Improving Energy Supply & Demand in Rural Thai Villages

An Assessment of Eight Villages in the Nakhon Ratchasima Province



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ABSTRACT

Obtaining an affordable and sustainable electricity source is a growing difficulty for rural Thai communities. This project assesses the impact of new energy technology, such as Solar Powered Water System, on rural Thai communities and provides recommendations to the Population and Community Development Association for improving energy generation. By interviewing and surveying villagers we were able to understand the social and economic factors that influenced how rural communities fulfilled their energy needs. These findings allowed us to take into consideration the socio-economic aspects of these communities and these considerations were used to inform our recommendations for energy system improvement.

EXECUTIVE SUMMARY

Everyday billions of people depend on having access to reliable energy and water sources not only in their personal lives at home but in their ways of making a living. In the farming communities of rural Thailand many villages are having difficulty acquiring electricity because of high costs and rising debt. Our sponsor, The Population and Community Development Association (PDA) has set up several programs in Thailand to assist villages in improving their access to energy and water. The PDA has been acknowledged several times for their success in these fields and in 2012 the Global Journal declared the PDA to be one of the top nongovernmental organizations (NGO) in the world. These programs build upon the PDA's philosophy that community involvement and participation is essential in the development of a community. Our project focuses on assessing the impact of energy-related programs while generating our own recommendations for their improvement.

BACKGROUND

The focus of our study was a group of eight communities located in the Nakhon Ratchasima Province. These villages are all part of the PDA's Village Development Partnership (VDP), a program designed to reduce poverty in rural communities. The most pressing issues facing these villages are related to energy and water use. Income in these villages is primarily from farming and farmers are dependent on water to grow their crops. During the dry season accessing water can be difficult and has driven many villages into debt as they struggle to pay high electricity and water bills. Additionally, during the dry season many of the middle aged residents of the community leave for the city to work for supplemental income, leaving behind a splintered community of older residents and children. Contributing to the problem further is the fact that over the last decades the cost of energy, primarily generated with fossil fuels, has soared in Thailand.

The VDP seeks to address these issues through active community involvement that aims to resolve village problems. Since its inception the program has been fairly successful in implementing sustainable farming; through cricket, cantaloupe and mushroom farming many villages have decreased their debt partially. In 2011, a subset of these villages had Solar Powered Water System's (SPWSs) installed with the help of the PDA. These systems use solar power to pump water that is used by villagers for consumption and irrigation purposes. Prior to the introduction of SPWSs, villages needed to use expensive electricity to pump water. Villages without SPWSs are eligible for this program, provided that they can find a way to fund installation. Many villages acquire funding through corporate sponsors or by taking low interest loans. The latter approach requires commitment to the program from the entire community.

The rising cost of energy coupled with increased debt has created a problem for these villages that the PDA has been trying to address. With programs like the VDP in place, the debt of these villages is beginning to shrink. New technologies such as SPWSs are making it easier for communities to access affordable energy in order to supply their homes and farms with a reliable source of water and energy. These technologies can also have a tremendous social impact because alternative energy can help the development of the communities in an environmentally friendly manner. Additionally it empowers members of the community by alleviating the stress associated with unreliable water access. Particularly woman in these villages are able to devote their time to other activities that have not been viable in the past, such

as community leadership and business endeavors. This study examined the impact that new energy technology has had on these communities while examining ways to improve how energy is consumed through conservation and renewable energy technology.

In order to effectively complete our study, we assessed eight villages in Nakhon Ratchasima to analyze the impact new energy technologies, such as Solar Powered Water Systems (SPWS), have on rural Thai communities. To achieve this goal, we conducted a community assessment to understand energy usage, SPWSs, social structure and physical layout of each community. We conducted interviews with local stakeholders including PDA representatives, community leaders, farmers and villagers. The interviews were conducted in a semi-structured format allowing the interviewer to ask new questions based on how the interviewee answered and reacted to earlier questions. Upon leaving Nakhon Ratchasima, we analyzed all the data gathered on-site and began developing recommendations for energy system improvement. As part of our analysis we decided that a second visit to communities was necessary in order to collect more quantitative data about energy consumption and conservation in the communities. During the second week of fieldwork we surveyed two specific communities: one with a SPWS and one without, Nong-Ploung and Koksad respectively. The surveys aided us in gaining a more detailed understanding of how SPWSs were affecting the communities they were in and what problems each village was facing.

COMMUNITY ASSESSMENT: SURVEYS, INTERVIEWS AND PHYSICAL ASSESSMENTS CONDUCTED IN EACH OF THE EIGHT DIFFERENT VILLAGES VISITED

RESULTS

During our field work, we were able to visit four different villages that had a SPWS. The ages of these systems ranged from two weeks to about a year at the time of our visit. Based on interviews conducted with the villagers, we received positive feedback in regards to the system. The interviewees were thankful to the PDA for providing the information and necessary resources to make this technology available to them. Many villagers expressed an interest in expanding the system by investing in more water storage tanks and piping. In each of the sites we visited there was no data collection system in place for the SPWS, making it impossible to quantitatively determine the success of the system.

In order to assess the impact of the SPWS in the communities, we also visited four different sites without SPWSs. In these communities the main challenges were debt and poor water quality. Two out of the four villages were concerned about increasing debt as a result of installing the SPWS in their communities. Based on the interviews, the villagers had little knowledge about SPWSs since the PDA has not yet provided them with this information. In one

village, Koksad, there was an alarming concern about the water quality from their current water source which has a high acidic content and many precipitates. These water impurities have caused health problems for the villagers.

As part of our community assessment in each of the villages we looked for additional potential alternative sources. We concluded that biomass would be a suitable alternative energy source in these villages due to the abundance of agriculture and animal waste available to them. Many of the villagers were concerned about the high investment necessary for the installation of the SPWS; therefore, further investigation should be made about biomass. This energy source could be an additional alternative energy option available to the communities that cannot afford or receive sponsorship for SPWS.

RECOMMENDATIONS AND CONCLUSIONS

Based on our field work and research, we have identified different factors involved in the impact of the new renewable energy technology available to rural communities in Nakhon Ratchasima. The successful integration of the SPWS in the four communities visited has allowed them to reduce their electricity and water bills; in addition it has also provided the villagers with different energy conservation techniques, such as drip irrigation systems.

We conclude that this new renewable energy source has a great potential for successful expansion, but community involvement and a data collection system are necessary to insure this success. Data collection systems will allow the PDA and the villagers to track the overall progress of the SPWS and provide information leading to modifications that can increase their overall positive impact. In addition to providing a collection system, the SPWS should be expanded in future community plans to provide storage systems and increase size of the pipes. This will increase the water available for households and irrigation.

For those communities without SPWS, the PDA should address the lack of accurate information about the SPWS and the debt problems leading villagers to be skeptical about the value of possible investment in the system. We found that even though the communities are not aware of this system, they are willing to learn from the PDA about it in order to improve their current water quality situation.

Lastly, we conclude that education and community involvement is essential for all of the communities for success in their socio-economic development. The educational programs will allow each individual member of the community to be aware of new potential sources of energy. If this source is not plausible for the communities then alternative energy sources such as biomass should be considered due to the abundance of agricultural and animal waste in the region. To improve the SPWS and overall quality of life in these villages we recommended changes to the program that PDA is sponsoring.

Upon completion of our study we presented our findings to the PDA at their office in Bangkok. Our project was well received and it is our sincere hope that our study will be used to aid the PDA in their continuing mission to reduce poverty in Thailand.

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AUTHORSHIP PAGE

Each member of the group contributed equally to the production of this report and to the projects overall completion, including the collection of information, the writing, and the editing of the report. The interviews and surveys were conducted in Thai and translated into English by our Thai group members.

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LIST OF ACRONYMS

COD- Chemical Oxygen Demand

EEP- Environment Partnership

EGAT- Energy Electricity Generating Authority of Thailand

EPPPO- Energy Policy and Planning Office

GPRD- Government Public Relations Department

kgoe- Kilograms Oil Equivalent

KWh- Kilowatt Hours

MCP- Monkey Cheek Project

NGO- Non-Governmental Organization

PDA- Population and Community Development Association

PV- Photovoltaic

SPV – Solar Photovoltaic

SPWS- Solar Power Water System

SSP- Small Power Producer

TAO- Tambon Authority Organization

TJ- Terajoules

VDP- Village Development Partnership

WBREDA- West Bengal Renewable Energy Development Authority

CHAPTER 1: INTRODUCTION

Everyday billions of people depend on having access to reliable energy and water sources but due to rising energy costs and limited funds, many rural communities across the world are having difficulty meeting their energy needs without falling into debt. Energy services address basic human needs and also contribute to social development by improving education and public health (World Energy Outlook, 2004). In addition to the rising cost of the energy, many of the rural communities are also facing inefficiencies in the energy management of the limited supply available. These energy management issues include limited education about energy conservation, poor maintenance of the energy currently available, and lack of communication between communities about the availability of new sources of energy, particularly renewable energy sources. In order to address these energy management issues, many non-governmental organizations (NGOs) and international agencies have assisted communities in switching to alternative energy sources and educating people about energy conservation methods. Thailand has currently taken measures in order to reduce their dependence on fossil fuels and supply its citizens with alternative energy sources.

Thailand experienced an economic boom in the 1980's, which created many job opportunities. As the country became more industrialized, the demand and consumption of electricity rose as well. Thailand has a modern electric grid that supplies about 98% of its households with power (Reliable Electric Power for Developing Countries, p. 5).Currently, a majority of the country's energy supply consists of non-renewable energy with the main source being fossil fuels. This dependency poses a problem for all citizens, particularly to the rural communities of the Nakhon Ratchasima Province. These communities in the northeastern region of Thailand are mostly agricultural; therefore they depend on this electricity source not only to provide energy to their homes but also to assist them in farming.

To understand the energy supply and demand challenges facing these communities, we specifically examined rural communities in the Nakhon Ratchasima Province. Nakhon Ratchasima hosts a major electrical distribution center for the northeastern region of Thailand. The province is largely a farming district with reasonable but expensive energy access. Farming equipment is typically fueled with fossil fuels while electricity is used primarily for the pumping of water, lighting and appliances. The electricity in Nakhon Ratchasima is typically generated by

nonrenewable resources, which cause air pollution and other detrimental impacts on the environment.

For this project we worked with the Population and Community Development Association (PDA). The PDA is a NGO based in Thailand with the mission of eradicating poverty in rural communities. Programs run by the PDA are based on the premise that community involvement and participation is essential for aiding the development of their own community. PDA programs primarily focus on empowering villagers to do just that. The PDA's methods have led to successes in many areas, including health care, AIDS prevention, family planning, water cleanliness, and general education. For our project the PDA has tasked us with assessing the impact that new energy technology has on rural Thai communities while providing recommendations for improving the existing energy system in several rural villages in Nakhon Ratchasima. We did this by observing the energy consumption patterns and needs of the community through interviews, surveys and direct observation.

The problem faced by the PDA is ternary, involving cost, efficiency, and sustainability. Energy is available to the village residents of the Nakhon Ratchasima Province, but its cost is rising. The rising cost of energy affects all facets of the farmer’s life from running farming equipment to pumping water for irrigation and personal use. Additionally, because of the increased costs associated with their profession, many farmers have fallen into debt. With the majority of the energy in the area being produced by increasingly expensive fossil fuels, it would seem appropriate for an expansion of energy resources to be carried out with cost effective and clean, renewable energy. For our project we sought to address these issues in rural Thai villages in a culturally sensitive and socially engaged manner. By conducting on-site field work in several rural villages, we were able find ways to reduce the impact of rising energy costs on struggling rural farmers through alternative energy, conservation and by informing the villagers about energy conservation methods. In order to discover effective solutions we had to acquire an understanding of the scope, magnitude and underlying social aspects of the energy management issues facing these North Thai villagers.

CHAPTER 2: LITERATURE REVIEW

This chapter reviews the research done by our team prior to going on-site. In order to fully understand the modernization of Thai energy resources, we focused our research on the period from 1970 forward. We present the sources relative to the different types of electrification in Thailand and the government policies that are currently in place concerning energy usage. Finally, alternative renewable energy sources and case studies are analyzed contrasting energy projects in two different global communities.

2.1 THAILAND

Thailand is a newly developed nation located in Southeast Asia with a population of over 66 million people. Modern society and politics in the country have been primarily influenced by Buddhism, monarchy, and military. In the 1980s an economic boom in the agricultural industry increased job opportunities in the industrial and service sectors. Due to economic growth many people migrated to Bangkok, the capital of Thailand, making it one of the most crowded and busiest cities of Asia. As the population of Bangkok grew so did the demand for energy as new businesses and factories opened for business. Just as Bangkok has been impacted by the influx of people into the city, various other smaller towns and communities across Thailand have felt the impact of population growth as well. All of this growth has been coupled with an increased demand for energy. Our project will focus on the largest province in the nation, the Nakhon Ratchasima Province.

2.2 SITE DESCRIPTION: NAKHON RATCHASIMA

Nakhon Ratchasima, also known as Korat, is located in northeastern region of Thailand. The province is the administrative, economic, and transportation center of the Korat plateau (Nakhon Ratchasima, 2011). The population of Nakhon Ratchasima is about 2.6 million inhabitants. On its borders are the provinces: Chaiyaphum, Khon Kaen, Buriram, Sa Kaeo Nakhon Nayok and Saraburi. The province serves as a gateway between Bangkok and other provinces in the northeastern region of Thailand.

Agriculture represents the dominant sector of the economy in Nakhon Ratchasima, employing more than 80% of the population and generating about 22% of the gross domestic

product. The main cash crops of the region are cassava, rice and sugar cane. The province has been known for its stable production in the agricultural and silk-weaving industries, but since the late 1980s production in the region has become more diversified. From 1986 to 1991 the agricultural industry only grew 4.7%, but during that same time period the businesses involved with transportation, electricity and water supply grew by 10.3% (Gebhardt, 2005). The expansion of these industries brought more technology to the province, which led to an increase in energy demand.

2.2.1 ENERGY USAGE IN NAKHON RATCHASIMA

The rapid economic growth in the region has caused an imbalance in the expansion of the city to meet the demands of the new industries. In 2009, the power demand forecast, produced by the Energy Electricity Generating Authority of Thailand (EGAT) predicted that from 2008 to 2021 the annual growth will be approximately 4.9%, so that the power demand of the next 13 years will increase to twice that of 2008. About 79% of the energy source demand is provided through fossil fuels (Thailand Power Development Plan, 2009). The dependence that Thailand has on fossil fuels has increased over the years as more factories have been constructed in the region. Figure 1 indicates that the majority of energy in Nakhon Ratchasima is used for transportation followed by industry, individual households, and services.

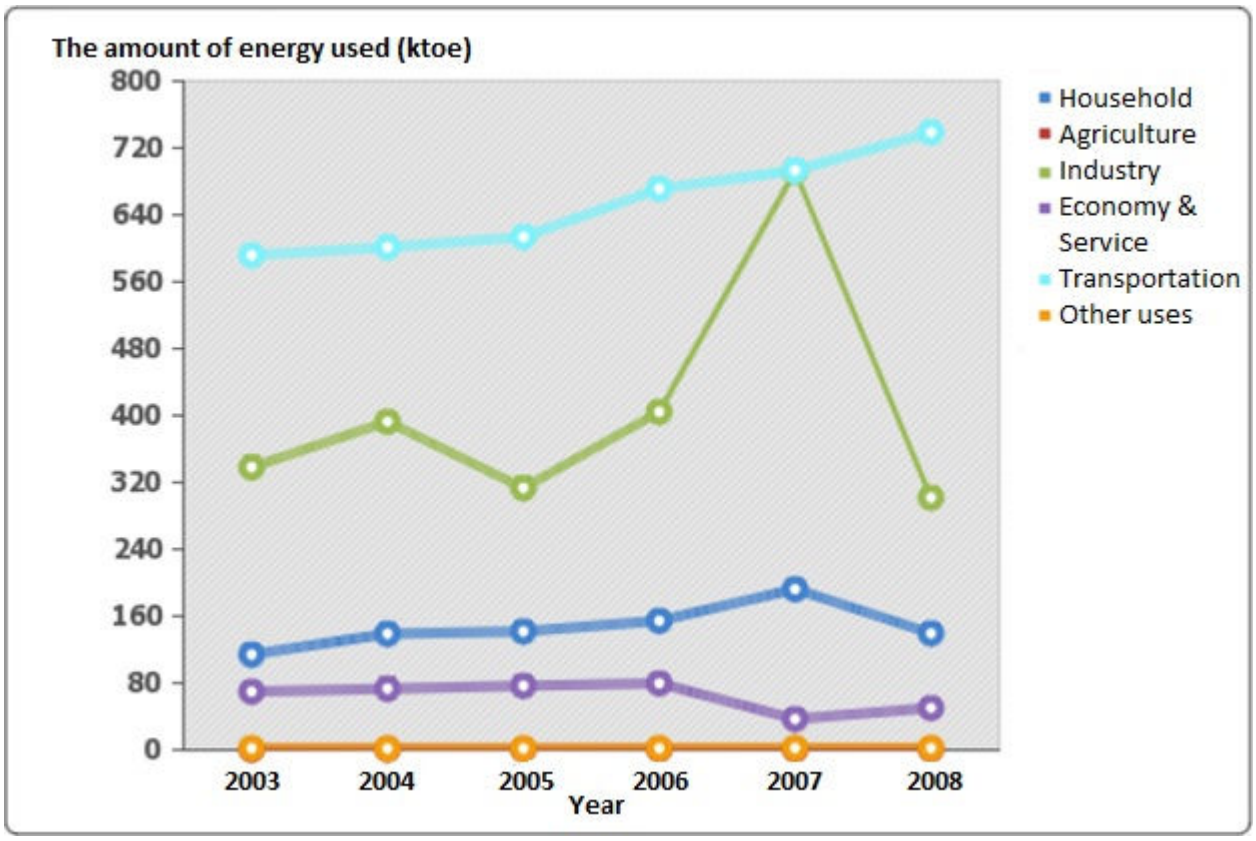

FIGURE 1: THE AMOUNT OF ENERGY USAGE IN NAKHON RATCHASIMA FOR EACH FIELD (MINISTRY OF ENERGY 2010)

The scarcity and destructive consequences of burning fossil fuels have motivated the local governments to become responsible about environmental protection. The Nakhon Ratchasima municipality developed their own environmental plan in 1995. This plan focused on the pollution of water and the need for construction of waste-water facilities. Non-profit organizations have also joined the efforts to reduce these problems by organizing seminars on environmental issues and provided programs to the local citizens on how to improve environmental conditions within their communities (UN Center for Human Settlements, 103-104). Figure 2 indicates that waste from sugar cane farming is the most popular alternative to petroleum in Nakhon Ratchasima, though its use is declining. Firewood and charcoal are both energy sources that have been consistently used. Other sources of energy, such as solar, biomass and biogas are not quite as popular in the region.

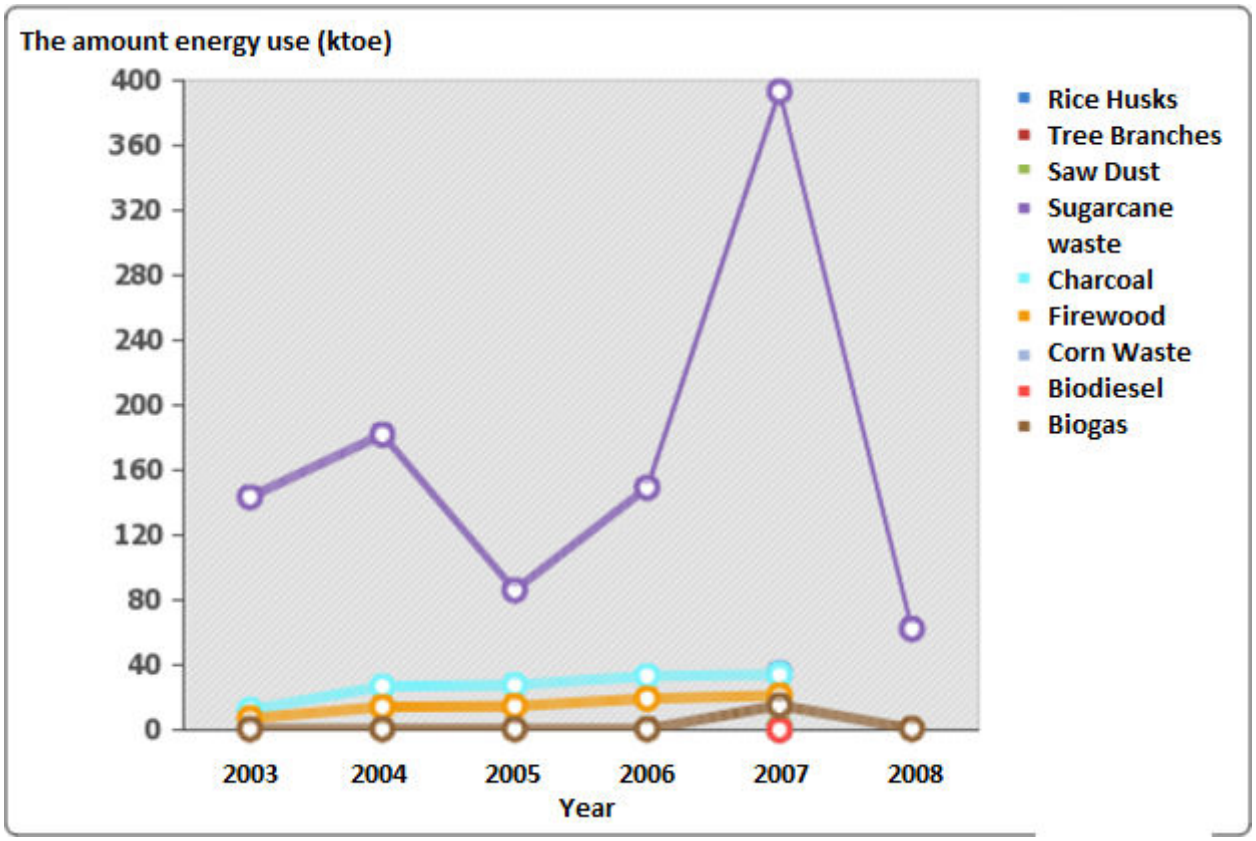

FIGURE 2: TYPE OF ENERGY THAT HAS BEEN USED IN NAKHON RATCHASIMA (MINISTRY OF ENERGY 2010)

Nakhon Ratchasima faces the challenge of providing an energy supply that can serve its population. Since the 1990's, more than 70% of the households in most villages have been connected to the grid. Even though some communities have been able to obtain energy supply through the electric grid, this source does not effectively address the needs of the citizens. As seen in Figure 3, EGAT has provided a map of the electricity grids throughout Thailand. In the region of Nakhon Ratchasima currently there is a 230 kV substation and various transmission lines.

FIGURE 3: THAILAND ELECTRIC GRID, NAKHON RATCHASIMA BOX OUTLINED IN PURPLE SEE EXPLANATION OF SYMBOLS ON THE NEXT FIGURE

(EGAT, 2001)

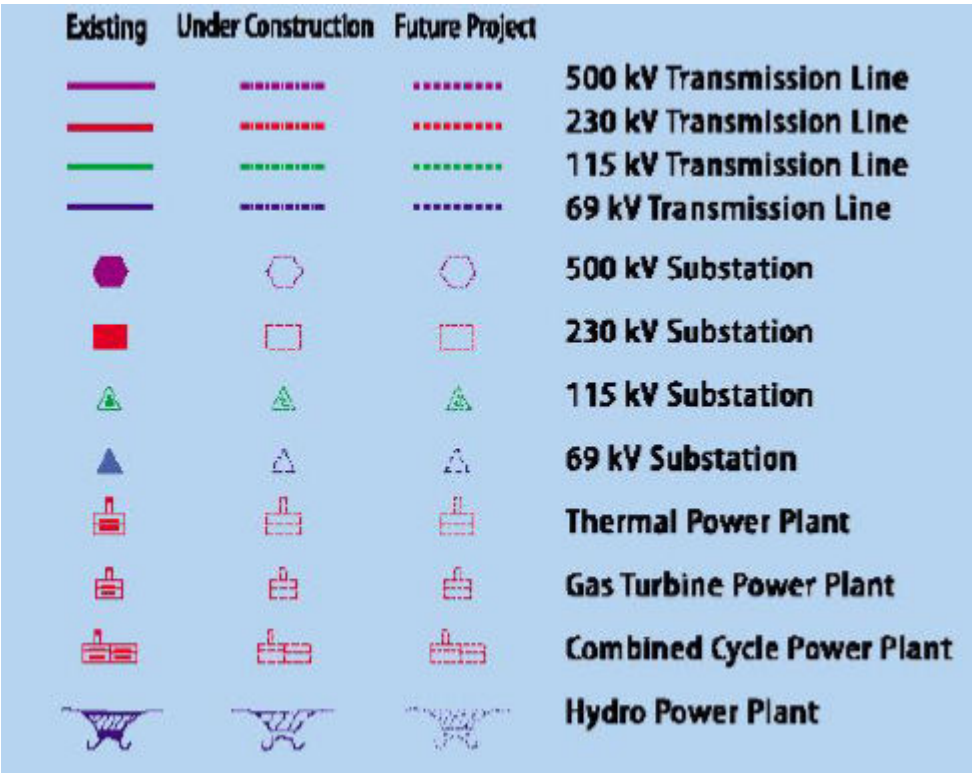

FIGURE 4: KEY CORRESPONDING TO ABOVE CHART
(EGAT, 2001)

2.3 POPULATION AND COMMUNITY DEVELOPMENT ASSOCIATION

The Population and Community Development Association (PDA) is a non-governmental organization founded in 1974. The organization aims to empower Thailand's rural communities in order to eradicate poverty. Initially, the PDA was involved in promoting family planning through education and awareness campaigns. Through the years they have expanded their efforts into many other areas to aid rural communities, including HIV/AIDS awareness, general education, conservation, and gender equality. The World Bank has estimated that the PDA has saved approximately 7,700,000 lives through their HIV/AIDS awareness program, and the PDA's family planning program has been credited as a major contributor to Thailand's annual population growth rate decrease from 3.3% in the 1970s to 0.6% in 2005. The success of the programs that the PDA has been involved in can be attributed to their educational approach of

solving problems by providing training and education to people in need (The Population and Community Development Association (PDA), 2011).

