PROMOTING RENEWABLE ENERGY USE THROUGH COMMUNITY-BASED EDUCATION

Powering and Empowering Rural Thailand

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Promoting Renewable Energy Use Through Community-Based Education

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Abstract

The goal of this project was to provide recommendations to the Population and Community Development Association (PDA) in Mae Mo to develop a learning center about renewable energy and its applications. Communities of Mae Mo currently rely on conventional sources of energy to meet their needs. There is a gap in knowledge about the costs of conventional energy and benefits of renewable energy technologies. Using a community-based approach, we have developed recommendations to PDA regarding the development of a learning center to educate communities on using renewable energy to reduce their dependence on energy derived from fossil fuels.

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Executive Summary

Anthropogenic climate change has serious social, economic, and environmental implications, making it one of the world's most prominent social and environmental issues (Castleden, Shearman, Crisp, & Finch, 2011). Climate change is caused by an increase in the concentration of greenhouse gases (GHGs) in the atmosphere, which results in an increase in temperature and a change in weather patterns throughout the globe. In a 2007 report, the Intergovernmental Panel on Climate Change (IPCC) concluded that it is "*extremely likely* that human activities have exerted a substantial net warming influence on climate since 1750" ("IPCC Fourth Assessment Report: Climate Change 2007," 2007).

Some nations are more vulnerable to climate change then others. A nation's vulnerability is "a function of the character, magnitude, rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity" (*Adapting to the Impacts of Climate Change*, 2010). Vulnerability suggests that nations will feel the effects of climate change differently. Thailand will be seriously affected by climate change due to its geographic location, economic status, and level of development (Marks, 2013).

A nation's vulnerability to climate change can be reduced through several methods. Present methods in reducing vulnerability focus around mitigating the effects of climate change by reducing carbon dioxide emissions, adapting to potential changes that result from a changing climate, and introducing renewable energies and renewable energy technologies (RETs). RETs offer a multifaceted approach to reducing a nation's vulnerability as they emit fewer GHGs compared to conventional energies, provide a decentralized power system, and improve the capacity of a nation to cope with dwindling fossil fuel supplies (*Adapting to the Impacts of Climate Change*, 2010).

Renewable energy and RETs can work to reduce Thailand's vulnerability to climate change. Currently, Thailand relies heavily on fossil fuels as a source of energy. Additionally, much of Thailand's energy is imported from neighboring nations (Mulugetta, Mantajit, & Jackson, 2007). Utilizing RETs can decrease Thailand's GHG emissions, decentralize power systems, and increase the nation's energy independence. Mae Mo is particularly affected by Thailand's fossil fuel dependence and energy insecurity. All 13 of Thailand's coal fired power plants are located in Mae Mo, Lampang Province (Soonya, 2012). Communities of Mae Mo are vulnerable to the negative environmental and health impacts of the coal-fired power plants (Forsyth, 2004). Renewable energy projects can address these impacts by reducing Mae Mo's vulnerability.

Nations around the world experience many barriers to the successful implementation of RETs. Barriers can stem from technical, informational, economic, political, institutional, and knowledge obstacles (Richards, Noble, & Blecher, 2012; Uddin, Taplin, & Yu, 2006). Knowledge barriers are the most fundamental roadblocks to successful implementation of renewable energies. Without the knowledge about technical, informational, economic, political, or institutional barriers that may be interfere with a project, they cannot be addressed in an effort to be overcome. In Mae Mo, knowledge barriers have prevented the successful implementation of renewable energy technologies. Lack of knowledge about other barriers has disabled successful implementation of RETs by actors. Community members face a knowledge barrier in

that not all of them are aware of the negative effects of coal mining, combustion or climate change and do not see RETs as a solution. The sponsor of this project, the Population and Community Development Association (PDA), hopes to address knowledge barriers such as a lack of access to information about RET, its benefits, and its social acceptance that are currently preventing the successful utilization of RETs in Mae Mo through a learning center. PDA has successfully overcome knowledge barriers in the past through the utilization of learning centers, an educational facility that addresses a gap in knowledge of a specific target group and works to provide them with the knowledge and skills to close that gap.

