Required	/	Peak Watts of Solar Panel	=	Solar Panels Required
13) 315	/	2) 75	=	14) 5

(To reduce the number of panels, use panels of a higher peak wattage rating)

Section V: Inverter Size

Total Wattage of all Devices
5) 1185

This is the minimum amount that the inverter must support. Inverters of higher wattage are recommended for safety and to facilitate system expansion.

Section VI: Summary of Design Parameters

Parameter	Source	Value
Total Load	Section II	5) 1185
Number of 24 Volt Batteries	Section III	10) 5
Battery capacity	Section I	4) 132
Solar Modules Required	Section IV	14) 5
Peak Watts of Solar Panels	Section I	2) 75
Inverter Size	Section V	5) 1185

Appendix E: Price quotes from PV Companies

BP THAI SOLAR

BP Thai Solar Corporation Ltd.
101/47/9 Navanakorn Industrial Estate
Phaholyothin Road, Klong 1, Klong Luang
Pathumthani 12120, Thailand
Tel. (662) 5291105-6
Fax. (662) 5294542

AC Power

	No	Unit cost	Total cost
Module 275	3	15,000.00	45,000.00
PS2212 Trace inverter	1	45,000.00	45,000.00
Battery 200Am	10	4,000.00	40,000.00
Regulator GCR2000	1	5,500.00	5,500.00
			135,500.00

Battery Charger	No	Unit cost	Total cost
Module 275	1	15,000.00	15,000.00
Regulator GCR800	1	3,200.00	3,200.00
			18,200.00
Total			153,700.00

Remarks 1. The Price is including VAT

บริษัท โซลาร์ตรอน จำกัด

38 อาคารชาณิชย์ ชั้น 2 ซอยสาลีนิมิตร สุขุมวิท 69 พระโขนงเหนือ วัฒนา กรุงเทพฯ 10110
โทร. 0 2392 0224-6, 0 2711 3698-700 FAX : 0 2381 2971
เลขประจำตัวผู้เสียภาษี 3 10 41678 7

SOLARTRON CO.,LTD.

38 CHAVANICE BLDG.2 FL.,SOI SALINIMIT
SUKHUMVIT 69 BANGKOK 10110,THAILAND.

ใบเสนอราคา
QUOTATION

รหัสลูกค้า : | **Rev. 2**

เรียน **Justin**
Sukhumv. Dormitory
759 Soi Chula 6 Butadthong Rd.
Wang Ma Patumwon
Bangkok 0330

เลขที่ใบเสนอราคา (Doc. No.) QT 470010
วันที่ (Doc. Date) 5/2/2004
กำหนดยืนราคา 30 วัน

ATTENTION :

พนักงานขาย คุณพิพัฒน์ วีรียธรานนท์

อ้างถึง (Referance) Tel. 0 9662 0489

บริษัทขอขอบคุณที่ท่านให้ความสนใจในผลิตภัณฑ์/บริการ และมีความยินดีจะเสนอราคาดังรายการต่อไปนี้

Thank you for considerin , our Product/Service we are pleased to submit our proposal.

ลำดับ Item	รหัสสินค้า/รายละเอียด Code/Description	จำนวน Quantity		ราคา/หน่วย Unit Price	ส่วนลด Discount	จำนวนเงิน Amount
1	Solar Module SQ75	8	Ea	20,000.00	30%	112,000.00
2	Controller Steca SR30+LCD	1	Ea	10,100.00		10,100.00
3	Inverter 2 kW G-24-200	1	Ea	31,500.00		31,500.00
4	Battery 1?2Ah	10	Ea	3,500.00		35,000.00
	ชื่อ บัญชี บริษัท โซลาร์ตรอน จำกัด					
	ธนาคาร กสิกรไทย จำกัด สาขา สุขุมวิท 39					
	บัญชีกระแสรายวัน เลขที่ 096 - 1 - 03069 - 2					

เงื่อนไขการชำระเงิน	**รวมเป็นเงิน** Total Amount	188,600.00
เงินสด	**หักส่วนลด** Discount	-
	จำนวนเงินหลังหักส่วนลด Sub Total	188,600.00
	จำนวนภาษีมูลค่าเพิ่ม Vat 7%	13,202.00
	จำนวนเงินรวมทั้งสิ้น Grand Total	**201,802.00**

....
ยืนยันการสั่งซื้อ/Confirmed by Customer
วันที่ Date ..../............../............

ในนามบริษัท โซลาร์ตรอน จำกัด SOLARTRON CO.,LTD.

พนักงานขาย..

Siam Solar quoted us a price through email. Below is the transcript of the email.