One of the important objectives of the PDA is to improve the energy supply and demand in rural areas of Thailand's villages in Nakhon Ratchasima Province. The campaign of improving energy consumption will enable the communities that are located around the target villages to enjoy a sustainable life with sufficient energy for future generations. For our project, the PDA has asked us to research the energy consumption of rural villages in the Chakkarat District of the Nakhon Ratchasima Province to develop recommendations for rural communities about how to conserve energy and supplement existing supplies with renewable energy sources.

In recent years, the PDA has created a demonstration community, Nong Pluek Village, in Chakkarat District. This community has successfully applied renewable energy and started this project by using solar energy to manage the water supply. This innovation has allowed the community to successfully reduce the cost of energy and replace conventional energy with renewable energy. The PDA has used this village as a role model to improve the energy efficiency in the Nakhon Ratchasima Province.

2.4 ENERGY CONSUMPTION AND PRODUCTION IN THAILAND

In order to understand energy production in Thailand, we examined the different types of energy sources used there. Overall, Thailand primarily relies on non-renewable energy sources, but there are many areas in the country that could utilize alternative sources. Energy consumption and demand in Thailand has increased rapidly since 1970. Until the mid-1970's electricity was generated in Thailand using hydro-power, imported fuel, oil, and domestic coal supplies. In 1976, large deposits of natural gas were discovered in the Gulf of Thailand. Although there was originally little demand for natural gas, in 1981 a pipeline was built to bring gas into Bangkok. Since then the use of natural gas to generate electricity has soared (Poonsombudlert, Talmage, & Chandler, 1996).

According to the Energy Policy and Planning Office (EPPO) the types of plants used to produce energy are hydro-power, thermal power, combined cycle power plants, diesel power plants, and renewable power plants. Figure 5 shows a breakdown of energy production in Thailand since 1986.

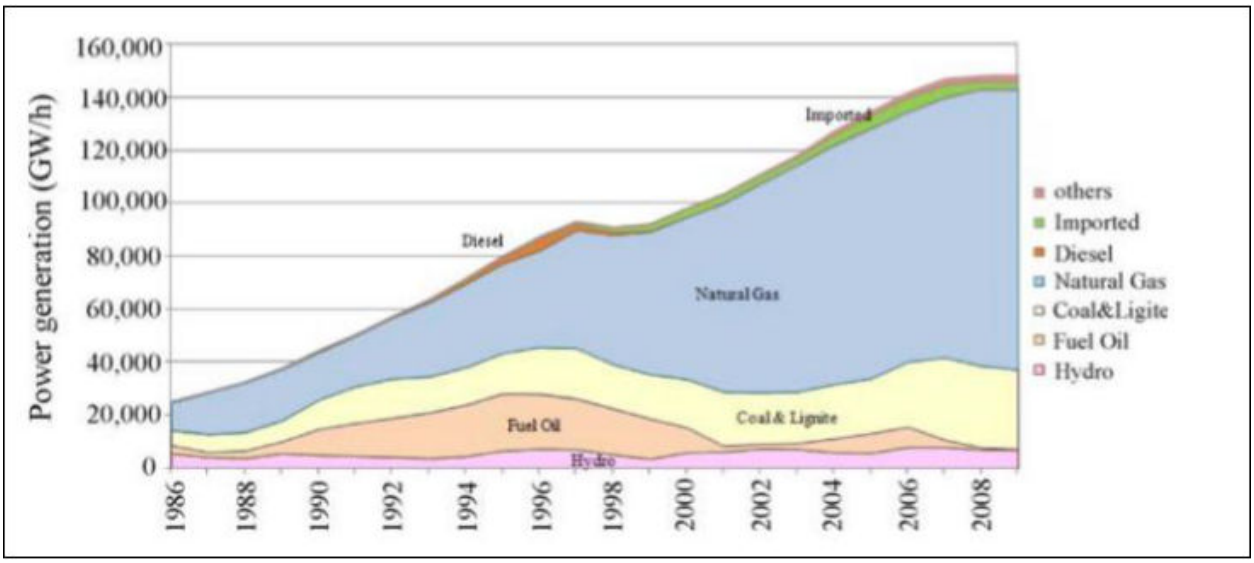

FIGURE 5: ENERGY SOURCES OVER TIME
(SAWANGPHOL& PHARINO, 2011)

As we can see from this Figure, the primary sources of electricity have changed from 1993-2009. The consumption of electricity in Thailand has increased from 56,279 Gigawatt Hours (GWh) to 135,420 GWh. Energy in Thailand is primarily used for economic purposes; Figure 6 shows how energy was distributed throughout Thailand in 2011.

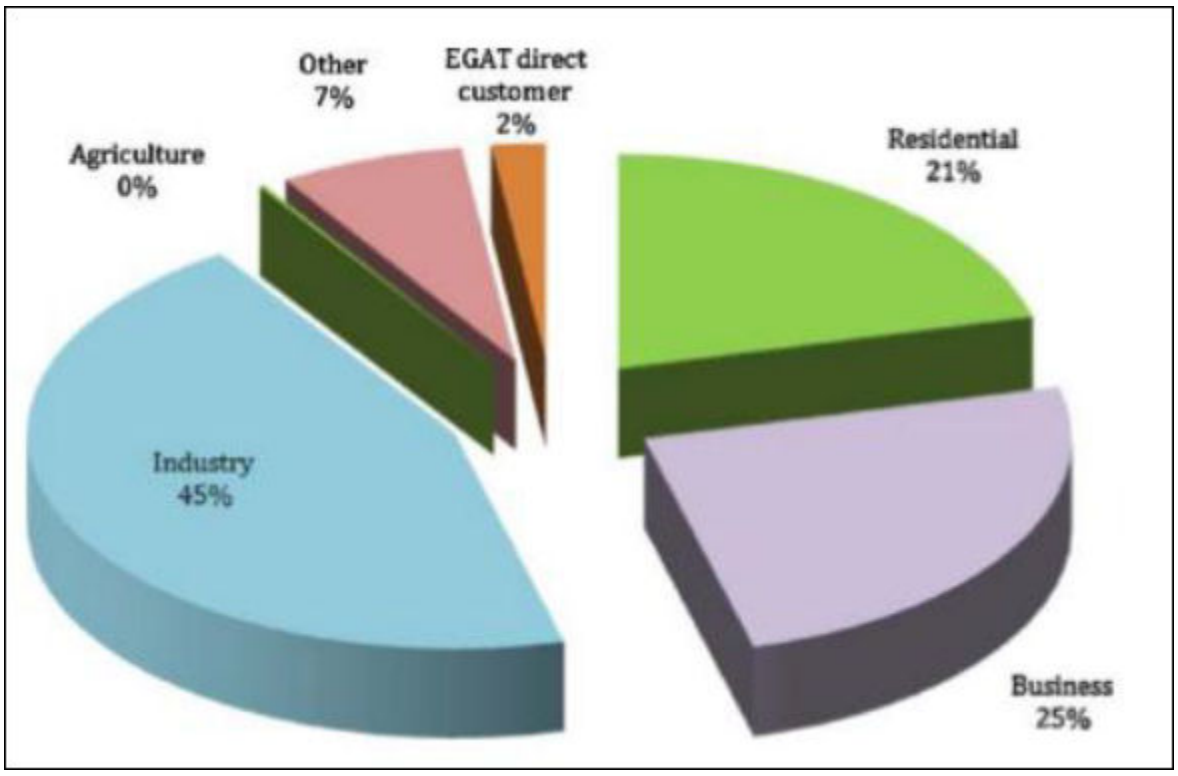

FIGURE 6: BREAKDOWN OF ENERGY USAGE
(SAWANGPHOL& PHARINO, 2011)

During the period of 2007-2010, Thailand consumed 80,019 thousand tons of crude oil that was imported from supplier countries. During these years, Thailand's total consumption in the electric power system was recorded at the highest it has ever been, which was 22,586 MW. From the records of the Ministry of Energy of Thailand approximately 90% of Thailand's commercial energy consumption was generated with imported fuels during the 1970's. Petroleum and crude oil are the energy products that are imported in the largest quantities and compared to other types of energy, incur the highest expenses. Furthermore, the Ministry of Energy revealed that Thailand could reduce the cost of energy up to 60% by using natural gas that was discovered in the Gulf of Thailand and also the lignite in the northern part of the country. However, since the mid 1980's, the country's dependence on imported energy has remained at 55-62% and since 2001, about 70% of electricity is generated from natural gas shown in Figure 7 below (Ministry of Energy 2010).

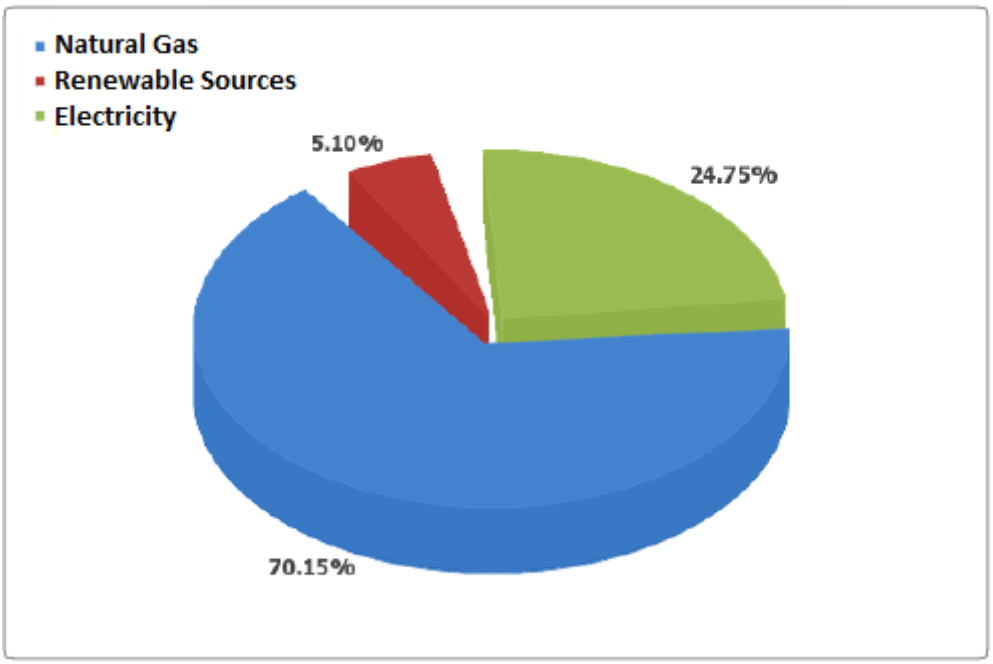

FIGURE 7: TYPES OF ENERGY USED IN NAKHON RATCHASIMA (MINISTRY OF ENERGY 2010)

The domestic demand for commercial energy has been growing at an annual compound growth rate of 7.6%. Between 2002 and 2011 there has been an increase in Thailand's net energy import to US$19.5 billion, equivalent to 7.9% of the GDP. The Ministry of Energy has estimated that greenhouse gases produced per capita are about 5.5 tons yearly (Ministry of Energy 2010).

2.5 THE THAI GOVERNMENT AND RENEWABLE ENERGY

In August 2011, the Prime Minister Yingluck Shinawatra released an energy policy statement stating that the Thai government would actively support research and development of alternative energy sources. One of the future goals of the government is to replace at least 25% of fossil fuel energy sources with alternative energy by 2021 (Kosit, 2011). The government encourages private pursuits of alternative energy by using tax incentives and business privileges as motivation for companies to develop and use alternative energy. Additionally the government eases the burden of rising fuel costs by subsidizing them. In 2011, the government spent roughly 16 billion baht (about 519.9 million US dollars) in order to keep the price of oil down to 30 baht per liter ($0.98) (Energy Intelligence Group, 2011). Although this may be an immediate solution to the energy problem, there are arguments that in the future, subsidizing oil will be damaging to the economy. Others claim that this is a tactic used by the Prime Minister to secure votes (International Energy Policy and Planning Office, 2011).

Since 2004, the Thai Government has been trying to increase the amount of renewable energy use. Their goal was to have renewable energy make up at least 8% of the total energy consumption by 2011 in their "Strategic Plan for Renewable Energy Development." In 2008 (the most recent year for which data is available) Thailand used 1570 kilograms oil equivalent (kgoe) per capita, a figure that has been increasing steadily every year. The World Bank also collected data on the amount of renewable energy being used. Based on the data collected, about 0.6% of the total energy use is produced by renewable sources (solar, wind, hydro, nuclear, geothermal), which brings the total number to 9.42 kgoe per capita. If we compare current Thai renewable energy use with that of the national goal set in 2004, the data indicate that they are falling short of the projections (World Bank Data Indicator, 2011).

Nakhon Ratchasima has the most renewable resource applications in Thailand, ranging from solar arrays to hydropower. In fact, the Government Public Relations Department (GPRD) of Thailand said, "Nakhon Ratchasima is considered to be Thailand's center of alternative energy production" (The Government Public Relations Department, 2010). As of 2010, the largest wind turbine power plant was installed in the Nakhon Ratchasima area. The GPRD found that the land around the Lam Takhong dam would be ideal for the placement of wind turbines because of the winds coming over the mountains in the area and the direct exposure to the occasional monsoon (The Government Public Relations Department, 2010).

The challenges that Thailand is currently facing are not related to implementing new traditional energy resources but providing renewable methods. The electrification of Thailand, as of 2011, is at about 98%. EGAT has developed a plan for increasing the amount of renewable energy that is available between 2010 and 2030. Proposed and approved in 2010, the plan outlines details for increasing renewable and clean energy production as well as offering solutions as to how to cope with the strain on the current grid (System Planning Division, 2010).

The plan summarizes a general concern about the overall reliability and stability of energy generation by new renewable technology. However, they expect that by the end of 2022 they will have increased their energy generation by wind by almost 1000-fold. They also expect generation by biomass, solar, municipal solid waste, and small hydropower to increase by at least 10-fold and for biogas use to increase by about 3-fold. As technology for these renewable energy generation methods is improved, there will be more interest across all nations to try out these energy sources within their local communities. EGAT claims that "power generation from renewable energy and co-generation SPPs (Small Power Producer) was the first priority in future planting up" (Thailand Energy Issues, 2011). This data suggests that the Thai government is taking renewable energy very seriously, which is positive and should mean that citizens are in support of moving towards a more sustainable method of energy production.

2.6 RENEWABLE ENERGY

Renewable energy is a promising source of electricity for rural villages because it is convenient, safe, environmentally sound, cost effective and can often be built near the village that will be using them. It is highly sustainable energy derived from inexhaustible resources. Additionally, it is typically safer for the environment because such modes of energy generation create less waste. Over time it has also been found that renewable sources are cheaper than their non-renewable counterparts. An additional benefit of using renewable energy is reducing dependency of imported crude oil from other countries. There are many different types of renewable energy that could be implemented in Thailand and the potential of these alternative sources is examined in the sections below.

2.6.1 BIOMASS

Although not the cleanest of alternative energy due to the usage of animal and agricultural waste, biomass has potential for reducing Thailand's dependence on fossil fuels. Biomass is the process of using plant matter, leftovers from agriculture, or animal waste to generate energy. Biomass is considered carbon neutral, because the CO_2 it produces can be absorbed by the next year's crops. In Thailand about four percent of all the energy is generated from biomass. Given the wide distribution of agriculture throughout the country this number could be raised much higher, just by utilizing the waste of agriculture and industry. Both of these energy production methods have strong potential in agricultural area, particularly rural Nakhon Ratchasima (Sawangphol & Pharino, 2011).

An abundance of agricultural waste is produced annually in Thailand, and it is feasible that this waste can be utilized to generate energy. The crop residues can be used as fuel to burn and produce steam, which will in turn start turbines and produce electric power. As can be seen in Figure 8, if all of the agriculture residues from 2004 were used for biomass about 612,891 terajoules (TJ) of energy could have been generated (Srisovanna, 2004).

Type	Production	Residues	RPR	Residue generated	Energy Use factor	Amount of Residue used for energy	Surplus Availability factor	Amount of surplus residue	Calorific value	Energy
	(10^6 kg)			(10^6 kg)		(10^6 kg)		(10^6 kg)	(MJ/kg)	(TJ)
Sugar cane	49,070	Bagasse	0.291	14,279	0.793	11,324	0.207	2,956	14.40	42,564
		Top & Trashier	0.302	14,819	0.000	0	0.986	14,612	17.39	254,097
Paddy	25,608	Husk	0.230	5,890	0.507	2,986	0.493	2,904	14.27	41,436
		Straw (top)	0.447	11,447	0.000	0	0.684	7,830	10.24	80,175
Oil palm	4,089	Empty Bunches	0.428	1,750	0.030	53	0.584	1,022	17.86	18,254
		Fiber	0.147	601	0.858	516	0.134	81	17.62	1,419
		Shell	0.049	200	0.588	118	0.037	7	18.46	137
		Frond	2.604	10,648	0.000	0	1.000	10,648	9.83	104,667
		Male bunches	0.233	953	0.000	0	1.000	953	16.33	15,558
Coconut	1,396	Husk	0.362	505	0.289	146	0.595	301	16.23	4,880
		Shell	0.160	223	0.413	92	0.378	84	17.93	1,514
		Empty Bunches	0.049	68	0.144	10	0.843	58	15.40	888
		Frond	0.225	314	0.159	50	0.809	254	16.00	4,066
Cassava	17,330	Stalk	0.088	1,525	0.000	0	0.407	621	18.42	11,433
Maize	4,397	Corn cob	0.273	1,200	0.193	2,320	0.670	804	18.04	14,509
Ground nut	135	Shell	0.323	44	0.000	0	1.000	44	12.66	552
Cotton	36	Stalk	3.232	116	0.000	0	1.000	116	14.49	1,686
Soybean	324	Stalk, Leaves, Shell	2.663	863	0.007	6	0.760	656	19.44	12,748
Sorghum	148	Leaves & stem	1.252	185	0.118	22	0.648	120	19.23	2,309
TOTAL	102.533			65,630		17,643		17,643		612,891

FIGURE 8: THE ENERGY POTENTIAL FROM AGRICULTURAL RESIDUE IN THAILAND IN YEAR 2001 (SRISOVANNA, 2004)

The management of wastewater from major industries in Thailand usually involves utilizing a large amount of energy to remove the hazardous chemicals before disposing of the waste through the sewage system. The Chemical Oxygen Demand (COD) is used to measure the oxygen needed to oxidize the organic compounds into carbon dioxide. The higher value of COD, the more harmful it is to the environment. However, the wastewater can be treated so that it becomes useful biomass energy by using anaerobic microorganisms to produce beneficial biogas such as methane and hydrogen. Figure 9 below shows the major industries that produce wastewater. As a result, it has been discovered that the highest energy from methane gas comes from the starch and sugar industries (Yokoyama, 2000).

Industries	Output (ton/year)	Wastewater (m^3/ton)	COD (kg/m^3)	COD loading (1000 kg/year)	CH_4 generation (1000 kg CH_4/year)	Energy	
						TJ	ktoe
1. Slaughter house	276,573	74.54	2.28	47,086	9135	456.74	10.8
2. Sugar	6,188,000	11.82	2.93	214,453	41,604	2080.19	49.2
3. Distillery	916,260	3.40	25.30	78,817	15,290	764.52	18.1
4. Brewery	756,810	4.12	2.73	7384	1432	71.62	1.7
5. Milk	1,012,064	4.05	1.28	5226	1014	50.69	1.2
6.Monosodiumglutamate	102,925	39.20	16.49	66,515	12,904	645.20	15.3
7. Coffee	12,283	21.77	2.60	695	135	6.74	0.2
8. Vegetable oil	394,570	2.89	6.80	7755	1505	75.23	1.8
9. Instant noodle	136,407	76.97	2.38	25,030	4856	242.79	5.7
10. Starch	1,906,292	24.72	7.65	35,6113	69,086	3454.29	81.8
Total	11,702,184			809,074	156,960	7848.02	185.8

FIGURE 9: THE INDUSTRIAL WASTEWATER FROM TEN MAJOR INDUSTRIES (YOKOYAMA, 2000)

2.6.2 GEOTHERMAL

Geothermal energy production is a process that generates energy by extracting heat from the earth. There are 64 sites in Thailand suitable for geothermal production; these sites currently produce 1.2 million kilowatt hours (kWh) per year. Although geothermal is a good source of energy, it has limited potential due to the small number of geothermal sites in Thailand (Sawangphol & Pharino, 2011).

2.6.3 HYDROPOWER

Hydropower is the second most used low carbon energy source in Thailand. Using hydropower to produce electricity is considered a clean form of energy that does not contribute any pollution to the environment however it can have other negative environmental consequences when building dams for water storage. Hydropower can be done in two different ways. One way is by the run-of-river technique, which is where the water flow is diverted from the river to the turbine via pipes or canals. Another option requires a reservoir where water is stored and released to create electricity when needed (Mulikelela, 2010).

Hydropower is feasible in Thailand since there are 25 river basins across the nation. However, hydropower requires a storage facility for the water such as a dam. Therefore, when using this type of energy, forest land will need to be sacrificed in order to fulfill the needs of the dam facility. Given this environmental impact, the government has been hesitant to invest too much into hydropower. Large dam projects have been disregarded because there are no rivers in

Thailand large enough to facilitate them, but micro-hydropower has become a promising alternative in rural areas. In 2010, a team of scientists analyzed rivers in Nakhon Ratchasima to find out if they were suitable for micro-hydropower. Several suitable sites were found and the team compiled a list of recommendations for the government to use (Kosa, 2010). Figure 10 identifies promising positions, indicated in red, for micro-hydropower in Nakhon Ratchasima based on the aforementioned study.

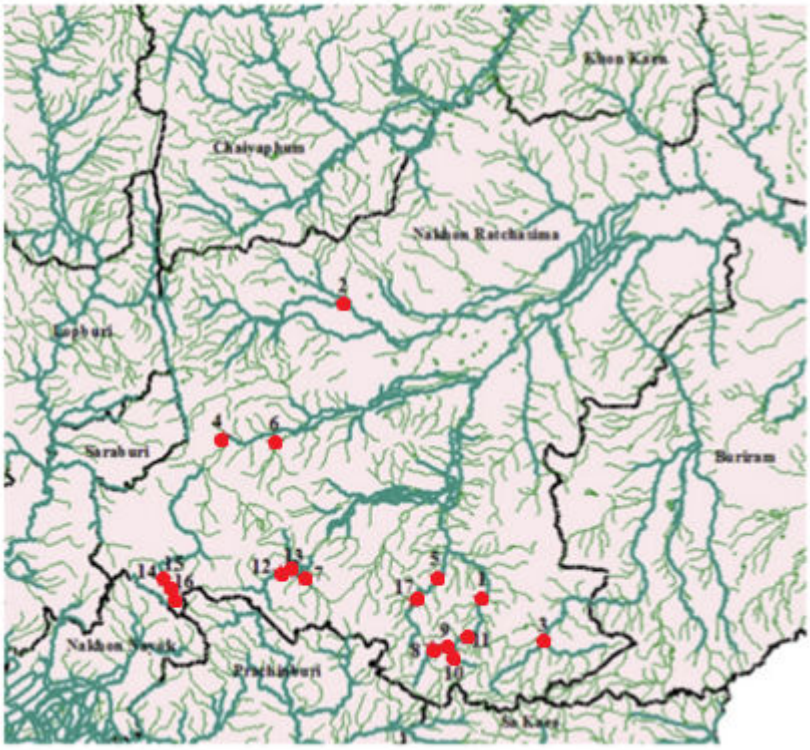

FIGURE 10: PROMISING POSITIONS FOR MICRO HYDROPOWER IN NAKHON RATCHASIMA ARE MARKED WITH RED DOTS
(KOSA, 2010)

2.6.4 WIND

Wind energy is dropping in cost and because it is very clean it is an attractive option for electricity generation. Unfortunately, with the exception of the coastline there is very limited applicability for wind power in Thailand. This severely limits the potential for wind energy in rural Nakhon Ratchasima. Although in other suitable areas, the government plans to increase the usage of wind power by 800 times between the years 2011 and 2022 (Sawangphol & Pharino, 2011).

2.6.5 BIODIESEL

Biodiesel is liquid fuel first used in Thailand in 2007. However, in the following year, the use of biodiesel was discontinued due to falling prices in 2008. The drop in biodiesel can be viewed in Figure 11, which displays no potential energy for the year 2008 after being initiated in 2007.

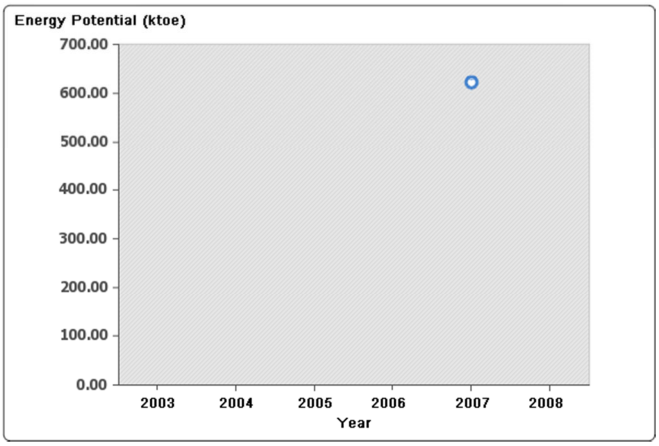

FIGURE 11: POTENTIAL OF BIODIESEL ENERGY IN NAKHON RATCHASIMA (MINISTRY OF ENERGY, 2010)

2.6.6 PHOTOVOLTAIC HYBRID SYSTEMS

The photovoltaic (PV) hybrid is a solar system combined with a diesel generator to produce power. Combining the solar system with a diesel generator allows for power output when solar radiation is unavailable or the available radiation does not meet the village's demand. Solar radiation is site-dependent and the combination system guarantees that electricity is always available. Another option is the PV/wind hybrid system. This system uses wind energy when solar radiation is not available. It consists of an energy conversion system that converts kinetic energy from wind into mechanical energy, which is then converted to electric power. This is a very complex system and requires a detailed survey of the area in which it will be located. This is necessary because wind energy, similar to solar radiation, is site dependent and season dependent. Careful analysis is necessary if a PV/wind system is to be implemented on-site. It is important to know the resources available prior to designing the system. There are currently ten off-grid PV hybrid systems installed in Thailand making it the largest PV user in Southeast Asia.