We chose a suitable site for a learning center and developed information about renewable energy technologies (RETs) to address a lack of information and important skills for the residents of Mae Mo. **The goal of our project was to provide recommendations to PDA Mae Mo to develop a learning center about renewable energy technology and its applications.**

Methodology

We approached the problem by adopting a community-based, participatory approach to problem-solving. This method has been used by PDA to effectively and sustainably address problems that rural communities face, such as family planning, job opportunities and income generation. In order to achieve our goal, we integrated this community-based approach into the following objectives:

1. *Determine criteria of a successful learning center to determine the location, design, and educational media to be used in the PDA learning center for Mae Mo*
2. *Assess the energy usage, energy needs, and the cost of electricity for community members of Mae Mo*
3. *Determine affordability, user-friendliness, and local availability of renewable energy resources to evaluate physical and social feasibility of renewable energy technologies for the communities of Mae Mo*
4. *Develop recommendations and materials about renewable energy technologies that will be made available in the Mae Mo learning center*

We focused on work in 5 districts in Mae Mo. Site visits and interviews were conducted to determine the criteria for a successful learning center. These criteria resulted from interviews with learning center staff as well as our target groups. Interviewing our target groups helped us to ensure that we gained a mutual understanding of what materials and characteristics would be most suitable for the learning center. We were then able to evaluate the potential sites for a learning center in Mae Mo to determine which site met the most criteria. Our questions worked to ensure that the input of community members and PDA representatives were carefully integrated into the ideas and recommendations that we developed, which will work to ensure that their needs will be addressed in the learning center. Once features and criteria of a successful learning center were determined, we focused on developing preliminary educational materials for the learning center. These materials were formulated while considering the needs of several different target groups.

After gaining an understanding of the types of materials appropriate for the learning center, we determined how Mae Mo community members use energy. Understanding energy needs was

important in developing an understanding of what RETs are useful in the districts of Mae Mo. Through interviews, we investigated the current energy problems communities are facing and began to develop an understanding of renewable energy applications that they can learn about through the learning center.

We determined that feasibility of RETs should meet criteria of user-friendliness, local availability, and affordability. Through our site visits, we gained an understanding of the technologies that can be supported given the geography of Mae Mo. Finally, interviews were conducted with our target groups identify the criteria of feasibility. We developed information from community members and then performed economic, social, and environmental cost-benefit analyses to compare information that we had gathered and form conclusions about feasible technologies.

Results

Content analysis was used to analyze all of our interview responses. By analyzing responses and identifying themes among the answers, we made several findings about the design, location, resources, and future of the learning center. Our findings are organized in relation to these main findings:

1. The Cabbages and Condoms restaurant and resort in Mae Mo offers a suitable location for a learning center.

Through visits to existing learning centers we developed a list of criteria that make a learning center successful. Successful learning centers should address an educational need, be in a location that is accessible and in neutral territory, have appropriate facilities, have a variety of educational media, and evaluate the effectiveness of the learning center.

We used these criteria to evaluate the different options for the location of the learning center which were Na Sak, Baan Dong, Royal Project Site, and Cabbages and Condoms. Comparing each site, we found that Cabbages and Condoms offers a better location for the learning center in Mae Mo. Through interviews with community members, we were able to determine some of the educational media that should be offered in the learning center. The majority of community members chose a combination of interactive trainings and visual aids, such as posters, presentations, and videos.

2. The benefits of renewable energy are not well understood by the communities of Mae Mo

Communities of Mae Mo can benefit from a learning center about renewable energy since they don't understand the benefits of using renewable energy. During our fieldwork, we were able to visit the 5 districts of Mae Mo that the learning center will benefit. Through interviews we found a gap in knowledge about the generation and costs of conventional energy. We also interviewed community members on their energy usage and needs. The community could benefit from a technology to reduce their cost of electricity and provide electricity to those who are not connected to the grid and increase access to a reliable source of electricity in the changing seasons. Energy uses that must be met through the technology include cooking, lighting, cooling, and agricultural uses to pump water to the fields.

The learning center must provide educational materials to address the gap in knowledge about the generation and costs of conventional energy. It also must cater to the energy uses and needs of the community to make the connection between these costs of conventional energy and how RETs can be a solution to the problem.

3. Solar PV and biomass technologies are feasible energy options for the learning center and communities of Mae Mo.

Through interviews with experts we gained information on steps to take in studying feasible technology, as well as what to look for while conducting a site visit. The information then led us to a site visit in the communities of Mae Mo, and it was established that renewable resources available support solar PV, solar thermal, biomass and micro-hydroelectric technologies. Through the interviews, the target groups confirmed that criteria to determine feasibility include affordability, user-friendliness, and local availability. New criteria were also formed through the opinion of the community members including familiarity and reliability. Through a cost-benefit analysis based on environmental, social, and economic factors we determined the most feasible renewable energy technologies for the learning center and communities of Mae Mo.