We want to know more detail for computer loading too high. Estimate price is :-

10 Modules SX 60 U @ 18000. Bht.
1 Inverter pure sinewave 1000 W/24 V 55000.- Bht.
1 Charge controller 3 Amp.24 V 12000.- Bht.

for battery you can find at local.
Not include installation and transport.
I would like to inform you the produce are import.
More enquiry pls. do not hesitate to contact us.

Thanks.

Appendix F: Parts list

3 DUW	4 XDQWLW
6 RODU R GXOH 4	
&RQWUROOH 6\VWHP 6 5 / &'	
,QYHUWHU N * -	
%DWWHU\ $ K	
$ %UHDNHU 6Z LWFK	
$ &KDQJH 2 YHU 6Z LWFK	
$) XVH	
) XVH %DVH	
: * ' & : LUH	P
/ XJ &RQQHFWRUV	
&ULP SHU	
: LUH &XW	
' LJLWDO 0 XOWLP HWHU 5 HG (OHFWULFDO 7DSH	
%ODFN (OHFWULFDO 7DSH	
: LUH 7LHV	
: LUH 7DFNV	
1 XWV DQG %ROWV IRU 6RODU 3DQHO 0 RXQWLQJ 1 XWV %ROWV DQG : DVKHUV IRU + LQJHV	
/ 6KDSHG 0 HWDO %UDFHV	P
5 HFWDQJXODU 0 HWDO %DU	P
&LUFXODU 5 RG	P
) ODW 0 HWDO %DU	P
6FUHZ V	
1 DLOV	
3 ODVWLF %R[DV &RQWURO %R[	
3 DLQW	
6 KHOI IRU ,QYHUWHU DQG) XVH	
%DNLQJ 6 RGD	

Appendix G: Meteorological data

Radiation in sun hours on a tilted surface in Ban Jalae (latitude 19°)

Radiation on equator-pointed tilted surfaces / Perez/Page method (kW/m²/day)													
Lat 19 Lon 100	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	*Annual Average*
SSE HRZ	*4.59*	*5.38*	*6.04*	*6.20*	*5.43*	*4.38*	*4.05*	*4.26*	*4.58*	*4.33*	*4.19*	*4.32*	*4.81*
K	*0.60*	*0.62*	*0.61*	*0.58*	*0.49*	*0.40*	*0.37*	*0.40*	*0.45*	*0.48*	*0.53*	*0.59*	*0.51*
PAGE DIF	*1.16*	*1.25*	*1.44*	*1.69*	*2.01*	*2.10*	*2.06*	*2.03*	*1.89*	*1.67*	*1.38*	*1.13*	*1.65*
PAGE DNR	*6.32*	*6.91*	*7.04*	*6.54*	*4.92*	*3.30*	*2.87*	*3.21*	*4.01*	*4.29*	*5.03*	*6.04*	*5.04*
Tilt 0	*4.57*	*5.33*	*5.97*	*6.09*	*5.40*	*4.36*	*4.03*	*4.17*	*4.51*	*4.29*	*4.16*	*4.23*	*4.76*
Tilt 4	*4.89*	*5.61*	*6.15*	*6.16*	*5.38*	*4.43*	*4.08*	*4.20*	*4.61*	*4.46*	*4.42*	*4.55*	*4.91*
Tilt 19	*5.92*	*6.41*	*6.58*	*6.17*	*5.09*	*4.52*	*4.11*	*4.13*	*4.80*	*4.95*	*5.24*	*5.55*	*5.29*
Tilt 34	*6.58*	*6.82*	*6.61*	*5.80*	*4.51*	*4.36*	*3.92*	*3.84*	*4.71*	*5.14*	*5.74*	*6.21*	*5.35*
Tilt 90	*5.37*	*4.71*	*3.40*	*1.81*	*1.25*	*1.86*	*1.54*	*1.22*	*2.25*	*3.33*	*4.50*	*5.20*	*3.04*
OPT	*6.83*	*6.87*	*6.65*	*6.21*	*5.40*	*4.52*	*4.13*	*4.20*	*4.80*	*5.15*	*5.89*	*6.49*	*5.59*
OPT ANG	*50.0*	*41.0*	*27.0*	*12.0*	*0.00*	*17.0*	*14.0*	*8.00*	*22.0*	*36.0*	*48.0*	*52.0*	*27.2*