Five systems are solar and diesel combined, four are solar, diesel and wind systems, and one is solar and wind.

The initial cost of the PV system is higher in comparison to a conventional power system, placing a barrier on its widespread use. However, PV systems have a lower maintenance costs and in the long-run, PV systems are more cost effective than the conventional systems which require constant transportation. Additionally, the transportation of fuels can be difficult and noisy and there is a high risk for leaks (Phuangpornpitak & Kumar, 2006).

2.6.7 SOLAR ENERGY

As the power of the sun has no foreseeable limit, solar energy has a major advantage since its main source of production is sunlight that is converted into a form of energy. The instrument that is used in the conversion is called a solar cell, which has become one of the main methods of alternative energy used around the world. In the northeastern part of Thailand there is a high level of irradiation from the sun as shown in Figure 12. Therefore, the potential for solar energy use in Thailand is very pronounced.

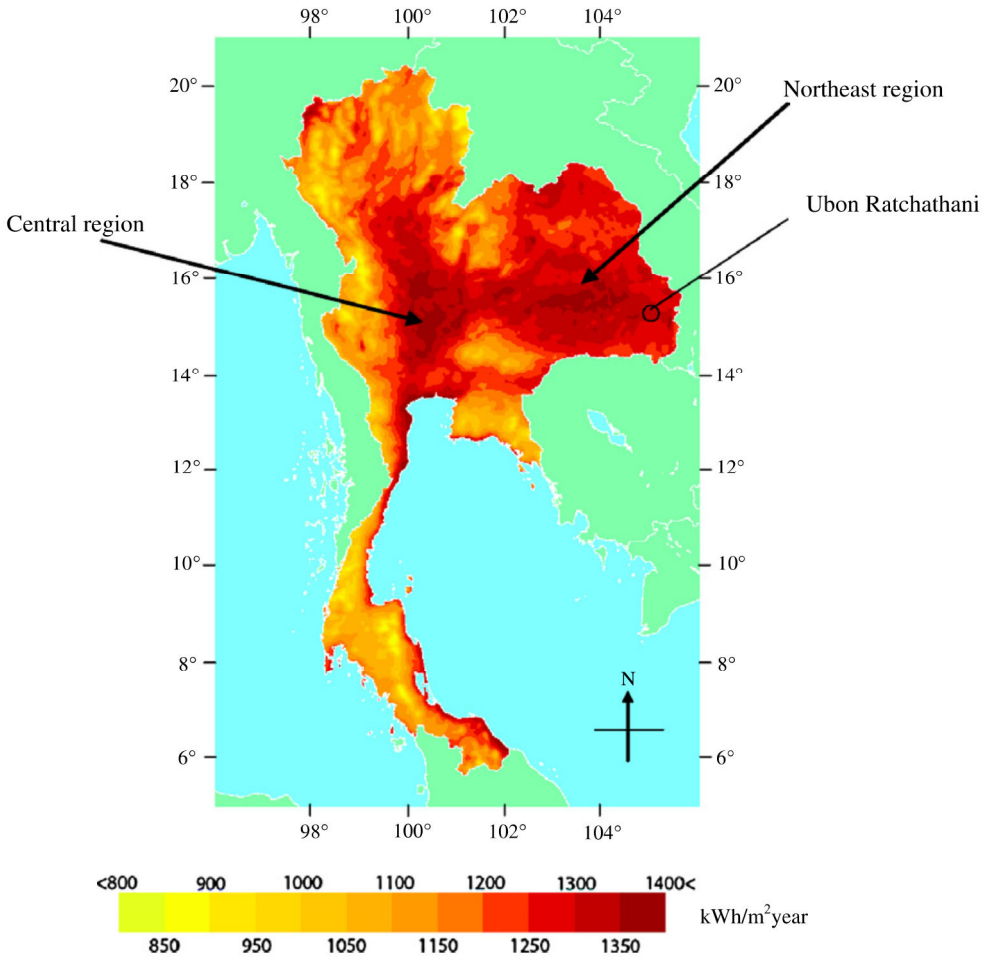

FIGURE 12: A MAP OF THAILAND SHOWING THE SUM OF DIRECT NORMAL SUN IRRADIATION PER YEAR (1) 2011
(JANJAI, 2011)

Due to favorable conditions in Thailand, solar energy has become a popular choice for energy generation in many rural areas and, as of March 2010, there are 51 solar plants running in Thailand. The government plans for solar energy to become ten percent of the country's renewable energy by 2021. As of 2011, solar energy makes up ten percent of Thailand's energy production. The Thai government wants this number to be higher but due to the high cost of solar panels increasing the percentage will take time. As the price of solar technology drops, it will become a more viable method of energy production.

2.6.8 SOLAR POWERED WATER SYSTEM

The Solar Power Water System (SPWS) utilizes solar energy panels to pump water from either groundwater sources or surface water sources. They are used to pump water from wells and rivers to villages for domestic consumption and irrigation of crops. A typical SPWS consists of a solar panel array, water pump, storage tanks, and pipes. The solar panels convert solar energy from the sun into electrical energy to power the electric motor that in turn powers the water pumps throughout the day. The water is stored in tanks located in the tower. The tanks have enough pressure and height to provide gravity driven feed to the areas needed. The gravity feed is energy efficient because consequently, energy storage is not needed.

The SPWS is a cost-effective alternative energy for agriculture in comparison to wind turbines, which are very expensive and not always usable. If the water is used for agricultural purposes, then the water is pumped from the water source into the water tanks that are used as storage until the water is needed for the crops. If the water is used for drinking water and other household purposes, the water goes through a filtration system (IDA-Tech, 2011); Figures 13 and 14 display the SPWS for both underground water sources and surface water sources respectively.

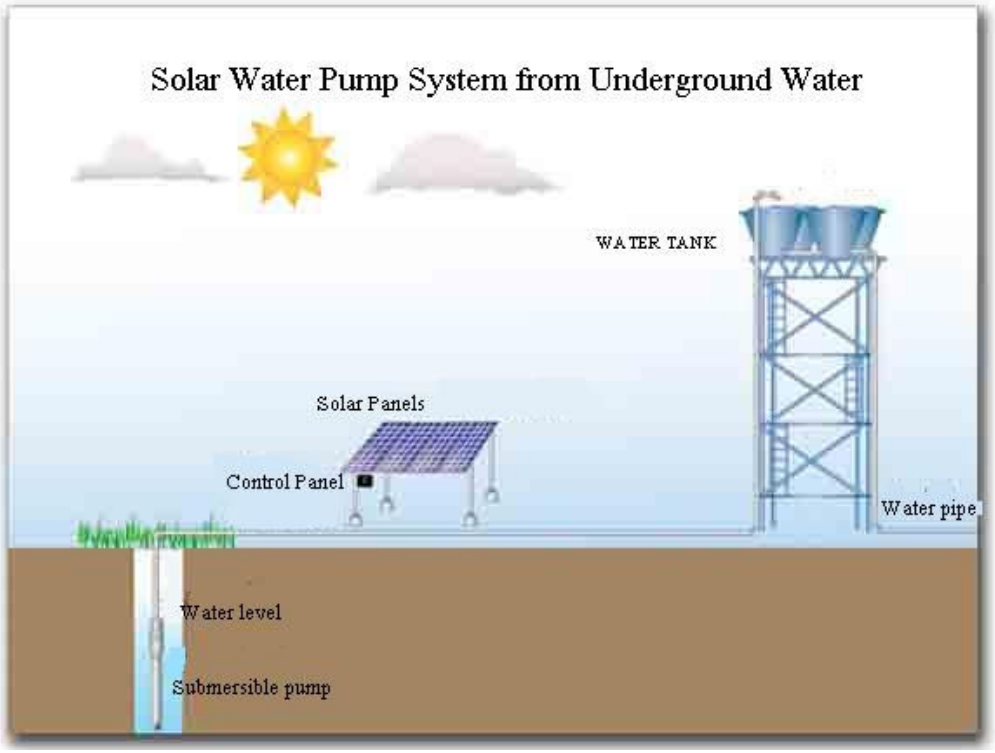

FIGURE 13: SOLAR WATER PUMP SYSTEM FROM UNDERGROUND WATER
(IDA-TECH, 2011)

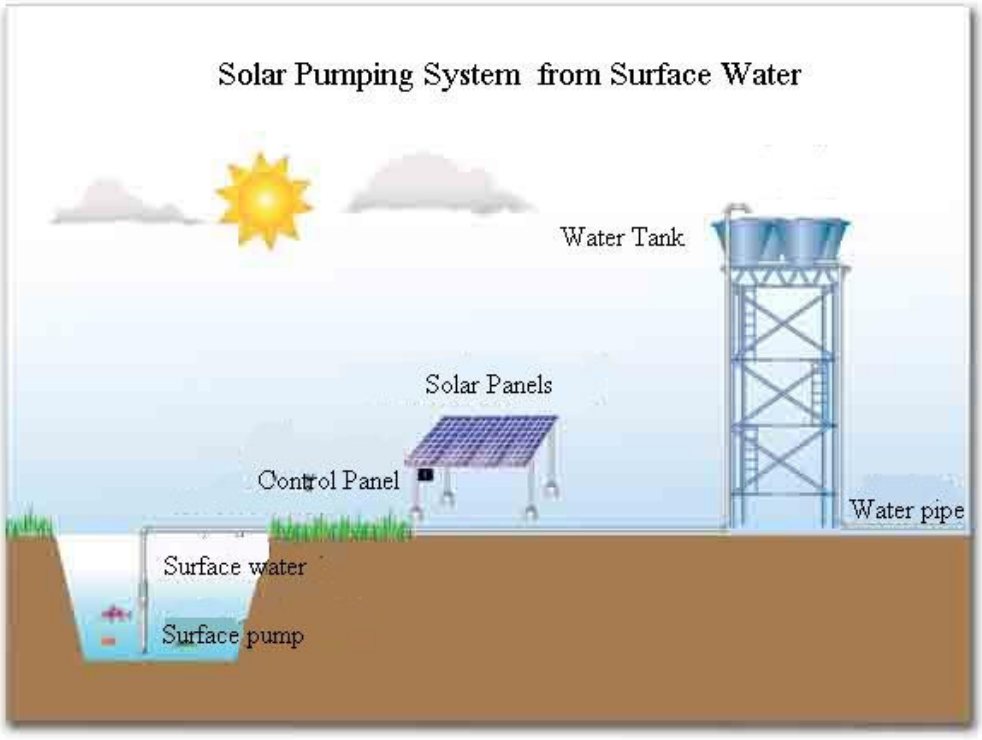

FIGURE 14: SOLAR PUMPING SYSTEM FROM SURFACE WATER
(IDA-TECH, 2011)

2.7 CASE STUDIES

Here we present two case studies to illustrate the successes and failures of alternative energy models that have been tested in conditions like the Nakhon Ratchasima region.

2.7.1 SOLAR PHOTOVOLTAIC (SPV) IN THAILAND

Technology used in the rural communities will depend on the needs and capacities of the specific communities. Solar panels not only reduce the need for kerosene and candles but are also adaptable to local conditions. In India, SPVs have been sponsored by the government through subsidy taxes and financial incentives. The general public and entrepreneurs have joined forces in this program to provide better plans for the villagers. SPVs have been used in Thailand in dry cells and car batteries for small needs but also central solar powered battery charging stations have been made available. There are many challenges associated with SPV use due to their size, high initial cost and in many cases quick battery discharge (Sriuthaisiriwong & Kumar, 2001).

The focus of this case study was in the Chiang Mai and Lumphun provinces. In these provinces ten sites were selected and the local villagers were responsible for battery appliances, operation and maintenance of the systems. After inspection, about 70% contained a charge controller that was not functioning. Some electrical wires were found with makeshift repairs that caused the cables to be unusable. The car batteries had to be recharged once a week and the availability of spare parts was a major disadvantage to this method. The inefficient utilization of this system is a measure of not only technical factors but also day-to-day operation and management of the system. If the pilot project had provided an educational program to the villagers in regards to the proper system maintenance then the project might have been more successful. Due to a lack of information about the system, the residents were not able to use the SPV system in an efficient and reliable manner.

2.7.2 SUNDERBANS ISLANDS

Biomass gasification based power plants were supplied to the Chottomollakhali Island of Sunderbans in India. Biomass gasification is the conversion of solid biomass into a combustible gas mixture. The islands have about 4,000,000 residents in total and they are about 130km away

from Kolkata. Prior to these power plants the villages depended on kerosene and diesel generating systems, but these supplies were purchased by the villagers at a high cost due to their remote locations. The inefficiency of diesel per unit of power generation was USD 0.49, but the cost per unit of gasifier-generated power is USD 0.09 (Mukhopadhyay, 2003). A pilot program of 10 biomass gasifiers and solar PV power plants were installed across the different islands of Sunderbans. The biomass plants had a 15-year lifespan with an average power generation of 400kW per day. The program designed the plants to be in operation from the hours of 5pm to 11pm and its fuel consumption to be 80% biomass and 20% diesel. In order to run the plants the wood biomass was bought at the local markets. A crucial factor in the success of the program was the cooperation of the local community. The residents were organized into a committee that consisted of the users of the plants and the West Bengal Renewable Energy Development Authority (WBREDA), which met once a month. The main responsibilities of the committee were to collect the monthly payments for electricity, inform villagers of the technology available and address the demand of the communities.

The pilot program received positive feedback from the residents. Many of the beneficiaries expressed willingness to pay extra for the new energy supply. The focus was mainly on biomass gasifiers, but the solar plants provided the people with many benefits as well. The households were able to save in their monthly electricity expenditures. Based on the surveys conducted during field work, the consumers stated that they were saving on average USD 2.67 per month after biomass gasifiers were put in place. The power increase in the area has allowed the local population to engage in nighttime activities such as night school and new job opportunities during the evening.

The advantages of providing a consistent energy supply to the communities are endless. The crucial factor in providing an efficient supply depends not only on the resources available to the communities but also on the community dynamics that exist as the people need to participate fully in the technical maintenance and control of the specific programs. This participation raises awareness of the modern technologies available to the community (Mukhopadhyay, 2003).

Through these cases studies, we learn that the key factors on the success of the projects depend on the participation of the recipients in the maintenance of the energy supply. Proper educational programs inform the residents about the different alternative energy and conservation methods. The lessons learned from our review of the literature and these case

studies will help form our strategies as we move forward on the project in Nakhon Ratchasima in cooperation with the PDA. The project will need to engage community involvement towards energy conservation and inform them about the technology available to the region. Community participation will result in a sustainable energy system since the residents will be in control of their energy supply. As a result the community will be more conscious about energy conservation and management, which have a long lasting effect on villagers in Nakhon Ratchasima, serving as a role model for other rural area.

CHAPTER 3: METHODOLOGY

The goal of our project was to assess for the PDA, the impact of new energy technology, such as Solar Powered Water Systems (SPWS), on rural Thai communities while providing recommendations for energy system improvement. In order to accomplish our goal, we met the following objectives:

1) Assessed the community's energy infrastructure and observed the physical layout of each community.
2) Gathered information on the impact that SPWSs have had on the communities.
3) Identified and interviewed the key stakeholders in each community we visited.
4) Evaluated the community's perception of energy conservation and renewable energy sources.
5) Developed recommendations to improve energy availability and conservation within the communities.

In this chapter we have outlined the different methods that we used to achieve these objectives. First, we conducted a community assessment of eight different sites in the Nakhon Ratchasima Province to obtain data. These assessments were focused on understanding the energy usage, SPWS, the social structure and the physical layout of the community. Second, we identified and interviewed stakeholders (PDA representatives, community leaders, farmers and villagers) involved in the communities that we visited. In order to establish a broader understanding we conducted surveys to collect quantitative data about energy consumption and conservation in these rural communities as well as data on the opinions of the villagers regarding renewable energy. The information obtained from the field work allowed us to draw conclusions regarding the impact of the SPWS on local residents. Below we have provided a detailed description of the strategies that we used to conduct our research.

3.1 COMMUNITY ASSESSMENT

A community assessment is "the process of gathering, analyzing and reporting information about the needs of your community and the capacities or strengths that are also

currently available in your community to meet those needs" (Preparing for a Collaborative Community Assessment, Page 1, 2001). Upon arrival in each of the villages we visited, a member of the community gave us a tour. This gave us an opportunity to gain an understanding of the social infrastructure of the community as well as see its physical layout. During these tours we were usually shown the main farms in the community, the water sources and any renewable energy systems located in the community. There were several other points of information that we wanted to observe while touring the community. These points are outlined in a checklist in Appendix B; some topics of interest were businesses, lighting and geography in the community. By following this checklist, we were able to have consistent points of reference for comparing each village. It also served as a reminder of the different energy sources and social infrastructure that we were looking for in each of the villages. This approach allowed us to observe the strengths and weaknesses of each community in relation to energy usage, consumption and conservation.

3.2 INTERVIEWS

After touring each village we interviewed key stakeholders in the communities. In his text on the art of interviewing, Professor Jim Doyle notes, "The purpose of such interviews is not to identify objective truth or to conclusively test hypotheses, but to help the researcher understand the experiences of the participants and the conclusions the participants themselves have drawn from them" (Doyle, 2006). We felt confident in taking this approach and it helped us to understand the needs of the community on a personal level. Insight gained from these interviews had a major impact on the direction of the project.

Logistically, our interviews were semi-structured and featured questions worded in an easy to understand way. Questions were presented in an open-ended way to avoid narrowing the range of responses that the interviewee could provide. A semi-structured interview does not enforce a strict set of questions but allows the interviewer to ask new questions based on how the interviewee answers and reacts to earlier questions (Berg, 2004). By taking this approach, we were able to clarify confusion that interviewees had and to find new information that we had not thought asking about prior to the interview. Interviews were conducted in Thai by the Thai-speaking members of our team and were recorded for later review. Our interviews followed a set

of guideline questions which can be found in Appendix A. By conducting semi-structured interviews we were able to gain an understanding of current conditions in the community.

3.3 SURVEYS

We surveyed a sample of each village's population to obtain quantitative data for an analysis of the overall energy and water consumption from the SPWS. We opted to use surveys, because, as defined by Salant and Dillman, a survey is "a scientific way to realize the great benefits of interviewing a representative sample instead of the whole population" (Salant & Dillman, Page 4, 1994). We conducted a needs assessment to learn more about the communities' views on the SPWS, and understand the effect that the system has on the villager's quality of life. The surveys provided us with relevant information to learn the characteristics, behaviors and opinions of the population as a whole.

To guarantee accurate estimates from our surveys, we chose a sample population. A sample "is a set of respondents selected from a larger population for the purpose of a survey" (Salant & Dillman, Page 53, 1994). This gave us the ability to obtain information from a few respondents and still obtain an accurate understanding of the entire community. First, we decided upon a sample size that was dependent on the population of each village we visited. We assured the sample size was large enough to gain the desired information. Second, we made our selection a sample of convenience.

In order to assure participation in our surveys, our questions were clear and concise, which allowed the residents to answer accurately. The questions were closed ended with ordered response choices where each choice represents a progression from a single concept. This allowed the responses to provide an accurate measurement and consistency for final data analysis.

3.4 DATA ANALYSIS

After one week of fieldwork, we returned to Bangkok to analyze the qualitative data gathered through semi-structured interviews in all of the villages that we visited. After compiling all interviews from the different sites, we began to analyze and synthesize our information. The interviews from all sites were compared with each other by first grouping together the interviews of one site specifically based on the different response obtained. After grouping together the

interviews of each site, they were compared as a whole to the remaining sites. This analytical approach is called coding in which we compared all the data collected and identified common themes within the data for future discussions and investigations. Coding helps the researcher to ask questions, to compare across data, to change and drop categories and to make a hierarchical order of them (Seidel & Kelle, 1995). This guaranteed that information from each sites' interviews were retained while making systematic comparisons between all interviews of the individual villages. This analysis method also allowed for a clear observation of variations, similarities, and differences between data gained from the villages. Based on what we learned from this initial analysis we decided where we would focus our efforts during our second week of field work.

Based on what we learned from our first round of analysis we returned to two specific villages in order to conduct surveys and a few more interviews. Surveys were tailored to answer specific questions that we discovered while analyzing our first set of data. When we returned from our second week of field work we analyzed the results using the same process we used for our first week of field work.

After an in-depth analysis of the findings, our group discussed which problems were most relevant to the communities in regards to sustainability and energy conservation. We discussed the community problems that were uncovered during the analysis and assessed the impact that SPWS and other energy technologies have had on the citizens of the communities we visited. Through this analysis we were able to develop possible solutions and recommendations for the PDA.

3.5 SUMMARY

The goal of our project was to determine the impact that renewable energy technology has on rural Thai communities while providing recommendations for energy system improvement to the PDA. During our fieldwork in the village, our main objectives were to establish a positive connection with the communities, to gather data about their electrical installations, and to examine potential areas of improvement in local infrastructure. We also assessed the geographic location of the communities to determine if any alternative energy sources were feasible.

These relationships were established by conducting semi-structured interviews with local stakeholders, distributing short surveys to residents, observing the physical layout of the communities, and gaining an understanding of their electrical infrastructure. We conducted semi-structured interviews that allowed us to obtain information about the social perceptions of the communities and their current energy consumption and usage. Also, through the short surveys we obtained quantitative information about the level of energy consumption in the local households and its impact on the communities. To conduct the geographical assessment we took tours of the communities to observe the different potential locations for alternative energy resources within the villages.

3.6 TIMELINE

Our fieldwork consisted of two separate weeks' on-site gathering data. Our first week was planned out as follows: each weekday consisted of us visiting two or three communities that were arranged with the PDA representative. We visited four sites that had SPWS installed either for irrigation or household usages and four sites that did not. The second week of our fieldwork required more in depth analysis of two communities. We went back to two communities to study them more closely with surveys and structured-interviews; one community with SPWS and one without. We spent one day in each of the communities to administer the surveys to as many people as possible.

CHAPTER 4: FINDINGS AND ANALYSIS

The findings of our fieldwork in Nakhon Ratchasima are presented in this chapter. We first discuss our findings in each of the eight villages we visited: Nong-Pluek Village, Nong-Ploung District, Takut-Klue Plok Village, Saparn-Thom Village, Koksad Village, Dangnoi District, Limptong Village, and Nong Takem Village. We then provide an analysis of all the villages comparing those villages with a SPWS to those villages without, as well as considering factors concerning the cost of living, and the effects of the PDA involvement. Attached in appendices E, H, and I, we have provided a summary of the interviews and surveys conducted during our fieldwork in Nakhon Ratchasima.

4.1 VILLAGE FINDINGS

In our first week of field work we visited a total of eight villages. Four of these villages used the SPWS: Nong-Pluek Village, Nong-Ploung District, Takut-Klue Plok Village, and Dangnoi District. The SPWSs installed in these villages range from one year to about two weeks in age. Some reoccurring problems for the SPWSs include low electricity generation during the rainy season due to shadows cast on the solar panels. Submersible pump breakage has also occurred, but it has not been a problem due to adequate insurance coverage for repairs. Each village has established a maintenance team of residents to clean and take care of the solar panels.

The other four villages are not using SPWSs but are considered candidates for this system as decided by the PDA: Saparn-Thom Village, Koksad Village, Limptong Village, and Nong Takem Village. Below are two maps, Figures 15 and 16, which mark the locations of the eight villages we visited in the Chakkarat District and the Burirum Province. The villages in blue have a SPWS installed, and the villages in red do not have a SPWS.