4. There are opportunities to expand the scope of the learning center

When interviewing the target groups, we found some recurring themes that may help expand the scope of the learning center in the future. When we first spoke with PDA, we found that they would eventually like to target a broader audience, so we found that a website may help reach people outside of Mae Mo.

Since PDA staff are not experts on renewable energy or climate change, we found that it would be useful to contact experts for knowledge on those topics. Through interviews with community members we identified a gap in knowledge about climate change. Many community members we interviewed did not know what climate change was, and as a result knew nothing about the negative consequences. Some community members knew about climate change, but not all understood the negative impacts and some did not show an interest in the topic. Through site visits and interviews we found that lowering the cost of electricity through RETs may result in an increase in demand for water. The effects of high demand could affect the water shortage problem in the Mae Mo. As a result, water conservation is an important issue to address in the future.

Recommendations

Based on our findings, we have come to several major conclusions about the development of the learning center, educational materials, and feasible RETs that the learning center can offer. Our conclusions and recommendations are multi-faceted and speak to several stages of development that the learning center will go through. Our recommendations are as follows:

1. **We recommend that PDA create the learning center about renewable energy technology and its applications at Cabbages and Condoms in Mae Mo**. This location is a suitable and easily accessible site for many people in Mae Mo. It meets many of the criteria

of a successful learning center as it addresses a specific target group that could benefit from learning about new information and skills; it contains useful conference rooms; it can be easily maintained by reliable staff. PDA can use many features already available at the site. Additional features added to the site can include prototypes of solar panels and biomass systems, training sessions for PDA representatives as well as community members, transportation to and from the learning center, and evaluation methods.

2. **We recommend that PDA increase communication between PDA offices throughout Thailand as well as with other experts in renewable energy and RETs**. We found that some PDA representatives were misinformed about the educational programs and facilities that different learning centers offered. PDA can benefit by increasing communication between their regional offices and learning centers and be more prepared to direct visitors to specific information through websites and informed contacts. There are a multitude of other NGOs, industries, and organizations that PDA can contact to gain more information about RETs. These experts can help develop information and RETs for the learning center.

3. **We recommend that PDA educate community members about the costsof conventional energy and the benefits of renewable energy.** After analyzing our fieldwork data, we discovered that several members of the population of Mae Mo lack an understanding about how their electricity is produced. Additionally, community members were unaware of some of the harms of the mining and combustion of lignite. In order for community members to understand some of the benefits and usefulness of RETs, it is important that they first understand the consequences of conventional energy production and its effects on health and the environment. PDA can complete this recommendation by developing a more comprehensive understanding of the potential applications of renewable energy in Mae Mo.

4. **We recommend that the learning center be expanded in the future to include new topics and programs and reach a broader audience**. The learning center at Cabbages and Condoms has great potential to expand and develop into an institution with a variety of learning opportunities. In particular, we believe that the learning center can be expanded to include information about water conservation and climate change. Our recommendations about renewable energy technologies will be used by PDA in order to pump water for agriculture. A potential increase in water usage could result in the need for education about water use and conservation techniques. This will make the scope of the learning center more comprehensive and sustainable

Through our recommendations, we believe that PDA can adequately address the gaps in knowledge of the community members of Mae Mo about costs of conventional energy and how renewable energy can mitigate these problems. Through this learning center, community members will be able to gain new knowledge, skills, and insights about their lives that will empower them to increase their quality of life. For some, access to RET will allow them to expand their business operation. For others, it can cut the cost of electricity or power remote systems. Still for others, RETs can allow them develop a greater understanding of the significance of energy usage. All of these impacts will serve to decrease the vulnerability of Mae Mo to the effects of climate change and a fossil fuel economy. Additionally, the learning center has many opportunities to grow and expand. The learning center can gradually expand the scope

of the concepts and materials that it teaches about. One day, the ideals in this learning center will be able to spread to other communities, reaching a greater audience and having a wider impact.