Hypothetical number of days for which no solar isolation is available

Equivalent number of NO-SUN days (days)												
Lat 19 Lon 100	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
1 day	*0.63*	*0.85*	*0.82*	*0.66*	*0.83*	*0.82*	*0.90*	*0.91*	*0.73*	*0.77*	*0.76*	*0.92*
3 day	*1.36*	*1.70*	*1.77*	*1.47*	*1.90*	*1.95*	*2.07*	*2.09*	*1.67*	*2.13*	*2.06*	*1.93*
7 day	*1.94*	*2.07*	*2.46*	*1.87*	*2.84*	*3.34*	*3.68*	*3.26*	*2.31*	*3.56*	*3.69*	*2.65*
14 day	*2.23*	*2.48*	*3.09*	*2.54*	*3.95*	*3.70*	*4.34*	*4.85*	*2.78*	*4.61*	*4.67*	*2.37*
21 day	*2.37*	*2.61*	*3.14*	*2.47*	*5.11*	*4.70*	*5.06*	*6.41*	*2.98*	*4.72*	*4.71*	*2.16*
Month	*1.55*	*2.28*	*3.02*	*2.08*	*3.99*	*4.24*	*4.66*	*5.67*	*1.63*	*3.15*	*2.86*	*2.00*

Sources:
http://eosweb.larc.nasa.gov/sse/
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Appendix H: PV company contact list for Bangkok area

Solartron Co. Ltd.
Address:
38 Chavanich Bldg., 2nd Floor, Soi Salinimit Sukhumvit 69.
Bangkok 10330
Tel: (662) 392 0224-6 / (662) 711 0698-700
Fax: (662) 381 2971

BP Thai Solar Co. Ltd.
Address:
Kian Gwan House, 7th Floor, 140 Wireless Rd.
Bangkok 10330
Tel: (662) 255 7945-6
Fax: (662) 256 7945
Email: thaisolar@bp.com

Siam Solar and Electronics Co. Ltd.
Address:
62/16-25 Krungthep-Nothburi Rd.
Nontaburi 11000
Tel: (662) 526 0578-9 / (662) 965 0690
Fax: (662) 526 0579 / (662) 526 0127
Email: siamsolar@hotmail.com

Appendix I: Annotated bibliography

A Place at the Table. Dir. Jim Carnes. Teaching Tolerance, Hudson & Houston, 2000.
- *Short film on historical struggles for equality; useful for the section on case studies*

Barkstrom, Bruce R. NASA Surface Meteorology and Solar Energy. 17 Jan. 2004. <http://eosweb.larc.nasa.gov/sse>.
- *Useful for obtaining solar radiation angles and other meteorological data for specific regions of the world*

Berinstein, Paula. Alternative Energy. Oryx Press, Westpoint: 2001.
- *Contains useful statistics concerning alternative energy solutions and their viability*

Boyle, Godfrey. Renewable Energy: Power for a Sustainable Future. Oxford University Press, NewYork: 1996.
- *Discusses some of the social and environmental benefits of renewable energy*
- *Contains information on photovoltaic systems in developing countries*

Christal, Mark. "School-Museum Partnerships for Culturally Responsive Teaching" The Electronic Library. 21.5 (2003): pp. 43542. 21 Nov. 2003 <http://iris.emeraldinsight.com/vl=1430549/cl=61/nw=1/fm=html/rpsv/cw/mcb/02640473/v21n5/s5/p435>.
- *Study that examines school-museum partnerships for virtual museum projects in American Indian culture; a useful case study*

Daniels, Farrington, et al. Introduction to the Utilization of Solar Energy. McGraw Hill Book Company, New York: 1963.
- *Details some of the engineering concerns when implementing a solar electric system*

Dickinson, William C., and Paul N. Cheremisnoff. Solar Energy Technology Handbook. Marcell Deckker, New York: 1980.
- *Contains potentially useful solar angular and shadow equations for correct placement of solar panel*

Dunlop, James P. Stand Alone Photovoltaic Systems: Fundamentals and Applications. 1997. 14 Nov. 2003 <http://www.fsec.ucf.edu/pvt/Resources/publications/pdf/FSEC-CR-1292-2001-1.pdf>.
- *Discusses the theory and practical applications of solar electricity*
- *Contains useful information on the capabilities of solar energy*

Durrenberger, E. Paul. State Power and Culture in Thailand. Yale University Press, New Haven: 1996.
- *Discusses the role of the state government in relation to cultural issues in Thailand*

Eggers-Lura, A. Solar Energy in Developing Countries. Pergamon Press, Oxford: 1979.
- *Contains addresses and contacts in Thailand*

"Energy Use Calculation Chart". 21 Jan. 2004. <www.co-nect.net/Schools/Energy/calcchart.html>.

- *Contains wattage values for appliances*

Greacen, Chris. "Renewable Energy Workshops in Burma". Home Power. (Issue 98). Dec. 2003.

- *Describes a very useful and detailed technical description of a solar installation in Burma*

Ingram, James C. Economic Change in Thailand since 1850. Stanford University Press, Stanford: 1955.

- *Contains discussions of economics in Thailand after it was exposed to world trade and western culture*

Jensen, Johannes, and Rent Sorensen. Fundamentals of Energy Storage John Wiley and Sons, New York: 1984.