FIGURE 15: MAP OF CHAKKARAT DISTRICT

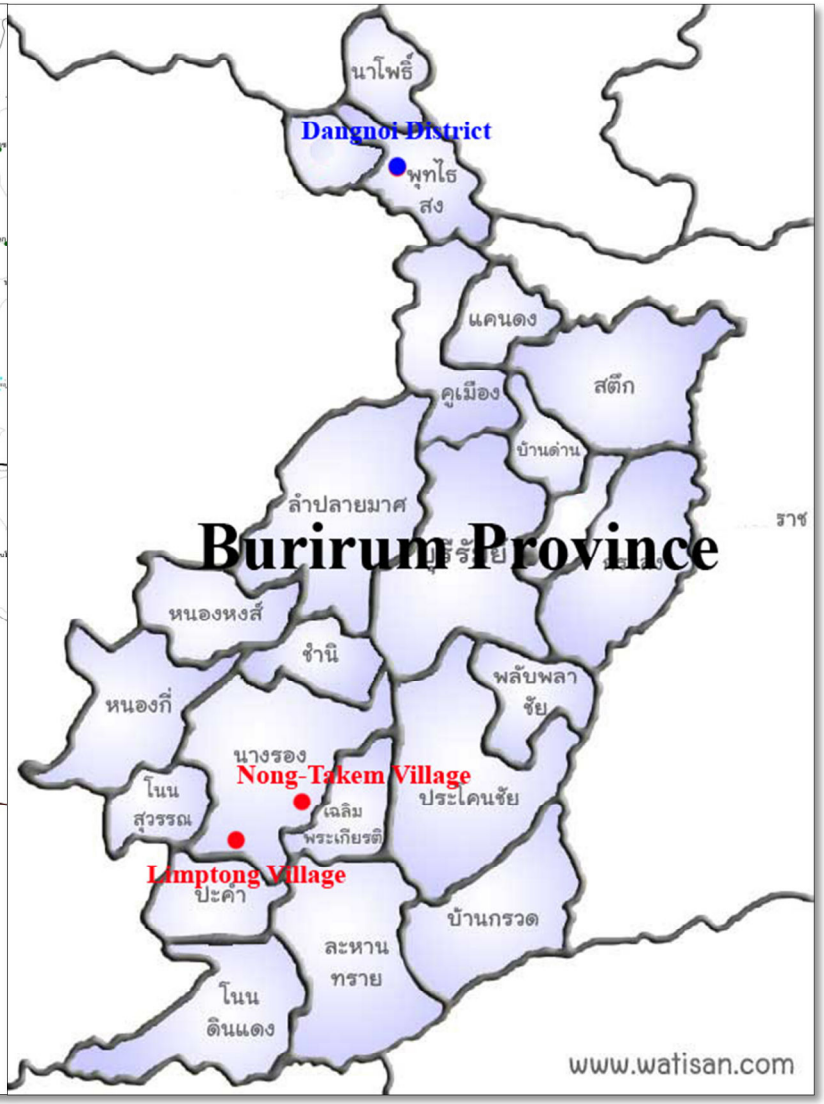

FIGURE 16: MAP OF BURIRUM PROVINCE

The PDA visits the villages without SPWSs on a monthly basis. According to Somphop Phuttaruksa, PDA staff responsible for Mechai Farm for 15 years now, the PDA will take the villagers to observe and study other villages that have a SPWS. Mechai Farm is a demonstration farm to educate other villagers about farming techniques. Somphop believes the SPWS is vital for all villages because the cost of electricity for pumping the water is very expensive and most villagers are facing debt problems. He believes that the SPWS is worth investing in for the long-term, in part because the solar cells are expected to have a life span of twenty years. The factors the PDA uses to choose a village as a candidate for a SPWS include participation in the VDP (Village Development Plan), a PDA program set up to help rural communities, and the extent of community involvement

The cost to install a SPWS is approximately 400,000 baht. In most cases the villages have worked with a private sector sponsor to help pay for the system, these sponsors include Standard Charter and the Environment Partnership (EEP). When sponsored, the villagers do not need to pay for the system but they help in the construction of the pipelines used move the water through the village. If villagers do not receive support money, they have to pay for the SPWS installation. The installation is typically paid by dividing the cost among all the families. There is a twenty year insurance plan on the water pumps. Each village with a SPWS used it for a different purpose; some villages used it specifically for agricultural purposes while others used it also for household purposes, and processed the water for filtration. Our findings for each individual village are detailed below.

4.1.1 NONG-PLUEK VILLAGE

Age Range	# Of Villagers (%)
1 – 11	81 (20.3%)
12 – 17	42 (10.5%)
18 – 49	211 (53.0%)
50 – 60	40 (10.0%)
60 and above	24 (6.0%)

TABLE 1: NONG-PLUEK POPULATION AGE BREAKDOWN
(TAO CHAKKARAT DISTRICT OFFICE, 2011)

Occupation	# Of Villagers (%)
Farmer	125 (79.1%)
Merchant	5 (3.2 %)
Craftsman	-
Industrial Worker	-
Government	-
Service	28 (17.7%)
Other	-

TABLE 2: NONG-PLUEK POPULATION OCCUPATION BREAKDOWN
(TAO CHAKKARAT DISTRICT OFFICE, 2011)

Nong-Pluek is a community of 98 households consisting of 398 people with an area of about 3,325 rai (1 acre = 2.53 rai). The community has been utilizing their SPWS for about a year. The water obtained through this system is used for household and agricultural activities such as washing and planting vegetables. As part of their energy conservation efforts, the community grows cantaloupes and uses drip irrigation to irrigate their crops.

Our first observations upon arriving on site were that individual households were connected to the regional electric grid and that each home had individual water storage tanks to store the water distributed from the SPWS. The assistant village headman, Mr. Samitr Junya gave us a tour of the village and also took us to where the system was located. As seen in Figure 17, the solar panels of the SPWS were located next to a construction site that posed as a potential hazard to the system. Mr. Samitr felt that the location was not appropriate since it was on unleveled land and in an unsecure area. The system was only protected with a lock (pictured in Figure 18) put on the water pump to prevent villagers from stealing water at night. The system is supervised by the headman and assistant headman of the village and the villagers rely on them for proper functioning of the system. The supervisors have been educated by the PDA on maintaining the system. During the day, the villagers use the SPWS to pump water, but in the evenings they use electricity from the grid to pump water for household usage. The SPWS requires about two hours during the day to fill the water tank completely and during this time the system is still able to provide water for the villagers to use constantly.

FIGURE 17: SOLAR PANELS NEAR THE CONSTRUCTION SITE

FIGURE 18: WATER PUMP FOR UNDERGROUND WATER

4.1.2 NONG-PLOUNG VILLAGE

Age Range	# Of Villagers (%)
1 – 11	64 (10.1%)
12 – 17	64 (10.1%)
18 – 49	361 (57.2%)
50 – 60	64 (10.1%)
60 and above	68 (10.7%)

TABLE 3: NONG-PLOUNG POPULATION AGE BREAKDOWN
(TAO CHAKKARAT DISTRICT OFFICE, 2011)

Occupation	# Of Villagers (%)
Farmer	104 (63.4%)
Merchant	5 (3.0 %)
Craftsman	-
Industrial Worker	-
Government	5 (3.0%)
Service	50 (30.5%)
Other	-

TABLE 4: NONG-PLOUNG POPULATION OCCUPATION BREAKDOWN
(TAO CHAKKARAT DISTRICT OFFICE, 2011)

Nong-Ploung is a village located in the Nong-Ploung district with a total of 160 households consisting of 631 residents. The village shares a SPWS with the other villages in the district; it has been in use for two months. As in other villages, there are no records of the amount of solar energy generated or water pumped from the system. In order to supply the entire district with sufficient energy and water resources, eight solar panels were installed for the system. The SPWS is located in a secure and remote area away from the villages and surrounded with barbed wire for protection. The system is used to provide its citizens with drinking water therefore the filtration system that was used with the old electrical pump was adapted to the new

system. This filtration system uses aluminum ammonium sulfate and chlorine to purify the water and make it drinkable (Figure 19). The chemicals cost around 9,000-10,000 baht per month

FIGURE 19: WATER FILTRATION SYSTEM

The water is distributed to the households through a main water pipe that is 6km in length and reaches only some of the villages; therefore, other villages depend on rain water as a source for drinking water. As part of their future plans, the representative of the Tambon Authority Organization (TAO), Mr. Samart, stated that they plan to obtain water pipes with a larger diameter size, which would allow them to make this water source available to all the households in the district. To ensure proper functioning of the SPWS, a representative from the PDA has instructed the villagers on how to turn on and shut off the system for now. The PDA is currently in the process of educating the villages about the system and proper maintenance techniques. As part of their efforts to train people in the use of each system there are illustrations indicating the process that the system goes through in order to provide the water to the individual homes (Figure 20).

FIGURE 20: INFORMATIVE POSTER NEXT TO SPWS

4.1.3 TAKUT-KLUE PLOK VILLAGE

Age Range	# Of Villagers (%)
1 – 11	144 (13.6%)
12 – 17	104 (9.8%)
18 – 49	596 (56.3%)
50 – 60	94 (8.8%)
60 and above	120 (11.3%)

TABLE 5: TAKUT-KLUE PLOK POPULATION AGE BREAKDOWN
(TAO CHAKKARAT DISTRICT OFFICE, 2011)

Occupation	# Of Villagers (%)
Farmer	550 (75.7%)
Merchant	25 (3.4%)
Craftsman	5 (0.6%)
Industrial Worker	-
Government	11 (1.5%)
Service	135 (18.6%)
Other	-

TABLE 6: TAKUT-KLUE PLOK POPULATION OCCUPATION BREAKDOWN
(TAO CHAKKARAT DISTRICT OFFICE, 2011)

Takut-Klue Plok village consists of 262 households and 1058 residents, the primary occupation, farming. At the time of our visit to Takut-Klue Plok their SPWS had been installed for only two weeks. Based on the interviews conducted to the TAO representative, Mr. Somchai Lumtakor stated that before the system was installed, the electricity bills for the community per household were around 500 baht per month and the water expenses were about 200 baht per month. The system is only used for irrigation purposes and distributes water to 288 households in the community, using surface water as the source (Figure 21). The villagers use rain water as drinking water. The water produced from the system is distributed to the individual households by a water pipe that is 8km long, connected to the central water storage tank. Water is transferred to the central storage tank via gravitational force (Figure 22).

Due to the recent installation of the system, the interviewees in the village were not able to provide any information in regards to electricity and water usage with this system. The PDA has been able to successfully inform the villagers about its proper maintenance and income generating techniques such as cricket farms. The village headman, Mr.Somboon Poonsri, showed interest in expanding the system into two sectors, one for agriculture and the other for household usage. During our interviews, the community responded positively to the recent installation of the system and looks forward to seeing how this system can help their community.

FIGURE 21: SURFACE WATER SOURCE

FIGURE 22: WATER STORAGE TANK

4.1.4 SAPARN-THOM VILLAGE

Age Range	# Of Villagers (%)
1 – 11	58 (18.1%)
12 – 17	40 (12.5%)
18 – 49	165 (51.5%)
50 – 60	37 (11.6%)
60 and above	19 (5.9%)

TABLE 7: SAPARN-THOM POPULATION AGE BREAKDOWN
(TAO CHAKKARAT DISTRICT OFFICE, 2011)

Occupation	# Of Villagers (%)
Farmer	116 (70.3%)
Merchant	5 (3.0%)
Craftsman	-
Industrial Worker	-
Government	-
Service	-
Other	44 (26.6%)

TABLE 8: SAPARN-THOM POPULATION OCCUPATION BREAKDOWN
(TAO CHAKKARAT DISTRICT OFFICE, 2011)

Saparn-Thom village consists of 75 households with 320 residents. In Saparn-Thom the majority of villagers are farmers. They rely on an electric water pumping unit connected to the grid for their household usage. They use rainwater as their source for drinking water and store it in large jars as seen in Figure 23.

FIGURE 23: DRINKING WATER STORAGE

The water bills in the community range from 40-80 baht per household monthly, but the electricity usage is free if the usage is less than 90KWatt/hour monthly because of a program instituted by the Thai government. The villagers have not been trained by the PDA about using SPWSs. They have only been taken to the Nong-Pluek Village in order to visit the SPWS located there. The assistant of the village headman, Miss Somchei Yuttiluck, informed us that many of

the villagers expressed their concerns about the possible installation of the system in the community since such an investment could possibly cause them more debt. Even though they are afraid to invest in the SPWS as a specific solution, they would still like to have a water storage tank (as pictured in Figure 24) in the near future because the current water supply available will not be enough to meet household needs.

FIGURE 24: WATER TANK

4.1.5 KOKSAD VILLAGE

Age Range	# Of Villagers (%)
1 – 11	12 (8.5%)
12 – 17	18 (12.8%)
18 – 49	78 (55.3%)
50 – 60	18 (12.8%)
60 and above	15 (10.6%)

TABLE 9: KOKSAD VILLAGE POPULATION AGE BREAKDOWN
(TAO CHAKKARAT DISTRICT OFFICE, 2011)

Occupation	# Of Villagers (%)
Farmer	68 (79.0%)
Merchant	2 (2.3%)
Craftsman	5 (5.8%)
Industrial Worker	-
Government	-
Service	11 (12.8%)
Other	-

TABLE 10: KOKSAD POPULATION OCCUPATION BREAKDOWN
(TAO CHAKKARAT DISTRICT OFFICE, 2011)

Koksad Village is a small community consisting of 42 households with 141 residents. This village has been working with the PDA for three years. The Koksad Villagers currently pay a lot of money for water and electricity expenses, about 800 baht monthly per household, which is more than the average individual household can afford. The majority of residents are farmers

and the main crops are cassava, sugarcane, watermelon, and cantaloupe. Water in Koksad Village has been provided by the government and managed by the sub-district government. The villagers currently use groundwater for irrigation and rainwater for household purposes. Every household pumps water from underground and stores the water in a tank. This underground water pump is surrounded by grass and not protected with any form of fencing as displayed in Figure 25.

FIGURE 25: PUMP ON UNEVEN LAND WITH WIRES WRAPPED AROUND THE DRIPPING SECTION

The pump drips constantly because the underground water is acidic, which has in turn, corroded the pump. There is also electrical wiring wrapped around the system near the dripping water, shown in Figure 26, causing a potential hazard. The quality of this underground water is very poor because it contains high sediment and has low pH. The water is not filtered and is unsuitable for consumption. Based on the surveys, the villagers stated that water quality ranged mostly from average to poor, as depicted in Figure 27. The villagers used this water in the past for household purposes and drinking water but consequently, the acidic water affected the health of many villagers, particularly with kidney disease and difficulties in properly urinating.

FIGURE 26: EXPOSED WIRES

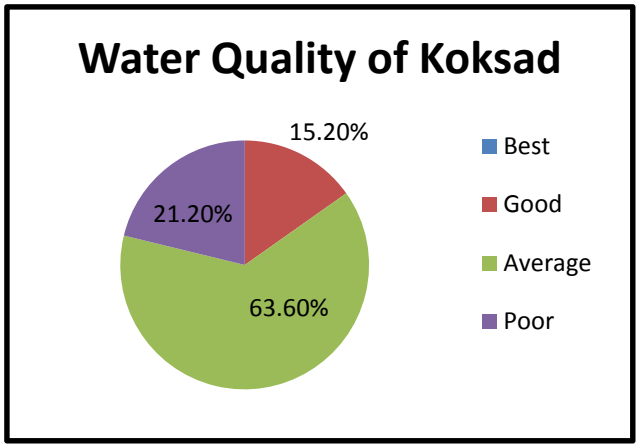

FIGURE 27: PIE CHART OF RESPONSES FROM VILLAGES SURVEYED

There is a surface water source, a lake, available to three villages, but only two villages are using the source. Koksad village originally used this water source as well, but their pump was stolen. The Koksad village wants to find a way in which they can use the lake water to support their needs and not risk more of their equipment being stolen. The villagers heard about the SPWS from a nearby village, Nong-Pluek, which is currently using this system. Mr. Paan Koptonglang, villager headman, also mentioned that the PDA stated that Koksad village is capable of using the SPWS due to the vast supply of surface water available to them. The PDA visits this village at least once a month to inform the villagers about supplemental jobs and farming techniques. Despite this, the Koksad villagers are skeptical about using the SPWS since the lake water source is so far from the village and they do not want the SPWS to be stolen, as noted by Samom Jongjaiklang, the vice village headman.

4.1.6 DANGNOI DISTRICT

The Dangnoi District has been utilizing the SPWS for five months to feed their diverse fields of crops such as onions, cabbages, and morning glory. The solar system consists of 36 solar panels total and Figure 28 displays how it is well secured with barbed wire surrounding the entire solar panel system. There were although some exposed wires under certain solar panels, shown in Figure 29. According to the Ministry of Energy, each solar panel collects 15 Watts per day.

FIGURE 29: SOLAR PANEL SYSTEM

FIGURE 28: EXPOSED WIRES

The solar panels were obtained without cost through a government program, however, the village needed to invest in the SPWS manufacturing and installation to successfully implement the system in the village. In total, The SPWS was approximately 400,000 to 500,000 baht so about 16,000 baht per household and about half of the households have already paid this in the five months this system has been installed.

Each family that invested in the SPWS has their own plot of land and will sometimes compete with other families in the village to see who can grow the best crops. Figure 30 displays a layout of various land plots with the individual water tanks for each plot. Each villager who has a plot of land is required to pay a maintenance fee of 20 baht per month that is collected just in case the system breaks down. As of now the only problem the village has had was in the beginning of the SPWS. The village used to have only one tank, but that was not sufficient enough to water all the crops, so the PDA installed a second tank. The villagers took out a loan to install this tank, but it has already been paid back. The tanks use a balloon sensor to automatically shut down the SPWS when the tanks are full. Figure 31 displays the water tower of Dangnoi Village. The villagers do not have to pay for the water provided by the SPWS, only the seeds for their own plot of land.

FIGURE 30: INDIVIDUAL WATER TANKS FOR EACH HOUSEHOLD LAND PLOT

FIGURE 31: WATER TOWER

The village has many goals for the future according to Kanlaya Kinapid, Minister of Puttaisong District for 11 years now. The village plans to buy a battery for the system so they can store the electricity for use in the night and in the rainy season when there is not as much sunlight available. The village also plans to make biodiesel from the Jatropa seed, which is a project with the community school Ban Dang Noi School. Dangnoi plans to grow these seeds for the young students in the schools to take care of and then sell them to the company in partial exchange for biodiesel fuel needed for tractors and other agricultural purposes. Biodiesel is also an attractive option because the initial investment in batteries is expensive and biodiesel could be used instead or in conjunction with a smaller less expensive battery. Finally, the village plans to use this system for households; however the cost of such a system is around 1.4-1.5 million baht.

4.1.7 LIMPTONG VILLAGE

Limptong Village is a community consisting of 627 people in 140 households. The main occupation of the villagers is growing rice, cassava, and vegetables. Each villager grows different crops and the amount of crops is consistent throughout the year. This village has been focusing on water management programs and has been considering SPWS as an option since 2005. However, the village has not installed the SPWS yet, but the villagers are closely

considering the SPWS as a viable option for meeting their water related needs. The SPWS would meet the water needs of the farmers because they are most affected, in comparison to other villages, by the drought, causing damage to their crops. The current main water source of this village is the local pond and its water quality is poor.

This village is well organized and all the members of the community record water and electricity expenses per month and also record the crop growth per month along with the amount of water needed. The villagers have constructed a record keeping system for all water related issues for future reference. The villagers focus on the cash flow record keeping system, of money that they spend on the agricultural sector, and they use Microsoft Excel to keep track of all their data. In the future, they plan to use this data to help them make informed decisions for expanding their community and one future goal for the village is to install a SPWS.

At the time of our visit the villagers had two ways to store the water, via canals and the Monkey Cheek Project (MCP). The MCP aims to provide water to the villagers during the summer drought season. Essentially, the main objective of this program is to store water during the rainy season when there are large amounts of water available, in hopes of providing water for the crops during the summer drought season. The water from the rainy season is drained by canals into small reservoirs used in the summer. Limptong Village is currently using the MCP and it appears to be working well as evidence in the success of summer crops. Figure 32 displays the water reservoir.

Projects at Limptong Village have been sponsored by many organizations and charities. For example, the Coca-Cola Company financially supports the MCP. The TAO representative of the village provided the villagers with 100,000 baht for the water maintenance cost. Moreover, the school in the community helps the villagers solve problems with pollution in the water supply. Limptong Village takes a community oriented approach to solving problems. When there is something that needs to be done an individual is assigned, by the community, a specific task that will help solve the problem. By taking this approach the village has successfully implemented energy conservation management and helped spread the information to other villages.

FIGURE 32: WATER RESERVOIR WITH PLOT

4.1.8 NONG TAKERM VILLAGE

Nong Takem Village consists of 170 households. This village does not use the SPWS, although the village is interested in adopting the system. The village is currently using the canal water for agriculture and household purposes other than drinking water because it is not filtered; they collect rainwater for drinking water instead. Each household in Nong Takerm has their own pump and a water tank, Figure 33 shows the water pump. The water tanks were provided by the Nanlong Hospital. The households use these essentials to gather water from the canal, but a vast amount of water is needed for each household for agriculture purposes, therefore, the electricity cost is high, as they acquire their electricity from the grid. It would be better to have the SPWS as a community based water system to lower individual electricity bills required to pump the amount of water needed by the village.

The village produces biogas from animal waste such as pigs and cows. The animal waste is passed through a polyethylene dome, which acts as both underground digester and gas storage tank. The resulted methane gas was kept in the dome for cooking purposes; this dome is displayed in Figure 34. There is no smoke from this system and it is also odorless. They do not have a storage system for this technique, although, they have plenty of gas to supply the entire village. The villagers mainly grow flowers and herbs, the flowers are sold and herbs are used for medicinal purposes. The problem facing Nong Takem is that all of its land is owned by the government and merely rented by the village. They want ownership of their own land. The village has a good retention rate for its citizens and typically they only leave to attend university.

The village is supported by the Thammasat School and by Microsoft who has contributed a number of computers to the village in order to equip a learning center. The learning center is open daily from 5-7pm and on weekends it is open all day. The only charge is for internet and computer lessons. The villagers are well trained about raising flowers and herbs. There is also a community bank in the village, which gives low interest loans to the community.

FIGURE 33: WATER PUMP

FIGURE 34: BIOGAS DOME

4.2 ANALYSIS

There was a noticeable difference between the villages that we visited, villages with SPWSs generally had lower water and electricity bills, allowing them to expand farming activities and generate more income while villages without SPWS had higher debt and less income. As seen in Figure 35 and Figure 36, we have provided a comparison chart of a village with SPWS (Nong-Ploung) and a village without SPWS (Koksad) in regards to their electricity and water expenses. In this section we have examined, from a social and economic perspective, how this new energy technology has impacted the villages. Additionally, we have examined the feasibility of other types of renewable energy technology in the villages we visited.

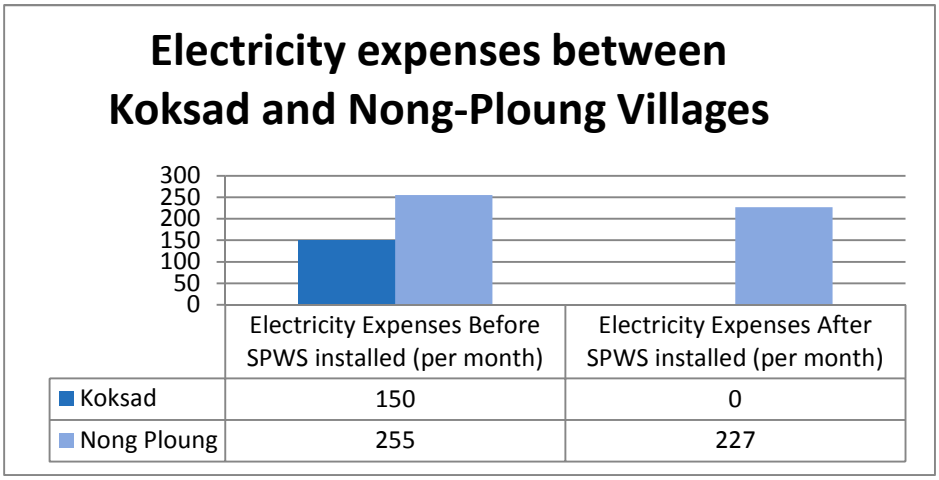

FIGURE 35: ELECTRICITY EXPENSES BEFORE AND AFTER SPWS INSTALLATION

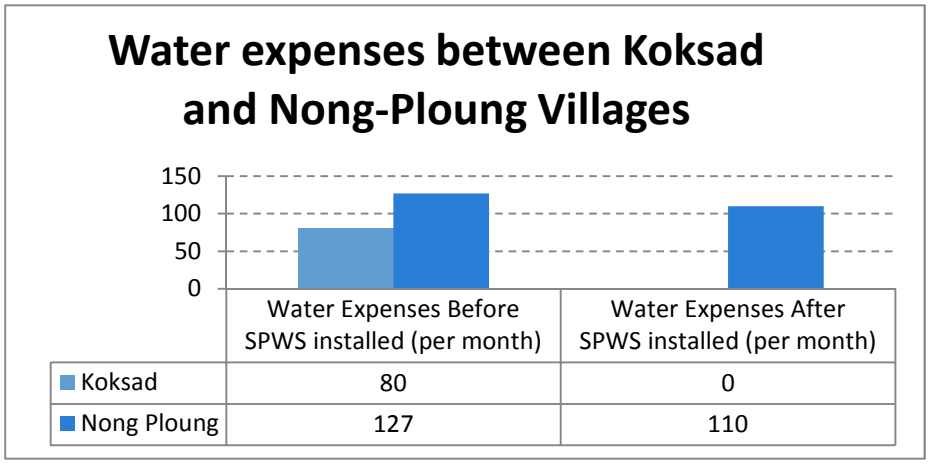

FIGURE 36: WATER EXPENSES BEFORE AND AFTER SPWS INSTALLATION

4.2.1 VILLAGES WITH SPWS

Villages with SPWS tended to have less debt and bigger plans for the future. Based on our surveys we observed that most of the villagers have a positive reaction towards the installation of the SPWS in their communities, as it can be seen in Figure 37.

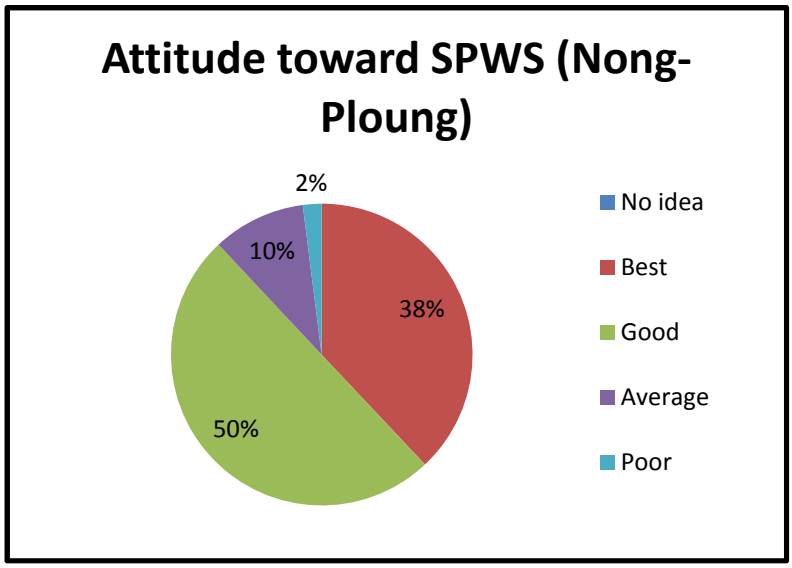

FIGURE 37: PIE CHART OF RESPONSES FROM VILLAGERS SURVEYED IN NONG-PLOUNG VILLAGE

All of the villages wanted to expand the systems in order to utilize them for irrigation and household consumption. At the time of our visit these villages used the SPWS for either irrigation or household consumption but not both. Many villages wanted to expand their systems and some residents were taking action into their own hands. In one case the headman had increased the price of water by 2 baht and was saving the extra money so that the village could invest in a new storage unit for the water pumped with the SPWS. This investment would allow the village to utilize the sunlight more effectively by pumping more water during the day. On the other hand, when asked about their future, members of the villages without SPWS, tended to say that they had no plans. Although some villagers in these communities did have goals to improve their village, there was not active organized community support for these goals.