Table of Contents

Figures and Tables

Glossary of Terms

BGET – Border Green Energy Team

Biofuel – any solid, liquid, or gaseous fuel derived from biomass

Biomass – biological material that can be converted into a biofuel

Community-based approach – PDA's model for engaging and empowering communities to solve social issues through collaboration

EGAT – Energy Electricity Generating Authority of Thailand

FiT – feed-in tariffs

GHGs – Greenhouse gasses

IQP – Interactive qualifying project

Knowledge transfer – education that supplies community members with information communicated from experts and researchers

Learning center – an educational facility that addresses a gap in knowledge of a specific target group and works to provide them with the knowledge and skills to close that gap

NGO – Non-governmental organization

PAR – Participatory action research

PDA – Population and Community Development Association

PV – Photovoltaic

Renewable energy technologies (RETs) – technologies that utilize renewable energy sources (e.g. wind turbine)

SHS – Solar Home Systems

SPWS – Solar Power Water Systems

TE – thermal energy

VSPP – very small power producers

1 Introduction

"Climate change is the greatest emerging threat to public health and the environment" (Castleden et al., 2011). Climate change is caused by an increase in the concentration of greenhouse gases (GHGs) in the atmosphere, which results in an increase in temperature and a change in weather patterns throughout the globe. In a 2007 report, the Intergovernmental Panel on Climate Change (IPCC) concluded that it is "*extremely likely* that human activities have exerted a substantial net warming influence on climate since 1750" ("IPCC Fourth Assessment Report: Climate Change 2007," 2007). There are serious social, economic, and environmental implications to climate change. A recent report commissioned by 20 governments revealed that "100 million people will die and the global economy will miss out on as much as 3.2 percent of its potential output annually by 2030 if the world fails to tackle climate change" (Chestney, 2012).

Some nations are more vulnerable to climate change then others. A nation's vulnerability is "a function of the character, magnitude, rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity" (*Adapting to the Impacts of Climate Change*, 2010). Vulnerability describes the idea that nations will feel the effects of climate change differently. For example, some nations will experience greater warming trends and more drastic sea level rise than others due to geographic location. Another component of vulnerability is the ability of a nation to adapt to these changes. Studies have concluded that Thailand will be physically affected by climate change due to its geography, and the nation's ability to adapt to climate change are limited by its economy and level of development (Marks, 2013).

Currently, Thailand relies heavily on fossil fuels for energy. Additionally, much of Thailand's energy is imported from neighboring nations (Mulugetta et al., 2007). Utilizing RETs can decrease Thailand's GHG emissions, decentralize power systems, and increase the nation's energy independence. Mae Mo is particularly affected by Thailand's fossil fuel dependence and energy insecurity. All 13 of Thailand's coal fired power plants are located in Mae Mo, Lampang Province (Soonya, 2012). Community members of Mae Mo have experienced negative health and environmental impacts from the surrounding mines and plants (Cohen & Buakamsri, 2006). Plant failures have occurred throughout the decades of their operation, leaking emissions and pollutants have resulted in the destruction of health, livelihood, and the environment (Forsyth, 2004). The area is very reliant on fossil fuels and is thus vulnerable to changes in fossil fuel economy as well as the destabilizing impacts of climate change.

A nation's vulnerability to climate change can be reduced through several methods. Present methods in reducing vulnerability focus around renewable energies and renewable energy technologies (RETs) as they offer a multifaceted approach to reducing a nation's vulnerability. RETs emit fewer GHGs than conventional energies, provide a decentralized power system, and improve the capacity of a nation to cope with dwindling fossil fuel supplies (*Adapting to the Impacts of Climate Change*, 2010).

Nations around the world experience many barriers to the successful implementation of RETs. Barriers can stem from technical, informational, economic, political, institutional, and knowledge obstacles that limit the success of these technologies (Richards et al., 2012; Uddin et al., 2006). These barriers are caused by actors such as the government, industry, and non-

governmental organizations (NGOs). These actors can also be a part of the solution. In many cases, technical and informational barriers can be addressed by providing communities with more information, training, and user-friendly technology. Structural and institutional barriers, such as poverty and regulatory policies, may not be so easily addressed.

In Mae Mo, knowledge barriers have mostly prevented the successful implementation of renewable energy technologies. Additionally, community members do not always recognize the scope of the problems they face and a lack of understanding about how renewable energy technologies can provide a solution. The sponsor of this project, the Population and Community Development Association (PDA), hopes to address knowledge barriers such as a lack of access to information about RET, its benefits, and its social acceptance that are currently preventing the successful utilization of RETs in Mae Mo through the use of a learning center. A learning center is an educational facility that addresses a gap in knowledge of a specific target group and works to provide them with the knowledge and skills to close that gap. To assist PDA in overcoming these barriers, the goal of our project was to provide recommendations to PDA Mae Mo to develop a learning center about renewable energy technology and its applications. To achieve this goal we executed four objectives:

1. Determine criteria of a successful learning center to determine the location, design, and educational media to be used in the PDA learning center for Mae Mo
2. Assess the energy usage, energy needs, and the cost of electricity for community members of Mae Mo
3. Determine affordability, user-friendliness, and local availability of renewable energy resources to evaluate physical and social feasibility of renewable energy technologies for the communities of Mae Mo
4. Develop recommendations and materials about renewable energy technologies that will be made available in the Mae Mo learning center

To develop these recommendations, we utilized PDA's community-based approach to knowledge transfer in order to actively engage the community in every facet of the project and ensure that educational materials met the needs of community members. By conducting interviews with many actors, we were able to understand the needs of the community and the goal of PDA and connect them in the learning center in Mae Mo.