- *Describes energy storage for power systems*

Keefe, Andrew E., et al. Improving Hill-Tribe Education with Solar Power. Worcester Polytechnic Institute, Worcester: 2001.

- *Provides an example of an IQP project that implements a solar electric unit into a rural school*

Lisu Lodge. 16 November 2003. <http://www.lisulodge.com/index.html>.

- *Provides somewhat useful information on Lahu culture*

Lopez, Donald S. Jr. Religions of China in Practice. Princeton University Press, Princeton: 1996.

- *Provides background information on the Lahu tribe and some of their rituals*

Macan-Markar, Marwaan. "Hill Tribes Go High-Tech to Preserve Way of Life." Inter Press Service News Agency (July 2003): 5 Dec. 2003. <http://www.iumien.com/modules.php?name=News&file=article&sid=99&mode=&order=0&thold=0#>.

- *Describes issues that hilltribes in Thailand are facing*

Morris, Rosalind C. In the Place of Origins: Modernity and its Mediums in Northern Thailand Duke University Press, London: 2000.

- *Provides general discussion of modernization in Thailand, somewhat useful for understanding cultural implications of appropriate technology*

Neff, Thomas L. The Social Costs of Solar Energy. Pergamon Press: 1981.

- *Describes some risks associated with photovoltaic technologies, public health, and environmental impacts*

Neville, Richard C. Solar Energy Conversion. Elsevier, New York: 1995.

- *Discusses alternate energy sources – sunlight and geometrical effects, solar cell configuration*

Northern Thailand Climate & Weather. <http://www.thaifocus.com/climate.htm>.

- *Talks about the climate and weather in Northern Thailand*

Orange & Rockland. "Calculating Energy Use". 21 Jan. 2004. <www.oru.com/energyandsafety/energyefficiency/calculatingenergyuse.html>.

- *Contains wattage values of appliances*

Perlin, John. Solar Energy Fact Sheet. Santa Barbara: 1975.

- Contains requirements for solar systems and their components

Roy, Edward Van. Economic Systems: Northern Thailand Cornell University Press, Ithaca: 1971.

- Contains information on Hill tribe economy / upland economy / economic development

Schaeffer, John. Real Goods Solar Living Source Book, 9th ed. Chelsea Green Publishing Company. White River Junction, VT: 1996.

- Discusses harvesting of solar power and its use in practical applications

Solartron. 22 February 2004. <http://www.solartron.com>.

- Useful for gaining technical information and equipment specifications

Ter-Gazarian, A. Energy Storage for Power Systems. Peter Peregrinus, Ltd., United Kingdom: 1994.

- Discusses energy storage for power systems

Thaipro. Thaipro Digital Engineering Co. 2003. <http://www.thaipro.com/thailand/lahu.shtml>.

- Contains information on the Lahu and their culture, somewhat useful

Thailand Online. Siam Sun Tours, Chiang Mai: 11 April 2000. <http://www.thailine.com/>.

- Contains information on the Lahu and their culture, somewhat useful

The Mirror Art Group. 16 November 2003. <http://www.mirrorartgroup.org>

- Contains our sponsor's website – has all the projects that the MAG are working on
- Contains the mission statement of the MAG

The Studio Museum in Harlem. New York. 2003. 21 Nov. 2003 <http://www.studiomuseum.org>

- Contains the website of the studio museum – interesting exhibits
- Contains the mission statement useful for case study

Virtual Hiltribe Museum. 16 November 2003. <http://www.hilltribe.org>.

- Contains the virtual museum that MAG wants to have in the Culture Center
- Contains stories of the hilltribes of Thailand

Warren, William. Bangkok. Reaktion Books, London: 2002.

- Discusses history and background of the city

Wilson, David A., and William H. Rankins III. Practical Sun Power: 5 Projects. Lorien House Publisher. Black Mountain, NC: 1974.

- Contains sections on safety, parabolic reflectors, and conversion to electricity

Worcman, Karen. "Digital Division is Cultural Exclusion. But Is Digital Inclusion Cultural Inclusion?" D-Lib Magazine. 8.3 (March 2002): 15 Nov. 2003. <http://www.dlib.org/dlib/march02/worcman/03worcman.html#MUSEUM>

- *Contains an article on issues surrounding digitization of cultural resources*
- *Discusses the Museau da Pessoa– useful example for case study*

Wyatt, David V. Thailand: A Short History. Yale University Press, London: 1984.

- *Discusses history and background of Thailand. Makes mention of the hilltribes*

Zweibel, Ken. Harnessing Solar Power: The Photovoltaics Challenge. Plenum Press, New York: 1990.

- *Discusses implementation issues when harnessing solar energy*