There has no doubt been success in the villages with SPWSs, but some residents feel there is room for improvement. Kasem Seetatalai of Takut-Klue Plok noted that villagers in his community continue to pump water at night using electricity. Mr. Kasem says that not all the villagers realize that they can save money by pumping the water they will use during the night during the day, when solar power is being used. He attributes this to a lack of understanding among his fellow villagers with regards to their SPWS. In one of the villages that we surveyed, Nong-Ploung, there was a similar feeling from the headman. Survey data shown in Figure 38 indicates that while most villagers saw a similar decrease in both the costs of electricity and

water there were households that experienced changes at both ends of the spectrum. These differences can be attributed to the way in which individual household's takes advantage of the SPWS in their community.

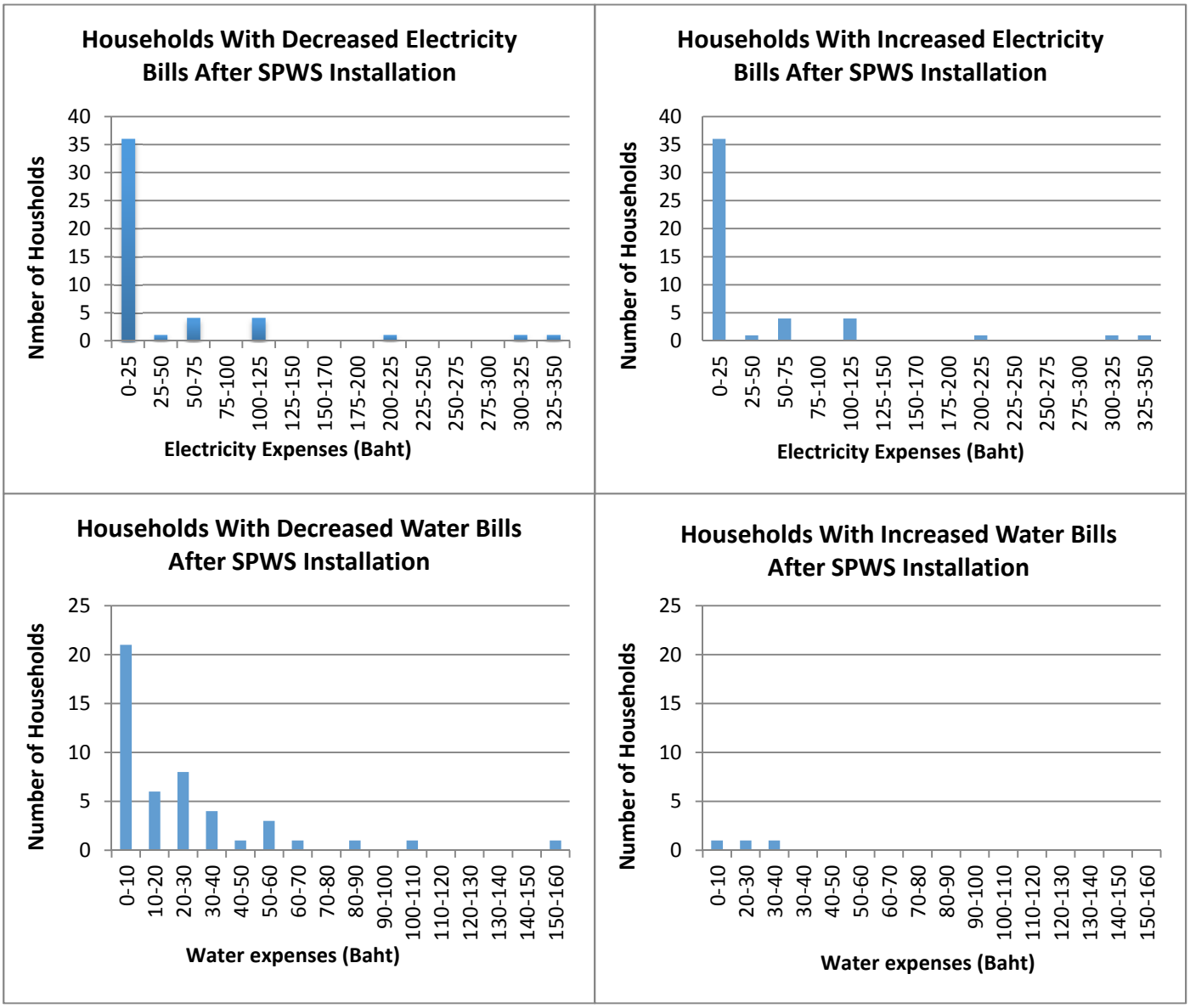

FIGURE 38: NUMBER OF HOUSEHOLDS IN NONG-PLOUNG THAT SAW CHANGES IN THEIR ELECTRICITY AND WATER BILLS AFTER THE INSTALLATION OF A SPWS

4.2.2 VILLAGES WITHOUT SPWS

We visited four villages without SPWS: Limptong, Nong Takem, Saparntom and Koksad. Two of them were prosperous without them, although they wanted systems and the other two were in much more debt and unsure if they wanted to get them. The more prosperous villages, Limptong and Nong Takem, were distinctly different from the other two villages, Saparntom and Koksad. Both Limptong and Nong Takem had corporate sponsorship and an evident appreciation for collective community participation as an answer to solving their problems. Saparntom and Koksad did not have sponsors nor did the community seem to be united towards a common goal. Below the conditions of Saparntom and Koksad are analyzed in order to find the common threads that have kept them from pulling out of debt and fixing the problems they face.

In Saparntom and Koksad, most of the residents we interviewed were aware of the SPWS in other villages. Some had discussions with and instructions from the PDA about how they could go about installing one in their own village but others had not. There are many obstacles hindering these communities from obtaining their own SPWS. Overall fear of debt seemed to be a major cause for hesitation in these villages. Many villagers are already in debt that has caused them to be wary of investing in a SPWS. The headman of Koksad village, Samorn Jongjaiklang, feared investing in SPWS because he was afraid it would get stolen or damaged, thus pushing the village further into debt without benefit. Other villagers were afraid that the maintenance of the system would be too expensive for the villages to afford.

Lack of accurate information seemed to be a major factor contributing to the doubtful attitude towards the benefits of the SPWS in villages that did not have them. In Saparn-Thom the Chairman said about the SPWS, “I have never heard of the SPWS before and I don’t know how it works. I do not know about the advantages and disadvantages of the system, so I can’t decide whether it is good for our community or not.” (Interview #6, January 24, 2012) Meanwhile the headman of the same village had this to say, “The PDA took us to see the system at another village. I haven’t told the villagers about its benefit yet.” (Interview #8, January 24, 2012) This lack of communication between two of the village leaders is representative of how information regarding the SPWS has not passed through Saparntom in a clear, concise manner. Similarly, in Koksad the headman told us: “I know the system is good. I need to show the villagers how much

it will help us." (Interview #1, January 24, 2012) The lack of accurate information about SPWS has made the villagers resistant to investing in one.

4.2.2 RENEWABLE ENERGY POTENTIAL

Throughout our community assessment we were looking at each community's potential for renewable resources. We evaluated each community based on the checklist that is attached in Appendix B. During the assessment we wanted to list each village as candidates for one or more of the following renewable energy sources: Solar, Wind, Hydro, Geothermal, and Biomass. In the following section we will examine the possibilities of each renewable system in the communities we visited.

First, we evaluated the potential for solar energy. We visited 8 villages in total over our first week of field work and half of the villages we visited were already using a solar system to improve their ability to prosper as a community. The other four villages were either already considering using a solar system or were in the preliminary stages of getting one. It is clear that the large, open, flat areas of Nakhon Ratchasima are not only good for growing crops but also for harvesting the sun's energy.

The second type of renewable energy we were considering was wind power. Nakhon Ratchasima is very flat and open so it may be possible for a small wind power system to exist. However, a large installation would not be feasible considering the amount of money that would be required for construction (Windustry, 2011). Smaller systems to charge a battery as an electrical supplement would be feasible to include in a household but still will cost more than the typical farming community could afford.

Thirdly, we examined the possibility of a small hydropower installment. It seems that none of the communities are well situated to use a system involving hydropower. All of the largest bodies of water nearby are still lakes/ponds and the sources of running water are too small to be used for hydropower. The Chakkarat canal is near several of the villages, but its slow flow is inadequate for a hydropower system.

The fourth potential renewable system we assessed was the possibility of a geothermal system. These systems require deep bore holes to be drilled into the surface of the earth. The equipment it would take to do this makes it less feasible than solar but more feasible than either wind or hydropower. Geothermal energy in Thailand is in very early stages of exploration still

and the lack of experience with large scale implementations would suggest that small scale (village level) geothermal installations are not available for use currently.

The last potential renewable energy system we evaluated in the communities was a biomass system since in all of them we found at least one pile of burning plant waste. All of them have some amount of plant waste on any given day that is being disposed of in an inefficient way, and in fact, these farming communities generate waste plant matter that could easily be used to fuel a steam powered generator. The impact that a biomass system could have on these communities may lessen their debt and help them increase their income. The biomass and other bio-energy processes of energy creation have already taken root in one community. The Nong Takem village already has a setup that allows them to use biogas. They currently do not have a way to store the gas for later use, but they are working on saving money for that in the future. It seems that without a way to store the gas the system does not have much of an impact on the village, but once some sort of storage method becomes available, the village can use the biogas for much of their fuel needs.

4.2.4 PDA INVOLVEMENT

As we conducted our community and physical assessment we were able to observe the PDA's involvement in various facets of the life of the villagers. At each of these sites we asked the villagers if the PDA had been a positive influence in their community, particularly through the offering of various training seminars provided by the Village Development Project (VDP). The PDA visits each of these communities about once a month to offer a free lecture on sustainable living and conservation. They also have begun to teach the villages how to cultivate their own cricket farms to increase the income that these communities can generate. These cricket farms are very popular since most of the people in the region see it as a delectable cuisine. All of the villagers we spoke to who knew about the classes or had attended them seemed to think that they were a driving force behind the community's success. One villager, Mr. Paan Koptonglang, stated "…after the PDA came in our lives improved a lot…." (Interview #1, January 27th, 2012). They have provided instruction about different income generating jobs, including possible part time jobs through the seminars and classes.

Various representatives of the PDA visited the villages or brought the villagers to the local center of the PDA to show villagers different agricultural techniques. In the PDA center, in

the Chakkarat district, the PDA representative Mr. Somphop Phuttarusksa is responsible for the Mechai Farm that has an SPWS available for demonstrations and viewing. In this farm they grow cantaloupe and lemon trees that Mr. Somphop Phuttarusksa uses to teach the visiting villagers about current farming techniques that can be brought back to their villages and shared with others. Through the use of the SPWS in the communities, they have been able to increase productivity of the crops since more water is now available. Mr. Phuttarusksa states that the sugar cane production in the area increased from 26 ton per rai with the usage of SPWS compared to 5 ton per rai that were produced before the system installation.

Even the communities that do not have the system installed have also been able to improve their quality of life. Besides growing crops many communities have begun to raise pigs, crickets, chickens, and even grow mushrooms. The waste produced from these animals and crops are then used as fertilizers. The PDA encourages the villagers to pursue economic sustainability in order to use all available resources available not only to generate income but to also be environmental conscientious about their waste. In the Nong Taken village, the waste produced by the pigs or cows is used in production of biogas whose fuel is then distributed to all the homes in the village for cooking. This additional energy is acquired by the community at no additional cost, decreasing expenses. Most of the villages that take advantage of these techniques and information have been able to reduce and in most cases eliminate debt problems.

Furthermore the PDA has successfully attempted to help these communities solve their debt problems, which most have acquired because of loans taken at high interest rates. For many villagers paying off these loans has been difficult and they are forced to work in the urban areas to make ends meet. One of the options that the PDA provides the villages is a village bank in which the money that is acquired is managed by the villagers themselves. This management system has allowed the members of the community to keep track of their expenses and thus reduce some monthly costs they are now aware of. In some cases the villages do not own the land, as in Nong Taken, because they do not have equity to take loans, but the PDA provided these village banks and low interest loans for the communities.

The involvement of the PDA in these communities has allowed the villagers to have different options to improve their quality of life. During the interviews, many of the villagers expressed an interest in learning more about different part-time jobs that the PDA has introduced in their communities since they have observed the positive impact that these have brought to the

village. In the village of Koksad, the village headman Mr. Paan Koptonglang stated, "We really suffered before the PDA came, but after the PDA come, our lifestyle has improved a lot, and they also offer us low interest loan for our personal investment." (Interview #1, January 27th, 2012) The involvement of the PDA staff in giving instructions on various practical topics to villagers, at least twice a month, has not only given support to the community but also provided solutions to both personal financial problems and community wide ecological problems.

4.3 SUMMARY

Overall our findings revealed a lot about the way communities communicate and adapt to the new renewable energy source available to them. The communities with SPWS have been able to reduce their electricity and water expenses, but they lack a collection system that can allow them to record the progress of the system. The success of this system is a result of the community involvement through attending workshops given by the PDA staff and raising money to invest in the system. This success could be experienced by communities without SPWS but without accurate information villagers will continue to discount SPWSs. In order for this alternative energy source to be successful it is necessary that the PDA extend its educational programs to these villages and encourage greater collective engagement in the future of the village.

CHAPTER 5: RECOMMENDATIONS AND CONCLUSIONS

After two separate weeks of fieldwork, analysis, and discussions, we have established a list of recommendations for the PDA. The recommendations cover emergent topics including: security and maintenance, education, water distribution, data collection, and renewable energy sources. Furthermore, we suggest additional actions for villages that require special attention.

5.1 SECURITY AND MAINTENANCE

While conducting our site assessment in multiple villages, we examined the importance of proper security and maintenance for the SPWS. Our findings revealed several vulnerabilities in the security and safety of the units. Koksad Village had exposed wires wrapped around a dripping water tank, and Nong Pluek Village had a construction site located directly next to the solar panels. **We recommend future installations of SPWS be located in a clean, secure, and centralized area.** The SPWS could be fenced or surrounded with barbed wire to keep out unwanted animals, and unwanted individuals from other communities that pose a threat to the system. The SPWS could also be placed in a centralized area in close proximity to the village. This will allow the villagers easy access to the SPWS especially the appointed person on whom the villagers rely to maintain the system. By having the SPWS in a centralized location, it will also ensure that the system is properly secure at all times.

As well as examining the importance of placing the SPWS in a clean, secure and centralized location, we found that many communities with the system had exposed wires beneath the panels. **We recommend that all wires for the SPWS solar panels be well secure and enclosed.** This will protect the solar panels and their maintainers from potential electrical hazards such as rusting due to moisture, and direct human contact. Enclosing these wires can increase the life span of the systems.

5.2 EDUCATION

During our fieldwork we discovered that several of the villages without a SPWS lacked accurate information regarding the cost and benefits of SPWSs. As a result, many villagers felt they could not safely commit to investing in a SPWS. **We recommend that the PDA take additional action to fully inform the residents of SPWS-eligible villages about the costs and**

benefits of a SPWS. There are several ways to make the villagers aware of the benefits of a SPWS; we suggest taking a peer learning approach. The villagers we spoke to with a SPWS had a positive view of the system. They told us about the money it had saved them and how much it improved their lives. By having residents of a SPWS village share their success stories we feel that they could make a good case for investing in a SPWS. We also found that some villagers were unaware of how the system worked. Providing more information on the construction and maintenance of a SPWS to these communities could also increase their interest in the system. Educating communities on the costs, benefits and details of SPWSs could lead to more interest in installation.

In many of the villages that had SPWS there also seemed to be an educational gap. Based on interviews and surveys we saw that not all communities were taking full advantage of their SPWS. **We recommend that the PDA continue educating villagers in communities with SPWSs on how to most effectively use the system.** During our fieldwork we discovered that despite having free access to water during the day some villagers have continued using the water pump in their community during the night. This practice incurs electricity costs that could be avoided by simply collecting all the water needed during the day. By showing the villagers how to take full advantage of their SPWS expenses for water and electricity could go down further.

5.3 WATER AND ENERGY DISTRIBUTION

Many interviewees in villages with SPWSs reported to us that the plumbing system attached to the pump did not reach as many households as they wanted. Because of this, many households in these communities were not able to easily access water that was pumped with the SPWS. **We recommend that that these villages, with the supervision of the PDA, expand their pipe systems to include additional households.** The pipe systems that are currently in place are built with PVC pipes, which is relatively affordable and easy to work with so this sort of extension could be done cheaply and quickly with positive results.

Another problem being posed to communities with the SPWSs was limited storage capacity. Once the storage unit of pumped water is filled, the SPWS has to stop pumping until there is more room in the storage unit. **We recommend that more water storage units be installed in these communities to allow them to fully utilize the system.** By installing additional water storage units more water will be pumped throughout the day. If this is done then

it is less likely that villagers will need to pump water during the night using electricity from the grid.

Similar to the lack of storage capacity is the waste of solar energy that occurs when the pump is not being powered. Many villagers we interviewed recognized that once their storage unit was full, the pump stopped pumping and any electricity generated by the solar panel went to waste. **In response to this, we recommend purchasing batteries for the solar panels to fully utilize the energy that they produce.** Although they can be expensive, batteries would allow the village to store energy that would otherwise be wasted. By installing batteries a SPWS could be used for more than just pumping water therefore increasing the benefits it provides to the community.

5.4 DATA COLLECTION

We recommend that the PDA install water meters in the pumps and electric meters in the solar panels of the SPWSs to obtain data and record the progress of the systems. To effectively understand the positive progress and changes resulting from the SPWSs, a data collection system could be developed. We observed that none of the villages had a system for recording the production of the water pumps and solar panels. The implementation of such a system is highly recommended for the following reasons:

- The data obtained from these meters would allow the villagers to track the effectiveness of the system in their communities.
- Based on the information obtained, the village can develop modifications that would allow them to take advantage of the system to its fullest potential.
- Gathered data can be provided to communities that do not have the SPWS to demonstrate the benefits of the system.

The systems are currently part of a pilot program in which the oldest installation is about a year old. It would be beneficial to record as much information as possible to create comparisons between the usage of the old electricity powered water pumps and the newly installed SPWSs. Along with the data, the villagers can also view the reduction of their expenses based on their current use of water and energy for their household and irrigation purposes. By

installing meters on the SPWSs, communities and the PDA will be able to document the overall progress of the system.

Recordkeeping can also enable the village to develop modifications that would allow them to take advantage of the system to its fullest potential. Most of the villagers that were interviewed expressed an interest in future plans with the new system such as obtaining more water storage tanks. These data can easily be obtained by the technician or person in charge of the system, and recorded in a bookkeeping system. The record-keeper will just need to write down the numbers obtained from the meters at the beginning of the day and at the end of the day when they check that the system has properly shut down. The data obtained from the collection system can be used as a reference by the villagers when discussing the progress and efficiency of this new renewable energy source in the community.

The positive feedback seen by the SPWS communities can be spread to neighboring communities. The feasibility of these systems in any of the surrounding communities in the Chakkarat district arises from the ready availability of a water source close by and adequate sunlight exposure. However, the main obstacle for many non-SPWS communities is the high cost of the system and their low income. Because of this many of the residents of these villages are hesitant to invest in a SPWS. Data collected from other villages that have SPWSs could provide the evidence that these villages need to also realize the benefits of a SPWS.

5.5 RENEWABLE ENERGY SOURCES

One of the main goals of our project was to analyze the feasibility of alternative energy sources in rural communities. Throughout our fieldwork we were able to identify villages that have high potential for alternative energy sources other than solar power. **We recommend that the PDA consider biomass as an additional alternative energy source because of the abundance of agricultural waste in the region.** In the Chakkarat district, all the communities we visited had agricultural and animal waste available to them. During the interviews that we conducted many villagers expressed great interest in exploring other alternative energy solutions. With this enthusiasm in mind, we believe that given the proper resources these villagers would be open to implementing biomass in their communities. Through the use of biomass these communities would be able to reduce their expenses by using already available waste instead of having to pay for grid electricity and/or fossil fuels.

5.6 KOKSAD KILLAGE

During our fieldwork we were able to observe and assess the conditions of each individual community that we visited. Although each village had its own unique set of challenges and solutions, **we recommend that the PDA conduct further investigation into the water and debt related issues in the village of Koksad.** Based on interviews with village leaders we discovered that Koksad no longer has access to a nearby surface water source and must rely on rain water and an underground source for consumption and agriculture. The underground source is highly acidic and has caused an array of problems for the village. By providing the villagers a way to cheaply access clean water many of their problems could be eased or resolved.

5.7 CONCLUSION

Throughout our research we have worked to understand the underlying social issues that pertain to energy technology in rural Thailand and more specifically to achieve an understanding of the way of life in rural Nakhon Ratchasima. During our time there we learned about how the residents lived and the problems they faced, such as severe debt, water shortages, high water costs and drought. By taking time to understand these issues, through interviews and surveys of the population, we have learned a great deal about how energy technology affects every facet of rural life, from harvesting crops to having clean water for villagers to drink. This information guided the path of our study and the recommendations we make above.

As climate change becomes an important issue in global politics and as the price of energy continues to rise, it is paramount to understand the importance of alternative energy. By installing SPWSs, these villages in rural Thailand have taken steps to a better tomorrow that most of the world has yet to take. In their efforts to educate rural villagers on the usage of alternative energy, the PDA has helped prepare these communities for the future. We hope that our research will be used to help expand the important work of the PDA and the continued implementation of renewable energy in Thai communities.

Our research reveals how successful the SPWSs have been in the communities that have them. In the future, similar social research projects should be done to examine the impact that renewable energy has on these communities over time, as aggregated data will more clearly

reveal long-term trends. The PDA has efficaciously empowered these communities by encouraging them to act collectively against their problems. The PDA has empowered us - both Thais and Americans - to experience an unfamiliar way of life. One striking difference between village life and what the members of our team have experienced is the daily struggle for water. In our own lives water has been something pumping itself out of a faucet or bought inexpensively from a store without much thought. In these communities though, it is different, both because of the water needs of their agricultural economy and because of their low level of income. Water is not just for consumption but it is a necessity to generate the limited income that these villagers can obtain. Seeing these differences gave us insights not available to the middle class American or Thais and boosted our understanding of the diversity of human experiences.

The diversity of our team also had a tremendous impact on how we functioned. Our team consisted of seven students, four American and three Thai whose academic interests span five majors: civil engineering, applied chemistry, electrical engineering, chemical engineering and computer science. Within the respective cultural groups of our team, both coasts of the United States were represented along with both the northern and central areas of Thailand. By accessing our collective knowledge and by a willingness to work collaboratively together, we were equipped to respond to any problems we encountered. Through the course of our project we saw first-hand the social forces that influence the future of rural communities. It is our sincere hope that this document can be used to further the mission of the PDA and the goals of the villagers they represent.

BIBLIOGRAPHY

Analysis of Alternative Energy Potential. (2007). Retrieved December 11, 2011, from Thai Energy Data: http://www.thaienergydata.in.th/energynew/energyReview/epotential/rotation_potential.php?prv_id=30&year=2551

Anonymous. (2005). Energy for Rural Communities. *Appropriate Technology, 32*(4), 58.

Berg, B. L. (2004). *Qualitative Research Methods for the Social Sciences*. Boston: Pearson.

Community Development - Data Information and Analysis Laboratory. (2001). *Preparing For A Collaborative Community Assessment* No. 334. Iowa

Doyle, J. K. (2006). *Chapter 11: Introduction to Survey Methodology and Design.* Retrieved November 19, 2006, from http://www.wpi.edu/academics/GPP/Students/ch11.html

Empowering Thailand's Rural Communities to Eradicate Poverty, (2011, August). Retrieved December 9, 2011, from The Population and Community Development Association: http://www.pda.or.th/eng/

Energy Usage in Nakhon Ratchasima. (2010). Ministry of Energy. Retrieved from http://www.thaienergydata.in.th/energynew/energyReview/energy/energyuse_prv.php?prv_id=30&year=2551&subtab=21&tab=2&main=use

Environmental Impact by Energy Source. (2011). Retrieved December 10, 2011, from Energy4Me: http://www.energy4me.org/energy-facts/environmental-protection/environmental-impact-by-source/

EREC. (2002, February). *Consumer Energy Information: EREC Reference Briefs*. Retrieved December 12, 2011, from The US Department of Energy: http://www.p2pays.org/ref/24/23989.htm

Eua-Arporn, B., & Ubonwat, J. (2006). Provincial Energy Strategy Planning: Case study in Nakorn Ratchasima. *Energy for Sustainable Development* .

Flawed Energy Policy Designed to Garner Votes. (2011). *Nation (Bangkok, Thailand)*

Global Energy Network Institute. (2001). Retrieved from http://www.geni.org/globalenergy/library/national_energy_grid/thailand/thainationalelectricitygrid.shtml

Hans, G. (2005). *The Impact of Internationalization Processes on the Region of Isan- the Examples of International Migration and Transnational Tourism.* Retrieved from:

https://docs.google.com/viewer?a=v&q=cache:rWCCnQgMpDcJ:www2.geog.uni-heidelberg.de/media/personen/gebhardt/isan.pdf+difficult+natural+conditions+have+forced+people+to+combine+different+jobs,+for+example+temporary+employment+in+Bangkok+or+outside+the+coun

Heckeroth, S. (2010, March). *The Promise of Thin-film Solar*. Retrieved December 10, 2011, from Mother Earth News: http://www.motherearthnews.com/Renewable-Energy/Thin-Film-Solar-Utility-Scale-PV-Power.aspx

IDA-Tech Solar Powered Pumping Systems, http://www.ida-tech.com/Solarpump.html

Inside Thailand -- Nakhon Ratchasima Province: A Prototype for Integrated Food, Energy, And Industrial Production. (n.d.). The Government Public Relations Department of Thailand. Retrieved November 28, 2011, from thailand.prd.go.th/view_inside.php?id=5278

Klunne, W. J., & Michael, E. G. (2010). Increasing sustainability of rural community electricity schemes—case study of small hydropower in Tanzania. *International Journal of Low-Carbon Technologies, 5*(3), 144.

Kosa, P., Kulworawanichpong, T., Srivoramas, R., Chinkulkijniwat, A., Horpibulsuk, S., & Teaumroong, N. (2010). The potential micro-hydropower projects in Nakhon Ratchasima province, Thailand.

Kosit, B. (2011). *New PM in Thailand Outlines Energy Policy* The McGraw-Hill Companies, Inc.

Lack of Natural Resources to be Alleviated by New Technology. (2007, May 5). Retrieved December 10, 2011, from Brilliant Fixer: http://brilliantfixer.wordpress.com/2007/05/05/lack-of-natural-resources-to-be-alleviated-by-new-technology/

Mukhopadhyay, K. (2004). An assessment of a biomass gasification based power plant in the sunderbans. *Biomass and Bioenergy, 27*(3), 253-264.

Mulikelela, M. (2010, *Rural Electrification Facing Challenges.* Times of Zambia.

Nakhon Ratchasima. (2011). Encyclopædia Britannica. Retrieved from: http://www.britannica.com/EBchecked/topic/402099/Nakhon-Ratchasima

Olson, S. (2010, June 2). *Plextronics Announces Developments in Organic Photovoltaics*. Retrieved December 10, 2011, from PV-Tech: http://www.pv-tech.org/news/plextronics_announces_developments_in_organic_photovoltaics

Osborne, M. (2010, November 29). *NREL Validates Konarka's 8.3% 'Power Plastic' Efficiency Record*. Retrieved December 10, 2011, from PV-Tech: http://www.pv-tech.org/news/nrel_validates_konarkas_8.3_power_plastic_efficiency_record

Palmer, Robert Nursey-Bray, Melissa. (2007). Alternative Energy. Encyclopedia of Environment and Society. Retrieved November 29, 2011, from:http://sage-ereference.com/view/environment/n20.xml

Phuangpornpitak, N., & Kumar, S. (2006). PV hybrid systems for rural electrification in Thailand. *Renewable & Sustainable Energy Reviews, 11*(7), 1530-1543. doi:10.1016/j.rser.2005.11.008

Poonsombudlert, R., Talmage, E. T. H., & Chandler, A. (1996). Thailand. *International Financial Law Review,* (02626969), 53-53. Retrieved from http://au4sb9ax7m.search.serialssolutions.com/?SS_Source=3&genre=article&sid=ProQ:&atitle=Thailand&title=International+Financial+Law+Review&issn=0262-6969&date=1996-0401&volume=1&issue=&spage=53&SS_docid=233209321&author=Poonsombudlert%252C+Ratana%253BTalmage%252C+E+T+Hunt+III%253BChandler%252C+A+T

Preparing for a Collaborative Community Assessment. (2001). (1). Ames: Iowa State University. Retrieved from http://www.extension.iastate.edu/publications/CRD334.pdf

Reliable Electric Power for Developing Countries. (n.d.). Retrieved February 6, 2012, from Humanitarian Technology Challenge: http://www.ieeehtc.org/files/Reliable_Electricity_Challenge_Description.pdf

Salant, & Dillman. (1994). *How to Conduct your own Survey.* New York: Wiley.

Sawangphol, N., & Pharino, C. (2011). Status and Outlook for Thailand's Low Carbon Electricity Development. *Renewable and Sustainable Energy Reviews, 15*(1), 564-573. doi:10.1016/j.rser.2010.07.073

Srisovanna, P. (2004). Thailand's Biomass Energy. Retrieved from: http://www.cogen3.net/doc/countryinfo/thailand/ThailandBiomassEnergy_report.pdf

Sriuthaisiriwong, Y., & Kumar, S. (2001). Rural Electrification Using Photovoltaic Battery Charging Stations: A Performance Study in Northern Thailand. *Progress in Photovoltaics: Research and Applications, 9*(3), 223-234.

System Planning Division. (2010). *Summary of Thailand Power Development Plan 2010-2030*

Thailand Energy Issues. (2011). Retrieved 11/14, 2011, from http://www.geni.org/globalenergy/library/energy-issues/thailand/index.shtml

No. 912000-5305). Thailand: Electricity Generating Authority of Thailand.

Thailand Raises Subsidies. (international)(Energy Policy and Planning Office)(2011). Energy Intelligence Group.

Thailand power development plan. (2009). Electricity Generating Authority of Thailand.

Thailand Raises Subsidies. (international)(Energy Policy and Planning Office)(2011). Energy Intelligence Group.

The Photovoltaic Effect. (2011). Retrieved December 10, 2011, from Sandia National Laboratories: http://photovoltaics.sandia.gov/docs/PVFEffIntroduction.htm

The Population and Community Development Association (PDA). (2011). Retrieved 11/12, 2011, from http://www.pda.or.th/eng/

UN-HABITAT, & United Nations Centre for Human Settlements. (2001). *Cities in a Globalizing World: Global Report on Human Settlements.* Sterling, VA: Earthscan.

World Bank Data Indicator. (2011). Retrieved 11-13, 2011, from http://data.worldbank.org/indicator

Yokoyama, S.-y., Ogi, T., & Nalampoon, A. (2000). *Biomass Energy Potential in Thailand.* Retrieved from: http://www.thaiscience.info/Article%20for%20ThaiScience/Article/3/Ts-3%20biomass%20energy%20potential%20in%20thailand.pdf

World Energy Outlook.(2004). Retrieved February 6, 2012, from Energy and Development: http://www.worldenergyoutlook.org/database_electricity/WEO2004-Chaper%2010.pdf

Yokoyama, S.-y., Ogi, T., & Nalampoon, A. (2000). *Biomass Energy Potential in Thailand.* Retrieved from: http://www.thaiscience.info/Article%20for%20ThaiScience/Article/3/Ts-3%20biomass%20energy%20potential%20in%20thailand.pdf

APPENDIX A: ALTERNATIVE ENERGY SITE REQUIREMENTS CHECKLIST

Solar Energy	• Must be built in an area with high exposure to natural light.
Wind Power	• Must be built in an area with heavy wind, potential sites include mountain passes, coastlines and offshore. • Potential Problems: limited sites, seen as eyesore by some residents, noise pollution.
Hydropower	• For hydropower it is necessary to build a dam on a river that is large enough to support it. • Potential Problems: does significant damage to the environment including killing local fish populations and degrading the landscape.
Geothermal	• For geothermal energy a borehole must be drilled to rocks that are at least 200 degrees Celsius.
Biomass Energy	• Uses animal and human waste to generate energy. • Potential Problems: Although biomass reduces the amount of waste in landfills, methane and carbon dioxide are still released into the air as a result.

APPENDIX B: SITE ASSESSMENT CHECKLIST

Direct Observations	Villagers/ Social Perceptions
Type of street lightning (Traffic lights, Lamppost)	**Daily Activities of the villagers** - labor (Agricultural techniques) - Children (school, transportation) - Transportation - Businesses - Household usage of electricity
Pictures of System, Water Meters, Electricity Meters	**Schools , Government, Business Facilities** - Their usage of electricity - Do they use the alternative energy source?
System -Location of the system (Centralized/ Secure Area?) - Pollutant Emission - Noise - Risk Reduction (Children at risk near the system?) - Maintenance program (Technical, Who is responsible?)	**Overall electricity usage in the community** - Is electricity turned off at a certain time? - Any energy conservation techniques - Training programs for the villagers
Area surrounding the system - Topography - Type of water source (Groundwater/ Surface)	**Chain of command** - Leaders in the community - Relationship between the PDA and local gov. - Relationship between the PDA and villagers
Geography of site - Landscape (Slopes, Flat, Hills) - Agriculture (crops, irrigation systems) - Distance from each site to the next and approximate to the villages - How many businesses in the site (Additional generators for backup?)	
Energy supplies - Possible alternative energy sources - Network distribution system for the households	
Houses - pictures of the outside of homes and if possible	

APPENDIX C: VILLAGER INTERVIEW QUESTIONS

Name:

Family member:

How many family members have worked outside the village? Have they come back or not?

Occupation

- What is your occupation?
- Do you do any non-farming jobs that supplement your income?
- Is your current income adequate to support your life style?
- What are your expenses per month?
- Do you have any other investments aside from farming?
- Do you sell what you produce?

Water

- How do you obtain water?
- Do you have your own water storage?
- What is your water bill per month/season?
- What is your water bill per month/season?
- What do you use water for?

Electricity

- What was your electricity bill before and after the SPWS was installed?

Solar Powered Water Systems

- How much do you know about the SPWS in your community?
- Do you know when the system was installed?
- What were your water expenses before and after the system was installed?
- Do you think the system is working well?
- Have you ever experienced a water shortage?
- How is the water quality? Is it consumable?
- How did the quality of the water affect your crops, animal and health?
- Is there any pollution caused by this system? (Noise pollution, air pollution, or water pollution.)
- How do you get water from the system

- Do you have recommendations or any suggestions about this system?

Education

- Is there any form of education about the system? Do you think it is practical?
- Do you understand its concept?

Concerns

- What is the biggest problem that you have encountered right now?
- What is the biggest problem that you think the village is facing now?

Future Trend

- Do you have any further plan for your life? (More investment?)

APPENDIX D: PDA STAFF INTERVIEW QUESTIONS

Name:

Position in the PDA:

Work experience:

Did you play any role in this system installation?

Water

- Where does the water come from?
- What is the cost of water irrigation? (Installing, maintenances, materials)

Solar Powered Water Systems

- Why did you use this system?
- How does the system work? (Mechanism)
- How many systems have been installed in the recent year?
- How much have you invested on this system?
- Who is paying for these systems? Or outsource income?
- Which company is responsible for installing the system?
- How do you transport the water to communities?
- What process are you using to purify the water? (Filtration, pH adjusting?)
- What is the life span of solar cell that the SPWS use?
- How do you check the water quality?
- How do you measure the electricity that is generated by this system?
- Is there any maintenance and how often?
- Were there any problems with the installation of the system?
- Are there any problems with villagers concerning this system?

Education

- Is there a training course for villagers about this system and energy conservation? Are the villagers cooperating?

Additional

- Are you concerned about CO_2 reduction? How have you tried to reduce it? And did it work?

Future Trend

- Are there any further plans for this village?
- Are there any plans for other alternative energy sites?
- Are there any other problems that have had an impact on the village? (e.g. electricity)

APPENDIX E: INTERVIEW SUMMARIES

January 23, 2012: Nong-Pluek Village

General information about Nong-Pluek Village

- Location: Moo 9 Chakkarat Sub-District, Chakkarat District, Nakhon Ratchasima Province.
- Area: 3,325 rai.
- 117 households and 398 villagers.

1) Mr. Samitr Junya, Employee and Assistant Villager Headman

Personal Background:

- His family consists of 6 members and he lives with his grandson and granddaughter, their parents work as employees in Bangkok Province.
- He has an income of 10,000 baht per month.

Information about Nong-Pluek village:

- The water in Nong-Pluek Village has been supported by the government and managed by the sub district government.
- This village utilizes underground water.
- Water usage is about 4,000 m^3 per month.
- Water is mainly used for household and agricultural activities such as washing, drinking, planting vegetables and agricultural products.
- After comparing the monthly electricity expenses before and after installing the SPWS, it was evident that the villagers pay slightly less after installing the SPWS.
- For example, Mr. Samitr Junya's family, paid 2,700-3,000 baht per month for electricity before the SPWS was installed. After the SPWS installation, they have been paying 2,000-3,000 baht.
- Mr. Samitr Junya and his family can now save about 2,000 baht per month, so he supports the SPWS.
- The cost of water has reduced from 5 baht/m^3 to 2 baht/m^3, aiding the villagers to save money for other expenses.

- The SPWS operates for about 10 hours per day from 7am to 5pm; afterwards the villagers use electricity to pump the underground water.
- The SPWS requires about 2 hours during the day to fill the tank.
- PVC pipes are utilized to distribute water from the central tank in the village to each household.
- The total distance of the pipes is about 8 km.
- Based on Mr. Samitr Junya's attitude towards the SPWS, he believes that this system is working well and it provides more water to the villagers than before system installment. He also mentioned that he now has less electricity expenses, so he agrees that the SPWS is suitable for his village so the residents can save money for other personal expenses.
- The village has local rules for the maintenance of the SPWS. If anyone breaks the solar panel, he or she will be responsible for funding the cost of repairmen. Also, the water pump is insured for 20 years and the company who installed the pump will fix it if there are any.
- Currently there have not been any problems or accidents in this village.
- Sometimes the village has trouble providing water to all the households at night because the water tank has a low volume of water making it difficult to distribute the water with low pressure.
- The water supplies adequate quality and it is clean enough for drinking and household purposes. Moreover, the water is used for irrigation without any harmful effects.
- The drip irrigation system has been used for sugarcane and this system has increased productivity from 13 ton/rai to 26 ton/rai (1 rai= 1,600 m^2)
- There have been no complaints of noise pollution or any other sorts of pollution from the SPWS.
- The PDA constantly provides educational approaches to inform the villagers about the SPWS and how to use the system. The villagers are also trained about energy conservation. Moreover, the PDA informs the villagers about irrigation techniques such as growing cantaloupe and out-season limes for earning their incomes.
- Based on Mr. Samitr Junya's idea for the future expansion, the village should acquire more water tanks to allow the villagers to group cantaloupe by using the drip irrigation. Since the water available now in the tank will not support this system.

- The assistant villager headman of Nong-Pluek Village plants to place more water tanks in the village this coming year. Moreover, he plans to move the solar panels away from the house under construction in order to reduce the potential of an accident occurring to the solar panels.

2) Mrs. Supin Sanuwong, Villager

Personal Background:

- His main occupation consists of making shoes and swine raisers (raising pig).
- Mrs. Supin Sanuwong's family consists of 3 members. She stays with her husband and they have one son. Her husband is currently working on a farm in Israel.
- She did not give us any information in accurate amount of her monthly income but she said that it is not enough to support her family.

Information about Nong-Pluek village:

- The villagers store the water in various for household use, but the most popular and easiest form is by using a jar. Mrs Supin Sanuwong and her family also store the water from the tank in this jar.
- The water expense per month for this village is approximately 24 baht per month. (Information from water bills)
- Water is used mainly for household and agricultural sectors such as growing cantaloupe. Moreover, the water is used for other supplementary occupations such as raising pigs.
- Based on Mrs Supin Sanuwong's attitude towards SPWS, she thinks that the system is very good because Nong-Pluek Village has not been faced with the situation of water shortage like other villages in the Chakkarat District.
- The water quality of this village is adequate enough for consumption and agricultural products without any harmful effects. However, every household uses a filter system before drinking it. On the opposite way, the water that used for the washing activities in household can be used directly without any treatment. Moreover, the water does not have any effects on agricultural products such as vegetables and crops.
- This water pumping system does not give any pollution to the village and it works very quietly.

- The water was distributed from the central tank of the village into each household by utilizing the water pipe system.
- For the educational side, the PDA provides staff members whom inform the villagers about the SPWS. Moreover, PDA always provides some field trips for the villagers about supplementary jobs such as growing vegetables and fruits. Most of the villagers can apply the knowledge that they obtain from the PDA staffs and fieldtrip to conduct their occupation and survive in the village.
- Based on Mrs Supin Sanuwong's idea about the future expansion, she suggests that amount of water is enough to support the whole village currently but fears it will not be enough in the future. This idea was be supported by the reason that the villagers interested in growing cantaloupe by using drip irrigation system currently cant due to the amount of water required. Moreover, she thinks that this village should improve in the infrastructure such as the public road because it can be inconvenient for visitors.

Nong-Ploung District

General information about Nong-Ploung District

- Location: Moo 2 Nong-Ploung Sub-District, Chakkarat District, Nakhon Ratchasima Province.
- Area: 23,125 rai.
- 170 households and 646 villagers.
- There are 6 villages in this district.

3) Mr. Samart, TAO Representative

Personal Background:

- The main occupations of Mr. Samart is farming, growing rice, cassava, and sugarcane. After the products are cultivated, he sells the crops to the middleman in the market.
- His family consists of 6 members, wife and children. Some of his sons and daughters work at the village. One of his son's is an employee in Bangkok Province.
- He has an income of about 10,000 baht per month.

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Information about Nong-Pluek village:

- The government supports the water in Nong-Ploung District and the villagers obtain water from the Chakkarat canal for both household and agricultural sectors.
- This district did not provide information about monthly water expenses.
- The villagers must first clean the water by chemical additives, aluminum and chlorine. This method costs around 9,000-10,000 baht per month.
- The SPWS has been installed in Nong-Ploung District for 2 months and currently is in the evaluation period.
- By comparing the monthly electricity expenses, from before and after installing the SPWS, it is evident the villagers pay less since the SPWS was installed.
- Before installing the SPWS the monthly electricity expenses were about 14,000-15,000 baht and after installation, the monthly electricity expenses have reduced to about 13,000 baht. Moreover, due to the data collected, the electricity bill will continue to decrease marginally.
- Nong-Ploung District does not keep any records about the amount of electricity used in the SPWS.
- The water meter is currently broken, so the head villagers are required to measure the amount of water used in this district by observing the water meter from each household and summing the value.
- The SPWS system requires about 2 hours to fill the water tank completely while, but the villagers are still allowed to use the water at this time. Although, the SPWS requires about one hour to fill the water tank completely if it is not in use at that time. This tank is used as the local water distributor for the entire district.
- The volume of the tank is 100 m^3.
- The water is used mainly for household and agricultural sectors such as drinking, washing, and planting the agricultural products such as vegetables.
- The amount of water used per household is approximately 7,000 m^3 per month.
- Based on Mr. Samart's attitude towards the SPWS, he believes that this system is efficient and would like to thank the PDA for all their help and support.

- From past information, water provided from the SPWS does not cause any effect to the crops and vegetables in this district.
- In the past, villagers of the Nong-Ploung District could not obtain enough water for their daily use because of constant water shortages. This was an occuring problem because the water pump being used was broken. Mr. Samart would need to prepare a second water pump in case the first one fails.
- However, since the SPWS installation, there have not been any recorded water shortage problems and the villagers now receive an adequate water supply.
- The system does not cause any form of pollution.
- Local water pipes are used to distribute the water from the main district to each individual household. The water pipeline is around 6 km in length.
- For the educational side, the PDA staff did not provide any knowledge for Nong-Ploung District about the way to maintenance SPWS. However, the PDA informs the villagers how to operate the system since it has only been installed for two months. However, in the future, the PDA promises to provide more information to the villagers about system maintenance.
- Currently this district is facing the problem of providing an adequate water supply to all households because the main pipe line does not reach. The remote households are required to use rainwater, which is not as good of a quality.
- Based on Mr.Samart's idea on the future expansion, the agricultural sector in this village will be better, if it is raining all the year. He thinks that the way to reduce the cost of electricity and water is by expanding the solar panels and water tanks for this district. Moreover, the diameter of main water pipe should be increased from 3 inches (at this present time). By increasing the diameter of the water pipe line, the remote households will receive the water supply.

January 24, 2012: Takut-Klue Plok Village

General information about Takut-Klue Plok Village

- Location: Moo 3 Chakkarat Sub-District, Chakkarat District, Nakhon Ratchasima Province.
- Area: 20 rai.

- 288 households and 1,058 villagers.

1) Mr. Somboon Poonsri, Villager Headman

Personal Background:

- He grows rice, cassava, and sugar cane.
- His family consists of 4 members, his wife and three children. One of his sons is employed as a caddy in the golf field of Bangkok Province.
- He has an annual income of about 200,000 baht.
- His income is enough to support his family.
- Most of his income is invested on fertilizer.

Information about Takut-Klue Plok Village:

- The villagers' main source of water is the Chakkarat Canal.
- Water is mainly used for household and agricultural sectors such as washing dishes, planting vegetables, and raising pigs.
- Water is stored in a jar for household use.
- The amount of water used per household is about12 m^3 per month.
- The SPWS has only been installed for 2 weeks.
- Due to the recent installation of the SPWS, there is no data available on the electricity bill cost changes.
- Mr. Somboon Poonsri heard about this system from Nong-Pluek Village, close to his village. He stated that the villagers in Nong-Pluek Village recommended the SPWS because it is a well working system, which can reduce the expenses for water and electricity.
- However, the SPWS poses a problem in the Takut-Klue Plok Village because it is a very large village with low sunlight intensity, affecting the operation of the system. The energy generated from this system is not enough to pump water and distribute to all households in the village.
- The water quality is good and it can be consumed and used for agricultural products without any harmful effects.
- The villagers treat the water before use with chemical additives, aluminum and chloride.
- The village has yet to have any water shortage problems.

- Based on Mr.Somboon Poonsri's attitude towards the SPWS, he suggests that this system is working well and easy to use.
- The SPWS does not create any form of pollution.
- Water is distributed to individual households by using water pipes connected to the central tank via gravitational force. The pipeline is about 8 km length with a diameter of about 2-3 inches.
- For the educational side, the PDA staff informs the villagers about the system maintenance such that it automatically shuts down during the night (5pm-7am). Moreover, they train the villagers about the supplementary occupations such as growing vegetables and fruits or caring for the cricket farms.
- Based on Mr.Somboon Poonsri's idea on the future expansion that he recommendeds to limit the SPWS usage for household and agriculture sectors only because of thehigh cost for water treatment.
- In the future, Mr.Somboon and his family plan to enhance the agricultural products by growing vegetables, mango and jackfruit trees. For the community, he thinks it should have a gate on the village's canal to store the water in case of a water shortage.

2) Mr. Somchai Lumtakor, TAO Representative

Personal Background:

- He is a farms rice and cassava, and he is a construction worker.
- His family consists of 7 members.
- His monthly income is enough to support his family.
- Most of the income is used for paying the installment on his car.

Information about Takut-Klue Plok Village:

- The villagers store rainwater in a large jar for household activity including drinking and washing. The tap water is used for the domestic purposes.
- Water is mainly used for household and agricultural sectors including growing rice and cassava.
- The monthly water expenses are about 200 baht
- The monthly electricity expenses are about 500 baht.

- Before and after installing the SPWS in this village, the water quality is adequate for consumption; the water quality does not cause any harmful effects to the health of the villagers or the crops.
- The villagers heard about this system from the Nong-Pluek Village.
- This system does not cause pollution to the environment.
- For educational aspect, the PDA has not provided staff to inform the villagers about the system, and the villagers have not gained any knowledge about the system.
- The main problem in this village is lack of farming area, so most of the villagers work as employees instead of farmers.
- Based on Mr.Somchai Lumtakor's ideas for future expansion, he wants to increase the current water supply.

3) Mr. Sariwong, the Chairman of this village.

Personal Background:

- He farms rice and cassava and sells his products to the market with help from the middleman.
- His family consists of 3 members and his daughter works as an employee in the city.
- He did not provide any information about his income, but he stated that his monthly income is enough to support his family.

Information about Takut-Klue Plok Village:

- Water is mainly used for household purposes, but the villagers obtain rainwater for consumption.
- The monthly water expenses are about 150 baht.
- Most of villagers did not hear about the SPWS before installation the village.
- On the educational side, the PDA staffs have not provided any information about this system to the villagers.
- There have not been any reported problems with this system.
- Based on Mr.Sariwong's attitudes towards the system, he believes this system is efficient and has many benefits like saving on the costs of water and electricity.
- In the future, Mr. Sariwong plans to grow vegetables in the garden of his house.

4) Mr. Sittiphop Pasi, SPWS Responsible person.

Personal Background:

- Farmer and employee for the PDA. He grows sugarcane, rice, and cassava and sells his products to the food processing plant.
- His family consists of 3 members and he lives with his parents.
- He receives a monthly income of about 7,000-8,000 baht.

Information about Takut-Klue Plok Village:

- Water is used mainly for household and agricultural purposes.
- Rainwater is stored in a large jar for drinking and tap water is used for all other household activities.
- The villagers clean water the water before using it by adding chemicals such as aluminum and chlorine.
- The monthly water consumption is about 10 m^3.
- The monthly water expense for each household is less than 100 baht.
- The monthly electricity expense for each household is about 200 baht.
- This village did not measure or record any information about water or electricity after the SPWS was installed.
- For the educational side, the PDA staff has not provided any information to the villagers about the SPWS or trained them about the usage and maintenance of the system.
- Based on Mr. Sittiphob Pasi's attitude towards SPWS system, he believe the system is efficient because the villagers utilize less electricity to pump water, saving them money.
- Sometimes the system does not automatically shut down at night, therefore someone from the village needs to check the system and ensure that it has been turned off.
- Based on Mr.Sittphop Pasi's ideas for future expansion, he recommends this village to obtain another SPWS agricultural use only. In the future, He plans for growing vegetables for selling to the market. The public road of this village also needs to be fixed to improve transportation.

5) Mr. Kasem Seetatalai, Villager and a role model for renewable lifestyle.

Personal Background:

- Retired but grows crops to generate extra income.
- Family consists of self and wife.
- Income around 20,000 baht per month.

Information about Takut-Klue Plok Village:

- The villagers store the rainwater for drinking only and use tap water for domestic purposes.
- Most of villagers have ways of conserving water for future use. For example, Mr. Kasem and his family recycle the water that is used for washing household equipment by using it to water trees around his house. He says that this is an easy way for everyone to save water for next generation.
- Mr. Kasem estimates that the water cost per month for each household in this village is around 200 Baht. During the summer season, the water expense is as high as 400 Baht per month due to the villagers using more water for agriculture.
- The electricity expense for each household is approximately 100 baht per month.
- The water in this village is distributed from the main storage site to each household using gravitational force.
- There have been no problems with the SPWS since it has been installed.
- This water system is very quiet and does not pollute the village.
- Water in the village is treated chemically by using chlorine or aluminum. When using chlorine the water needs to be left in the sun long enough for the chlorine to be evaporated. Chlorine treatment has worked well causing no problems. On the other hand, aluminum treatment has made the water harder, which damages the crops it is used on. As a result the village now avoids using chlorine as a cleaning agent.
- Mr. Kasem reports that in general the villagers are all enthusiastic about the SPWS. Before the system was installed the headman gathered the entire village to provide information on the SPWS and get feedback from the rest of the village. Mr. Kasem feels that the system is valuable. In order to prove this to others he has suggested that the

headman collect data to compare water bills from past years to this year. He says the difference will be noticeable.

- Mr.Kasem suggests that the villager should cooperate to use the water at daytime more than night period because they can use SPWS that can help to save the money for electricity bills. Moreover, everyone in the village should have the knowledge and understand about this system before using it.
- Mr. Kasem suggests that the villagers should try to pump water as little as possible at night to avoid using electricity instead of SPWS to pump the water. In order to do this he says that all the villagers need to understand how the system works and why they should only use it in the day.
- Mr. Kasem says that the main problem in the village is that there is not enough cooperation and everyone has their own goals. He reports that the Thai culture is still alive in the village and people are willing to help others even when they gain nothing from it. He believes that is everyone works together to solve the village's problems then the village will be a great place to live.
- In the future, if the government supports the village, they will construct a new public road and build a learning center for children.
- PDA staff taught the village headman and village chainman about SPWS but not the rest of the community.
- Mr. Kasem thinks that the SPWS is a very good system but it will be better if in the future, the system is enhanced for agriculture.

Saparn-Thom Village

General information about Saparn-Thom Village

- Location: Moo 12 Chakkarat Sub-District, Chakkarat District, Nakhon Ratchasima Province.
- Area: 20 rai.
- This village consists of 74 households with 300 villagers.

6) Mr. Vichiean, the Chairman of this village.

Personal Background:

- He works outside of the village and grows vegetables for sustenance.
- His family consists of 3 members and everyone lives together in the village.
- He did not give specific information about his income but he says that it is enough to support his family.

Information about Saparn-Thom Village:

- The main water source for this village is underground water that provided by the government.
- The villagers collect rainwater in each household for drinking and use tap water for household activities such as washing and cleaning.
- The water expense for this village is approximately 40 to 80 Baht per month.
- In this village the cost of electricity is covered by an outside program as long as each household uses less than 90 KWatt per month. Households that go over the limit must pay for it.
- The water quality is reported as sufficient. However, the crops that used the rainwater are said to be better than those grown with tap water.
- The water is not treated in this village prior to distribution
- The villagers including Mr.Vichiean have never heard about SPWSs. Villagers are not aware of the advantages and disadvantages of the system, so they cannot make a decision on whether or not the village should try to obtain the system.
- The PDA gives a lot of support to this community by giving the money to the local bank, which supports the villagers to invest in agriculture and farming sectors. Moreover, PDA staffs take a responsibility to give information to the villagers about agriculture and farming techniques. However, PDA staffs have not provided any information about SPWS to the villagers.
- The PDA helps support the village economy by funding a community bank that allows villagers to take out loans to invest in agriculture. The PDA has also educated the villagers about a variety of farming techniques. However, the PDA has not provided the village with information on SPWSs.

- Saparn-Thom Village does not have much debt.
- Residents of the village plan to continue working as farmers in the future. They did mention installing a SPWS as part of their future plans.

7) Miss Somchei Yuttiluck, Assistant Villager Headman

Personal Background:

- She works as an employee for the PDA and is the assistant village headwoman and she grows rice, sugarcane, and cassava.
- Her family consists of 6 members and everyone lives together in the village.
- Her income is approximately 8,000 Baht per month.

Information about Saparn-Thom Village:

- Saparn-Thom Village is another village in Chakkarat District that does not have a SPWS installed.
- The villagers use rainwater for drinking and use tap water for domestic purposes such as watering vegetables.
- Each household stores rainwater in a big jar for use when the water runs out.
- The water quality in this village is quite bad.
- The water expense for this village costs 40-60 Baht per month.
- The electricity expense for this village is approximately 400 Baht per month.
- The PDA supports this village by funding the local village bank and training the villagers on cricket farming and other farming techniques.
- Villagers know about SPWSs from visiting nearby Nong-Pluek village.
- Miss Somchei Yuttiluck feels that installing a SPWS would have a positive effect on her village. She thinks it would reduce the cost of water. She thinks a lot of villagers are hesitant about installing a SPWS because they are not aware of the benefits of having one and they do not to create more debt. She suggests that the PDA provide more information on the system in order to convince the villagers of the benefits of installing a SPWS.
- The main problem in this village is that there is a lot of debt and the residents fear going further in debt. They are also afraid that in the future there will not be enough water in the village to support its entire population. The village only has a small tank for water

storage. During the dry season this tank has been broken several times, which prevented the villagers from accessing water for many days although a PDA official did come and fix the tanks at some point. The village wants access to another tank to prevent this problem from happening again.

8) Mr. Kaen, Assistant Villager Headman

Personal Background:

- He is a farmer who grows rice, sugar cane and cassava. He sells his crops to a food-processing plant.
- His family consists of 6 members and everyone lives together in this village.
- His income is approximately 10,000 Baht per month and he thinks that it is enough to support his family. At the end of the month he still has money left over to invest in fertilizers.

Information about Saparn-Thom Village:

- Water in this village is pumped from the ground and collected from rain. Water is stored in a large ceramic jar.
- The villagers use rainwater for drinking and tap water for agriculture.
- Water costs the villagers approximately 70-80 Baht per month.
- Electricity costs this village approximately 400-500 Baht per month.
- The water in this village is of a high quality and does not require chemical treatment.
- Mr. Kaen believes that the village should try to install a SPWS but thinks many villagers would not support the idea due to a fear of debt.
- The PDA took several villagers from Saparn-Thom, including Mr. Kaen, to Nong-Pluek (A Village with SPWS). The villagers who saw the SPWS have not shared what they learned with the rest of the village according to Mr. Kaen.
- Mr. Kaen says that the main problem in his village is related to space. He says that there is not enough space to farm so villagers have to leave for the city to make the money they need to survive.
- Water shortages are frequent in the dry season due to frequent problems with the storage tank.
- This village has been involved in the Village Development Project (VDP) for almost two years. In the past, they did not have enough money to grow crops and the villagers

needed to take loans from the Bank of Agriculture and Agriculture Cooperatives. This bank had high charges, which were difficult for the villagers to pay. Fortunately, the PDA stepped in and set a low interest local bank to help fund projects in the community.

9) Mr. Chalong, Tumbon Administration Organization (TAO) Representative.

Personal Background:

- He works as a farmer who grows rice, sugar cane, and cassava.
- His family consists of 3 members but they live separately.
- He gets income around 9,100 Baht per month and he spends more than half of it on buying fertilizers.

Information about Saparn-Thom Village:

- The water sources of this village are from rainwater and tap water.
- The villagers use the rainwater for drinking and tap water for cleaning and planting the crops.
- The water expense of this village is around 50-60 Baht per month. (Approximately)
- The electricity expense is around 300 Baht per month. (Approximately)
- He thinks that everyone in the village should cooperate and obtain information about the SPWS. Most of the villagers do not have enough information about the system, so they think that if the system is installed in the village it will create more debt.
- The main problem of this village does not have enough public transportation and many health care problems.
- PDA staff has educated the villagers about different agricultural techniques such as growing different fruits about twice a week. However, PDA staff has not provided any information about SPWS to the villagers yet.

<u>January 27, 2012: Limptong Village</u>

General information about Limptong Village

- Location: Moo 4 Nong-Bhod Sub-District, Nang Rong District, Burrirum Province.
- Area: 3,800 rai.
- This village consists of 135 households and 510 villagers.

Information about Limptong Village:

- Since about 7 years ago, most of villagers are facing with the poverty and living with difficulty. The villagers have conducted community discussions in order to find solutions to their various problems.
- The main occupation in this village is farming. However, they cannot grow crops during the dry season but during the rainy season the villagers grow their crops. In many instances the village faces a lot of water shortage causing their crops to dry.
- The village does not have a water storage system and they have to share the available storage in the reservoir with nearby villages. When one village uses water for the events such as funeral, another village needs to stop using water from the reservoir to supply the other village.
- This village tried to solve the problem of water shortage by using surface water. They also obtained a budget from Coca-Cola (Thailand) Foundation of about 250,000 Baht to make water storage supply to use for household activities.
- The water needs to be purified by chemical water treatment from aluminum and chlorine. However, the villagers have been faced with the problem of aluminum shortage, which has caused bad water quality. Moreover, the chemical treatment for cleaning water is too expensive for the villagers to afford.
- The villagers have set up the meetings every week to discuss the problem that they are facing in the community.
- The main problem in this village is there is not enough water to use for agriculture and many of the crops such as rice die because of water shortage.
- The villagers decided to solve the water shortage problem by finding new sources of water. They are using satellite images to observe the surrounding 3Km area for 8 months from the dry season to rainy season. In rainy season, the villagers observe the land to see the direction that the water rushes down based on the geography of the community.
- When the information was be obtained from the satellite images, almost all of the villagers participated in helping to analyze the information and recommend the best way to get water for agriculture.
- The villagers can get the water for planting the crops by applying the Monkey Cheek Project to store the water from rainy season for dry season.

- The villagers need to find ways to generate the income by using their water in an efficient manner. They need to plan how to manage the cultivation of their crops for the entire year such as when and how long these crops will be grown. For example, rice needs 120 days to cultivate, mushroom 30 days and cucumber for 80 days.
- In some cases, some crops need much more time and water to cultivate therefore the farmers defer from growing these specific crops. These decisions are made when the community meets and discuss what crops will be grown and how much money they can generate from these crops. As well they input all their data about the crops in Excel to calculate the amount of money they can get obtain in the whole year.
- This village uses "Air-Ware", which is a Thai word, technique that helps to increase the water pressure in the pipe.
- They spread out the water management program from this village to other three districts and their goal is to educate the local villagers about how to improve the water reservoir. In 2008, around 1700 rai were benefited from this water management program.
- The villagers pay attention to solve the problem together to brainstorm the problems and ideas, so they can get help from many sponsors. For example private sector, PDA, and the government sector. Each sponsor supports the village by providing more information and money to solve the water supply problem. For example, Coca Cola Company donated the budget to this village to construct the water reservoir for the Monkey Cheek Project.
- However, for public benefits the private owners donate the lands so that the villagers can use it to construct a local canal for the Monkey Cheek Project.
- The main problem in this village is about the low quality of water in the community due to the pigeon excrete that is found in the water tank thus the local school cannot use this water since it is not safe for drinking. However, the Coca Cola Company makes the drinking tap water available to the school in this community.
- The villagers have learned how to grow "vetiver glass" that is used for preventing the canal from collapsing because its root is very deep and supports the soil very well avoiding the soil from washing away.
- Also the villagers have conducted a field study on other villages for farming technique and sustainable living.

- Before the water management program was implemented the villagers only grew rice and cassava. In order to make ends meet before many worked outside their homes as construction workers or employees. However after the water management program was put in place the villagers are now able to generate mange in the villages.
- The villagers have been able to benefit in various ways from planning and recording their expenses since they have been to able learn on how to reduce their expenses. For example, Miss Noi used to drink two cups of coffee per day, which costs around 20 Baht, but at this time, she learns to drink instant coffee instead which cost around only 7 Baht.
- The villagers had studied about alternative energy to use in the community. For the areas that electricity cannot reach, the villagers plan to use the solar panels. As well, the villagers are learning how to use biogas for cooking. Some villagers still use the diesel oil to pump the water from the canal for planting their crops. However, some of them still carry the water on their shoulders to plant the crops.
- The main water source for this village is from the water reservoir, water storage from the Monkey Cheek Project that has the area around 40 rai, which use the rainwater to full the reservoir.

Nong-Takem Village

General information about Nong-Takem Village

- Location: Moo 11 Chakkarat Sub-District, Chakkarat District, Nakhon Ratchasima Province.
- Area: 200 rai.
- This village consists of 158 households with 765 villagers.

Information about Nong-Takem Village:

- The main occupation of this village is farming and the main agriculture products are rice, fruit, Chrysanthemums flower, and silk- weaving.
- The villager is made up of different groups such as farming, silk-weaving and growing flowers, and making medicinal herbs.
- Nong-Takem Village is under the Village Development Project (VDP) of the PDA who is helping to support them on the economic side by providing the local village bank. This

bank helps the villagers to develop a budget for investing on their agriculture sector and other businesses.

- PDA educates the villagers on how to reduce their expenses on daily life. For example, the PDA staffs provides education about different incoming generating techniques such as making their own dishwashing liquid, grow different vegetables, and raising frogs for sale.
- By learning to produce dishwashing liquid instead of buying, the villagers can reduce their expenses from 50 Baht to 16 Baht. One liter of the soap can be used for a month thus saving money to the villagers for other expenses.
- PDA staff teaches the villagers to make their own fertilizer from animal and agriculture waste, which help villagers save a lot of money for investing on the farming.
- The villagers sell their own agriculture products such as sunflower, silk, and vegetables in the village, so everyone in this village can afford at a lower price.
- This village has a leaning center for the villagers to learn about the sufficient economy, ways to produce fertilizer and herbal medicine through hands-on workshops.
- This leaning center has many visitors, around 20 groups per month, who come to study about the sufficient economy, how to produce capsule herbs as medicine, growing vegetables, planting different types of flowers, and learn more about biogas.
- Nong-Takem Village gets the support from many sponsors such as PDA, Thammasart University and Microsoft Company, which provided computers and built a library for the villagers.
- PDA works with the communities to find companies that can support them.
- SPWS has not been installed in this village yet but the villagers wish to obtain this system in order to help other villages solve their water problems and use for agriculture.
- The main water source of this village is from water reservoir that is about 16 rai in area.
- The villagers use electricity to pump the water into their household tanks and to their farms in order to irrigate their crops.
- This village has no water shortage problem since they have another water reservoir available in case the village runs out of water.
- Every household needs to pay for water service and maintenance around 100 Baht per year.

- The villagers do not own their land; they still need to rent from the Thai Government. They do not have equity to apply for a mortgage on the land they are using. The villagers need to pay 10 Baht per rai per year to government for using the land.
- The approximately water expenses of this village is costing around 400 to 1,000 Baht and 500 to 800 Baht for electricity expenses. Every household in this village need to use the electricity to pump the water for using in their farm.
- The villagers plan to install the SPWS in the village but right now they cannot afford the money for investing in this system. However, they think that this system will help them to solve the water problem and reduce the water cost. So, they have very strong positive attitude with SPWS.
- Currently they do not have any water treatments in the community because they obtain clean water from the reservoir.
- However, the villagers store rainwater in jars for drinking purposes. Nang-Rong Hospital donated water jars to every household in the village for collecting rainwater.
- The villagers have learned to manage their own products learn to manage and promote their products, which are flower, herbal, and medicine, to the market

January 24, 2012: Koksad

<u>Koksad Village</u>

General information about Koksad Village

- Location: Moo 3 Chakkarat Sub-District, Chakkarat District, Nakhon Ratchasima Province.
- Area: 20 rai.
- This village consists of 170 households and 752 people.

1) Mr. Pann Koptonglang, Villager Headman of Koksad.

Personal Background:

- He works as a villager headman and merchant.
- His family consists of 3 members but they live separately. He and his wife have only one child and he is currently staying in Taiwan.

- He earns an income of about 30,000 baht per month. More than half is spent investing on his watermelon and garlic farm. He thinks his current income is not enough for survival.

Information about Koksad Village:

- The main water source is underground and the water is stored in separate household tanks.
- Underground water is used for household activities and rainwater is used for consumption and agriculture.
- The villagers pay about 100 baht per month, and do not pay for electricity.
- The underground water quality is very poor and cannot be used for drinking and irrigation.
- The villagers do not pay for a filtration system because the water is only used for household activities.
- PDA informed the villagers about the SPWS a year ago, so the villagers already have information about it and agree that it is a good way to resolve their water problem. The PDA has been supporting this village for about 2-3 years
- PDA states that the environment of Koksad Village is good and capable for installing SPWS and the villager already has the surface water source available.
- The PDA visits the village once a month to inform them about solar panels and part time jobs such as teaching the villagers to grow the cricket and cantaloupe farm. The PDA also informs the villagers about energy conservation and sustainability.
- The mostly critical problem of Koksad Village is their debt.
- The villagers have a positive attitude towards the SPWS. Everyone agrees and is trying to install this system in the village. They believe that they can solve the water problem and can expand the use of water for other activities such as growing the crops or drinking.

2) Mr. Jaruek Tamtai, TAO member of Koksad.

Personal Background:

- He works as a member of TAO and farmer who grows cassava.
- His family consists of 5 members but they live separately. One son is studying at the village school.

- He earns an income of about 100,000 baht per month. He invests on agriculture such as fertilizer. He believes his income is not adequate for survival.
- *Information about Koksad Village:*
- The water source of this village is underground water and rainwater.
- The villagers need to store the rainwater in a large jar but they do not store any underground water.
- The water quality of Koksad Village is poor and highly acidic. The villagers cannot use the water to plant the crops because it can make bad agricultural products.
- The underground water is used for household activities such as cleaning, washing, and bathing. The villagers obtain rainwater for consumption.
- Most of the villagers do not pay for electricity because they use a minimal amount, so the government supports them. However, they still need to pay for the water expenses that cost around 500 baht per month per household.
- The villagers first heard about the SPWS from a nearby village, Nong-Pluek Village. The villagers of Koksad would like to install this system in their village because of the benefits it has provided to the Nong-Pluek Village.
- Villagers use the information gathered from the PDA to grow the crops and find more part time jobs such as cricket farms or lemon farms to increase their income.
- The villagers should be trained to filter their underground water to achieve a better quality.

Dangnoi Village

General information about Dangnoi Village

- Location: Moo 3 Chakkarat Sub-District, Chakkarat District, Nakhon Ratchasima Province.
- Area: 20 rai.
- This village consists of 170 households and 752 people.

3) Mr. Kanlaya Kinapid, Minister of Puttaisong District.

Personal Background:

- He works as head minister of Puttaisong District for 11 years and he is a merchant.

- His family consists of 5 members but they live separately.
- He earns an income of about 24,900 baht per month. He invests in the village festival. He believes that his current income is enough to support his family.

Information about Dangnoi Village:

- Dangnoi Village already has the SPWS.
- The water source is surface water, underground water and rainwater.
- The villagers the rainwater in a large jar but they do not store underground water.
- The villagers lack water each summer so they installed the SPWS as a solution to this problem.
- The villagers are doing the research about the difference between the farm that use the solar power and the farm that use the electricity.
- The government has already tested the quality of water and it is clean enough for irrigation.
- There was a slight difference in the soil type of each farm, so the crops from each farm are different.
- After installing the SPWS, there was still a lack of water so the villagers now have 2 storage tanks.
- The solar panels were free from the government program, but the villagers need to invest in the solar panel manufacturing, pump management, and the soil manipulation. In total, the cost was about 400,000-500,000 baht, around 16,000 baht per household. Half of the household have already paid their debt.
- The villagers pay for electricity and water expenses and a maintenance cost for the SPWS, which is about 200 baht.
- PDA staffs visits the village frequently.
- The village plans to have an electricity storage system for the solar SPWS to store electricity for nightly use and for use during the rainy season.
- The villagers also plan to produce biodiesel from the Saboo dum (สบู่ดำ).

4) Mr Sin Kranantaisong, Farmer of Dangnoi Village.

Personal Background:

- He works as a farmer and merchant for cabbages.
- His family consists of 8 members but they live separately.
- He earns an income of about 5,000 baht per month. He invests in raising pigs. He believes his current income is adequate for survival.

Information about Dangnoi Village:

- The village utilizes underground water and stores their water in a tank near the farm.
- The monthly electricity expense is about 2,000 baht and the villagers also pay an additional 150 baht for water expenses.
- The villagers first heard about the SPWS from a nearby village.
- The villagers have a positive attitude towards the SPWS and the PDA.
- The PDA visits the village about once to twice per month to inform them about other renewable energy techniques such as biomass from the rice husk.

APPENDIX F: SURVEY FOR VILLAGES WITH SPWS

Sex: ◯ Female ◯ Male

Age: ◯ Under 20 ◯ 20-30 ◯ 31-40 ◯ 41-50 ◯ 51-60 ◯ Over 61

Family member(s):_____

Does anyone in your family have to work outside the village? ◯ Yes ◯ No

Occupation: ◯ Farmer ◯ Employee ◯ Other_____

Income per month: _____Baht

Water Bill per month: _____Baht

Electricity Bill per month: _____Baht

Quality of water: ◯ Very Good ◯ Good ◯ Bad

What do you use water for?

◯ Household for washing/cleaning ◯ Agriculture ◯ Drinking

Have you met any water problem **before** installed SPWS?

◯ Water shortage ◯ Dirty ◯ Odorous ◯ Have precipitate ◯ Acidic

◯ Other_____

Have you met any water problem **after** installed SPWS?

◯ Water shortage ◯ Dirty ◯ Odorous ◯ Have precipitate ◯ Acidic

◯ Other_____

Have you use Petroleum Oil before? (If yes, please choose the section of usage)

◯ Household for washing/cleaning ◯ Agriculture ◯ Industry/Business

◯ Transportation ◯ Other_____

Do you know about the SPWS in your village?

◯ Yes From who? _____.

◯ No

Has the PDA informed you about the system before?

◯ Yes ◯ No

Do you think that the system is good or not?

◯ Good

◯ Bad Why? _____

How do think the system should be improved?

◯ Increase the number of storage tanks for water

◯ Have a separate system for agricultural use

◯ Have energy storage (battery) within the system for electricity use in households

◯ Other _____

Does the system cause any pollution to you or not?

◯ No ◯ Yes How? _____

What is the main problem that the community has?

◯ No job ◯ Debt ◯ Quality of water ◯ Lack of water

◯ Other_____

APPENDIX G: SURVEY FOR VILLAGES WITHOUT SPWS

Sex: ◯ Female ◯ Male

Age: ◯ Under 20 ◯ 20-30 ◯ 31-40 ◯ 41-50 ◯ 51-60 ◯ Over 61

Family member(s):_____

Does anyone in your family have to work outside the village? ◯ Yes ◯ No

Occupation: ◯ Farmer ◯ Employee ◯ Other_____

Income per month: _____Baht

Water Bill per month: _____Baht

Electricity Bill per month: _____Baht

Quality of water: ◯ Very Good ◯ Good ◯ Bad

Have you met any water problem before?

◯ Water shortage ◯ Dirty ◯ Odorous ◯ Have precipitate ◯ Acidic

◯ Other_____

What do you use water for?

◯ Household for washing/cleaning ◯ Agriculture ◯ Drinking

What do you use electricity for?

◯ Household for washing/cleaning ◯ Agriculture ◯ Industry/Business

◯ Other_____

Have you use Petroleum Oil before? (If yes, please choose the section of usage)

◯ Household for washing/cleaning ◯ Agriculture ◯ Industry/Business

◯ Transportation ◯ Other_____

Do you know about the SPWS in other villages?

◯ Yes From who? _____.

◯ No

Has the PDA informed you about the system before?

◯ Yes ◯ No

If the SPWS is installed in the village, what do you think the system should be used for?

◯ Household for cleaning/washing

◯ Agriculture (growing crops and raising animals)

◯ Other _____

What is the main problem that the community has?

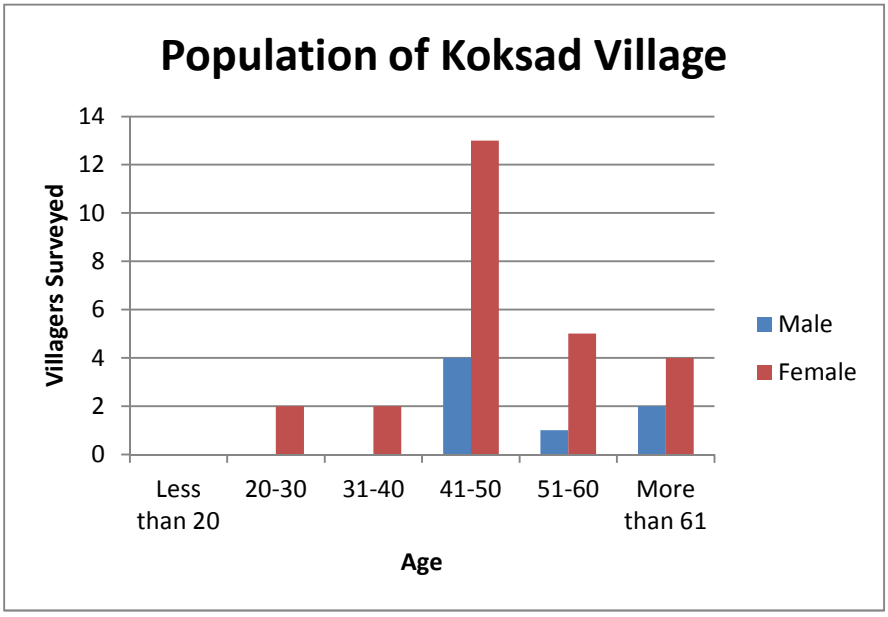
◯ No job ◯ Debt ◯ Quality of water ◯ Lack of water

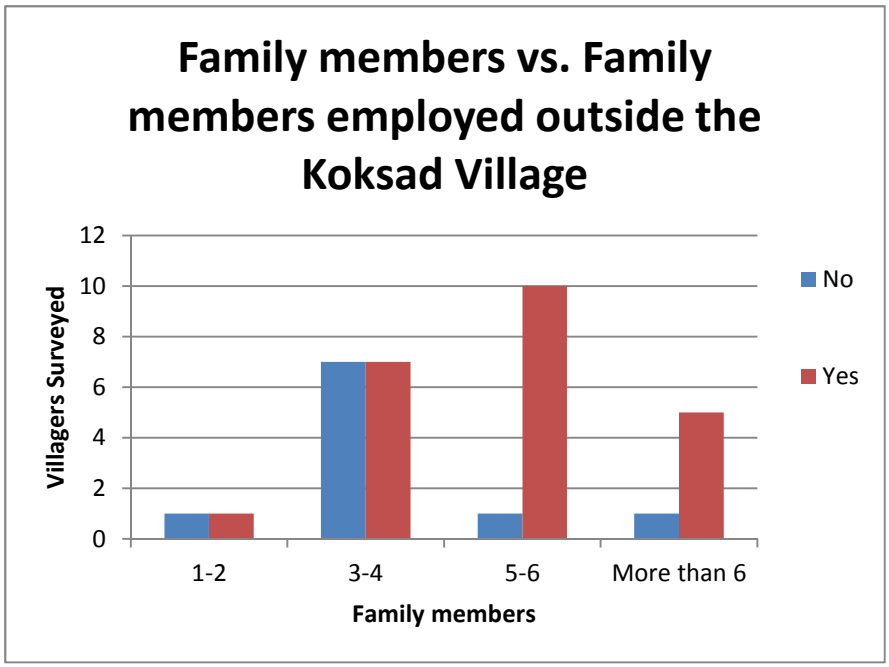
◯ Other_____

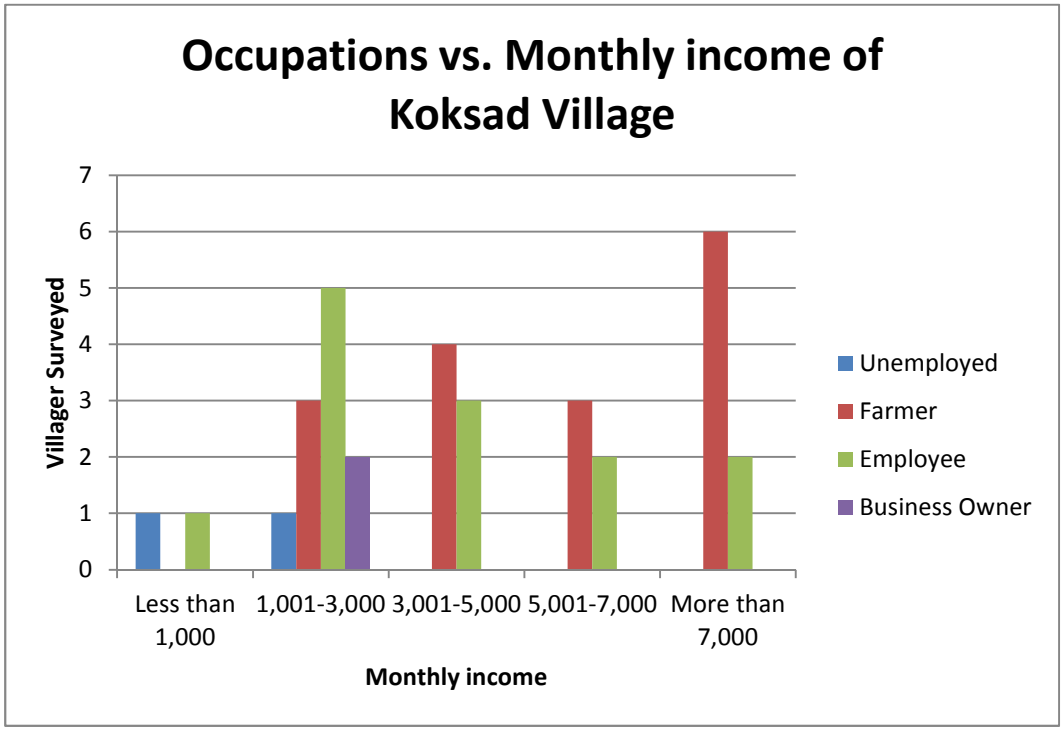
APPENDIX H: SUMMARY OF SURVEYS CONDUCTED IN KOKSAD VILLAGE

The following charts depict the responses that we obtained from the surveys in the village without SPWS installed. These charts display the demographics of the village and the current water and energy situation that villagers are facing based on the responses obtained.

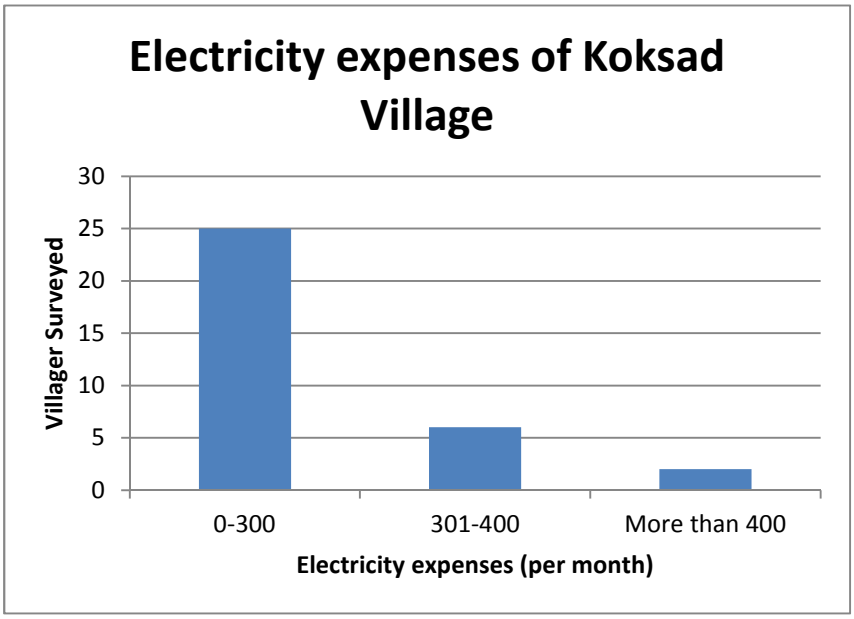
Demographics

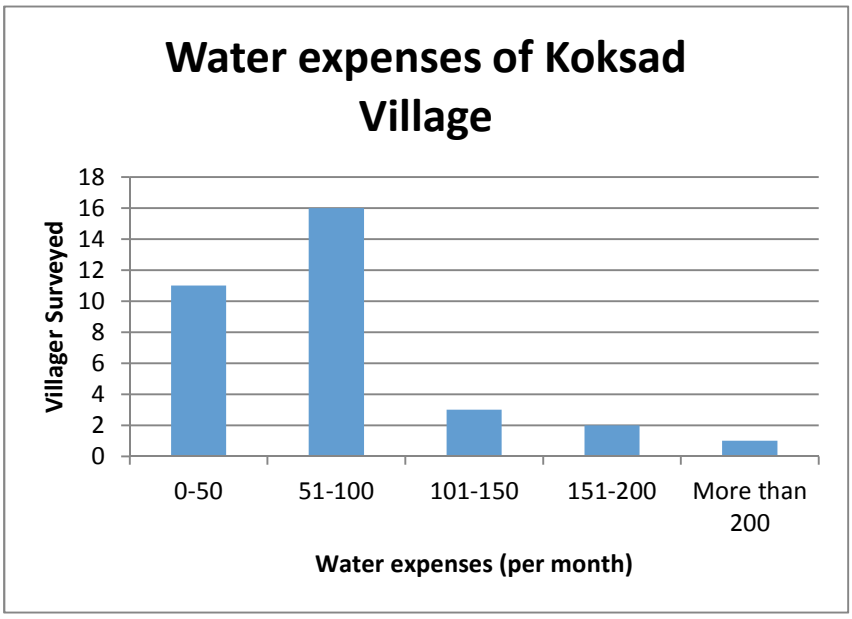


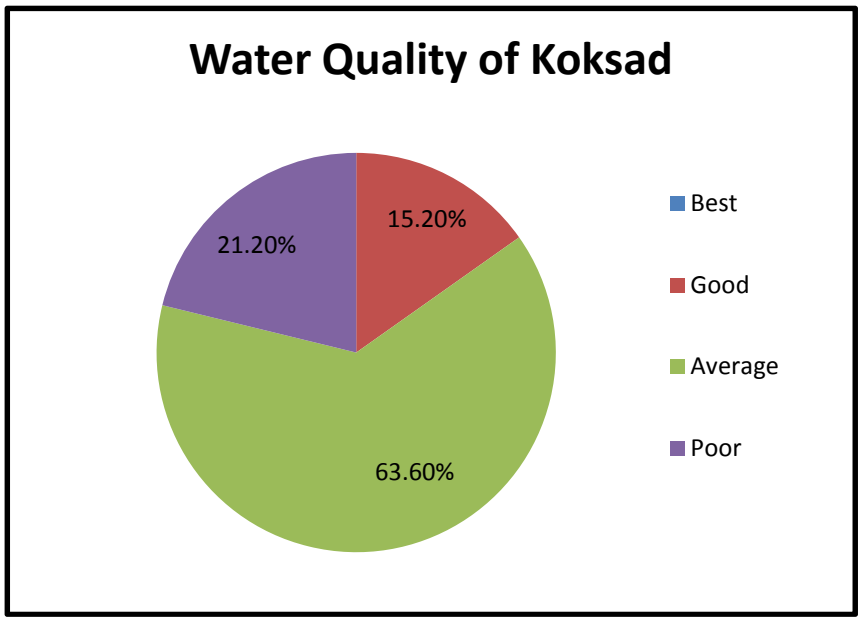



Occupations vs. Monthly income of Koksad Village
Villager Surveyed
0
1
2
3
4
5
6
7
Less than 1,000
1,001-3,000
3,001-5,000
5,001-7,000
More than 7,000
Monthly income
Unemployed
Farmer
Employee
Business Owner

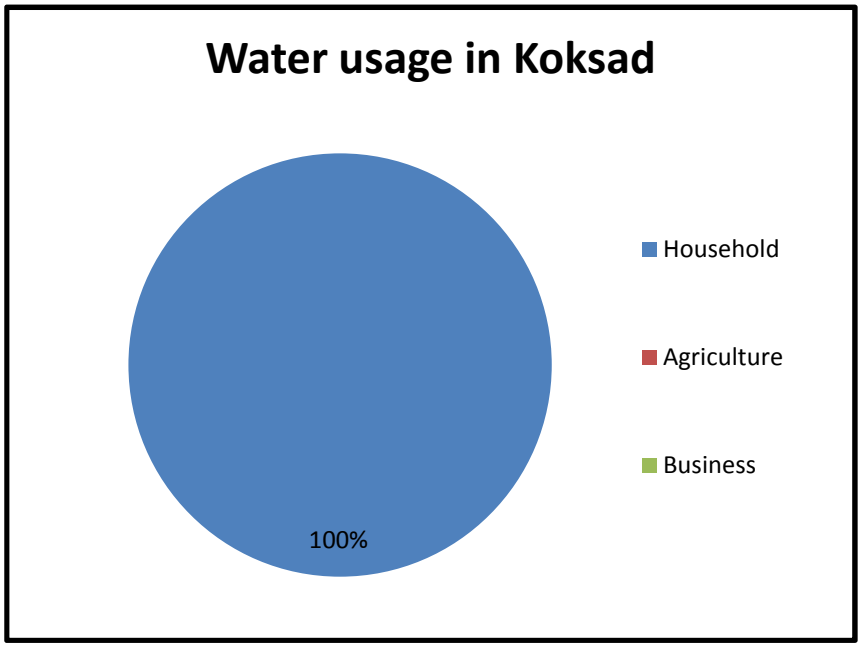
Water and electricity expenses

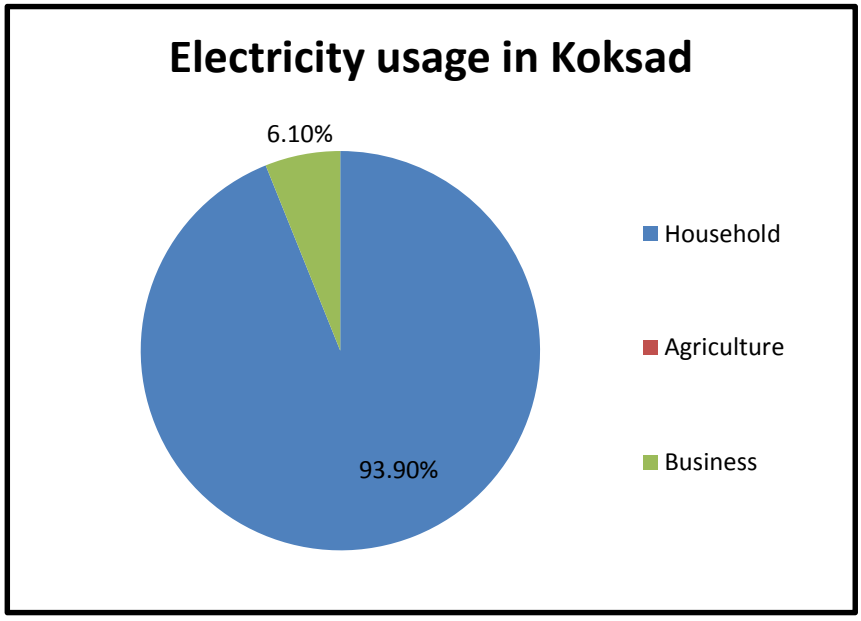




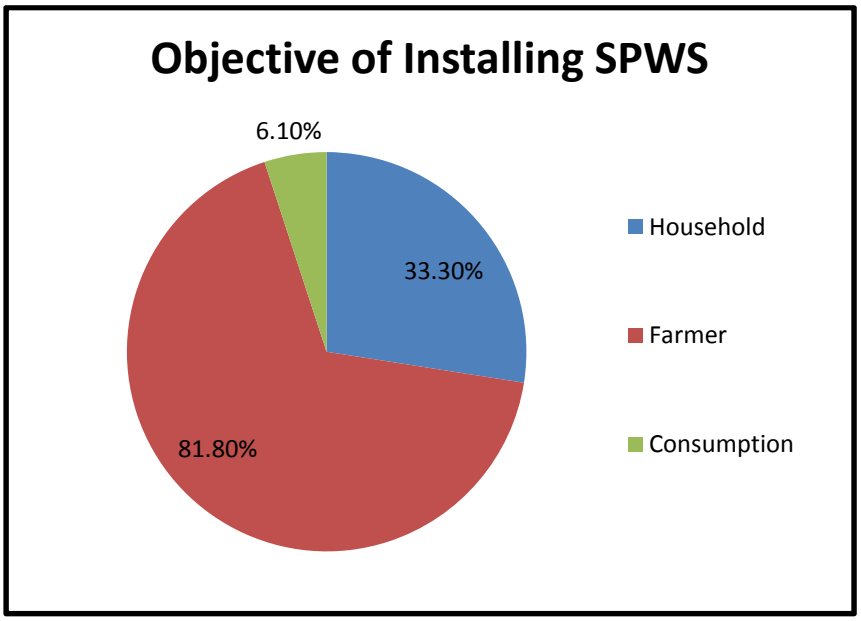

Water Quality of Koksad
15.20%
21.20%
63.60%
Best
Good
Average
Poor

Water and electricity usage





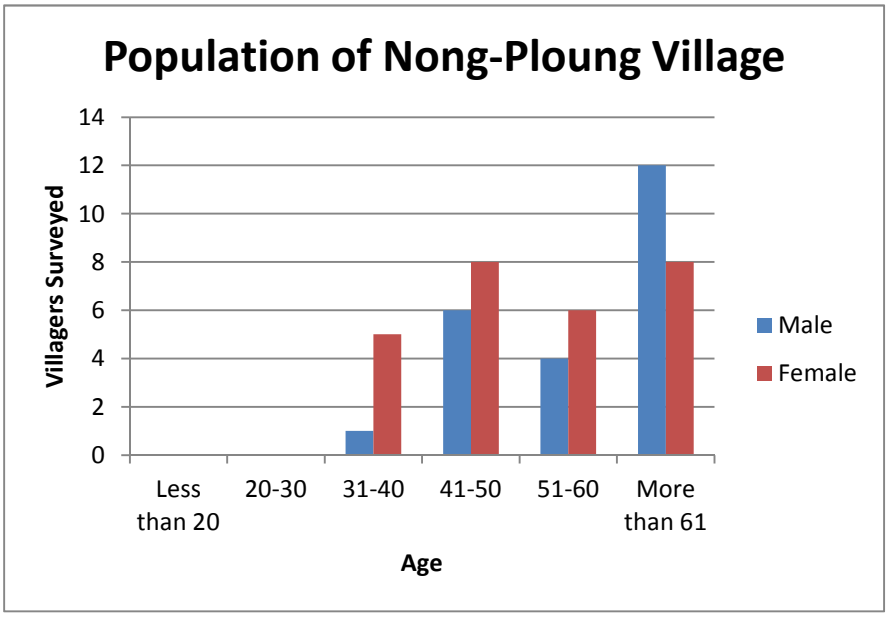
Main purposes of installing SPWS in the village

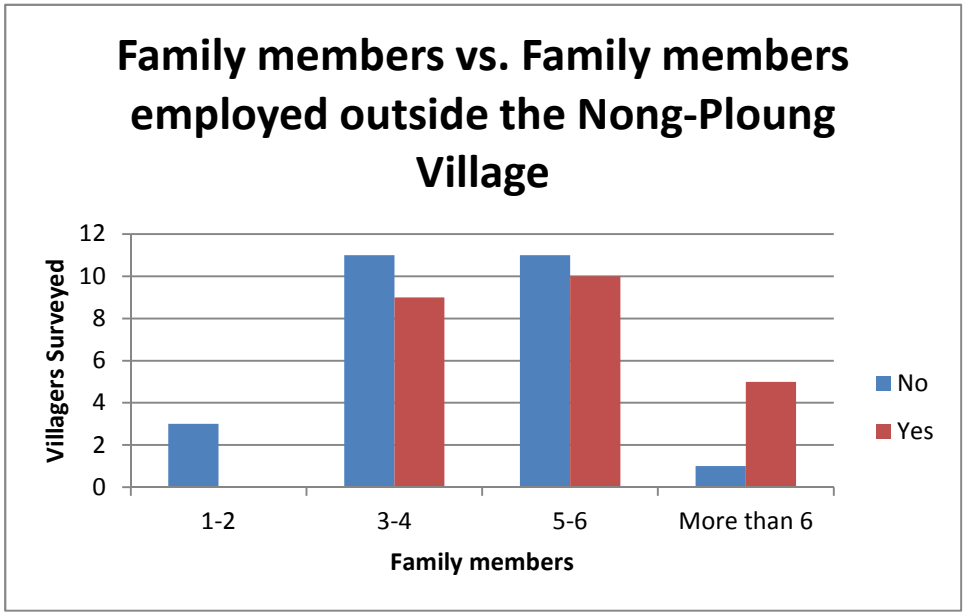


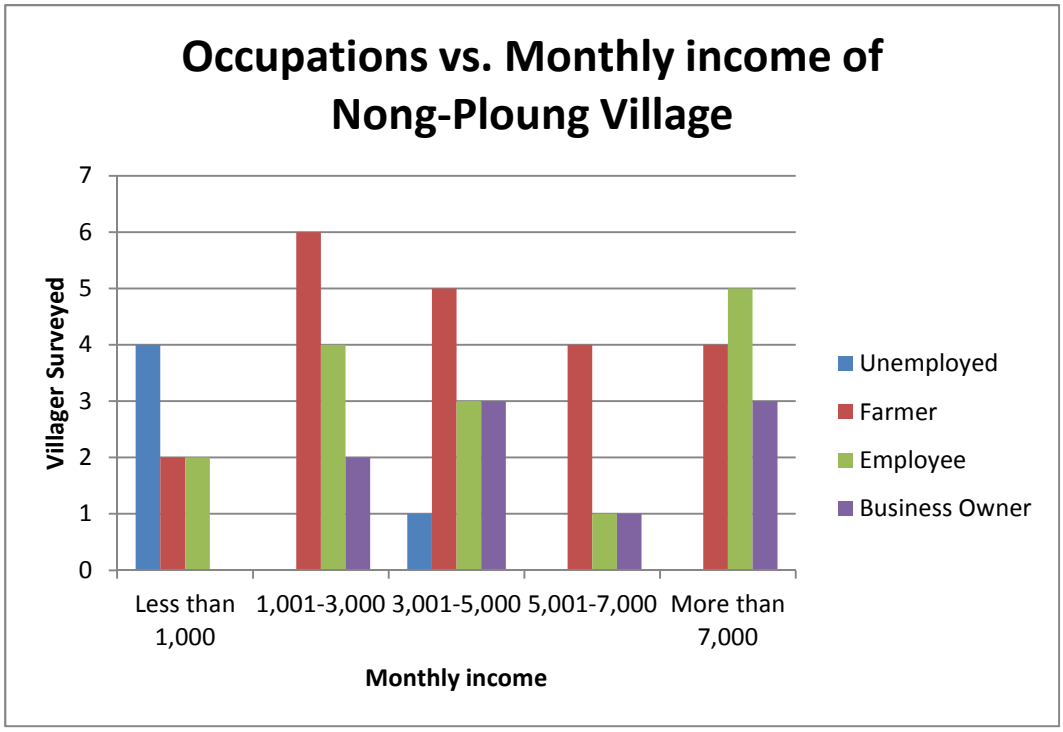
APPENDIX I: SUMMARY OF SURVEYS CONDUCTED IN NONG PLOUNG

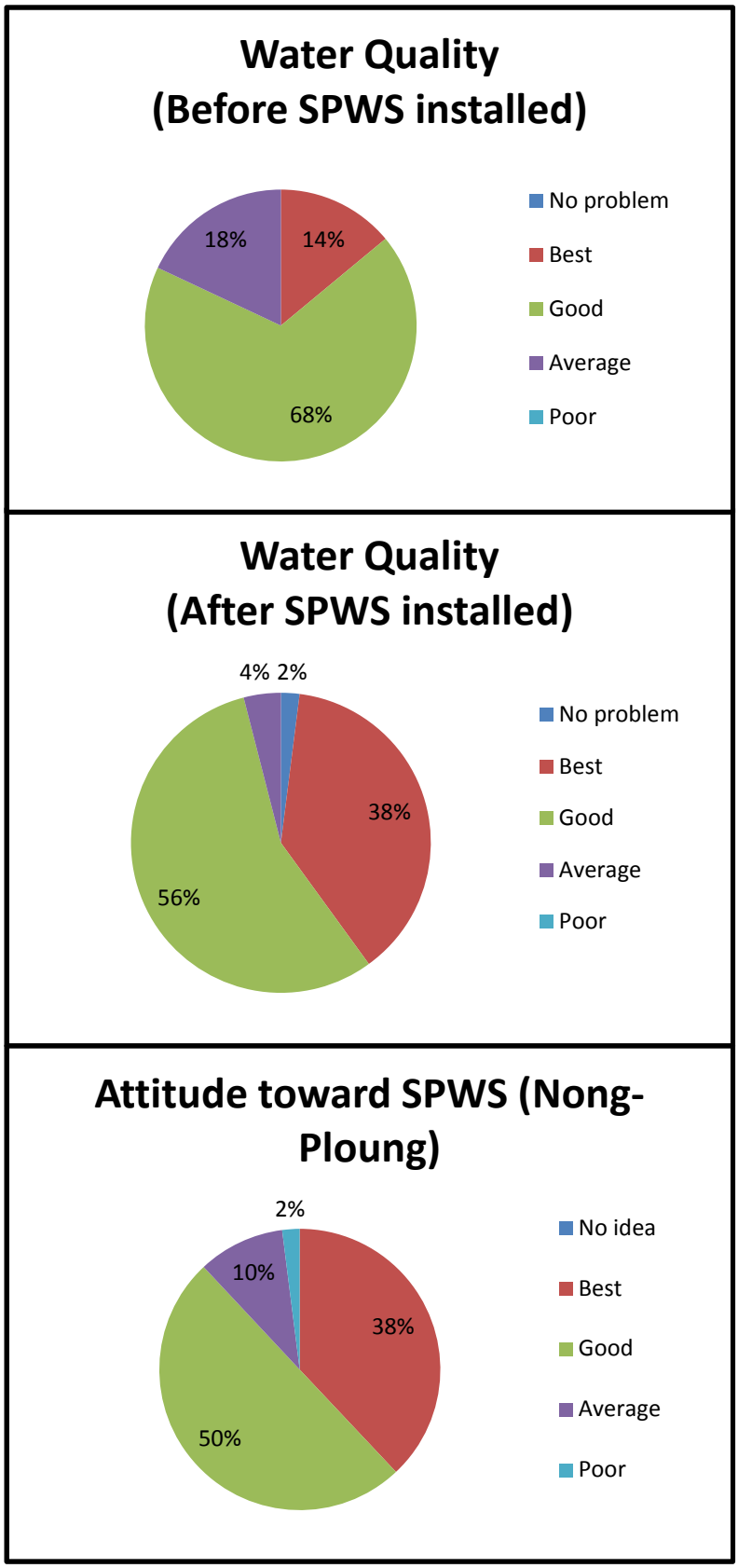
The following charts depict the responses that we obtained from the surveys that were conducted in the village with the help of our Thai partners. These charts display the demographics of the village and their responses towards the recent installation of the SPWS.

Demographics






Occupations vs. Monthly income of Nong-Ploung Village
Villager Surveyed
0
1
2
3
4
5
6
7
Less than 1,000
1,001-3,000
3,001-5,000
5,001-7,000
More than 7,000
Monthly income
Unemployed
Farmer
Employee
Business Owner


Water Quality
(Before SPWS installed)
18%
14%
68%
No problem
Best
Good
Average
Poor
Water Quality
(After SPWS installed)
4%
2%
38%
56%
No problem
Best
Good
Average
Poor
Attitude toward SPWS (Nong-Ploung)
2%
10%
38%
50%
No idea
Best
Good
Average
Poor

Additional responses in regards to PDA involvement and current problems in the community