Through this methodology, we were able to recommend an appropriate learning center site and layout for PDA. Additionally, our research helped us identify gaps in the knowledge of community members that can be addressed through the learning center. Specifically, community members can benefit from information about the specific applications and benefits of RETs and how these benefits apply to their lives. In the future, we believe that this learning center will effectively address the knowledge and economic barriers hindering renewable energy implementation while creating an engaging and sustainable learning environment.

2 Background and Literature Review

This chapter will begin by examining the implications of conventional energy on human health and the environment, with a focus on climate change. We will explain how vulnerability to climate change varies from nation to nation. We will then examine how the implications of conventional energy use specifically affect Thailand and how they are compounded by Thailand's increase vulnerability to climate change. Next, we will identify how these implications have manifested in Mae Mo. Located in northern Thailand, Mae Mo holds all 13 of Thailand's coal-fired power plants and has experienced many of the negative aspects of fossil fuel consumption. We will then introduce renewable energy technologies (RETs) as a solution to vulnerability in Mae Mo. While renewable energy is a way to mitigate the negative effects of reliance on conventional energy, many barriers prevent the success of RET projects. We will examine the economic, policy, social, technology, and knowledge barriers that act as roadblocks to the successful implementation of RETs. A barrier in knowledge is the most fundamental of all the barriers. Without knowledge about the other barriers, renewable energy technology projects will continue to suffer. We will introduce how effective knowledge transfer can work to overcome these barriers. We will examine how non-governmental organizations (NGOs) in Thailand that have worked to address these barriers. The Population and Community Development Association (PDA) is an exemplary organization of successful knowledge transfer. We will demonstrate what has been developed as effective methods to transfer knowledge to community members through learning centers. Lastly, we will determine why PDA has been so successful in their knowledge transfer methods and how other actors can execute these steps as well.

2.1 Implications of conventional energy use

This section will explore some of the implications of conventional energy use. Conventional energies describe energy sources that the world currently relies on for the production of energy and electricity, such as coal and petroleum. The production of fossil fuels through mining and refining can negatively affect people and the environment. The consequential combustion of these fuels releases many harmful pollutants, including carbon dioxide, sulfurous and nitrous oxides, particulate matter, and heavy metals (*Climate Change 2001: The Scientific Basis*, 2001). These pollutants have many negative environmental and social impacts on local, regional, and international scales.

Of all fossil fuels, coal is a particularly reliable and particularly dangerous form of energy and has had devastating effects on areas throughout the world. While the physical act of mining serves to mar and degrade the land, the mining process and the combustion of coal severely pollute the land, air, and water (Tiwary, 2001). Communities located near coal mines have a higher risk of developing many respiratory diseases including asthma, lung disease, and chronic obstructive pulmonary disease (COPD) (Castleden et al., 2011). A study completed in the mines of West Virginia, USA, states that a higher mortality rate was seen for respiratory diseases than in a non-mining area (Castleden et al., 2011). The health impacts and medical bills accumulated from coal related illnesses are detrimental to US society. "The health costs of burning coal are equivalent to a national health burden of around $2.6 billion per annum" (Castleden et al., 2011). The health effects and economic difficulties experienced by these communities can also contribute to depression, stress, and other mental health illnesses.

Climate change is another impact of conventional energy use. Climate change has been caused by an increase in greenhouse gases that warm the earth. The greenhouse effect is a natural result of the earth's atmosphere absorbing long wave radiation from the sun after entering the atmosphere (Schmidt, 2007). Infrared spectra from space indicate that carbon dioxide, methane, and ozone are examples of gaseous components in the atmosphere that work to absorb this radiation. As an efficient and reliable means of energy production, the use of these fuels has expanded rapidly along with industrialization. Carbon dioxide concentrations in the atmosphere in particular have risen from 280 parts per million (ppm) to 380 ppm in the past 150 years (RealClimate, 2004).

As a result of climate change, the world has experienced gradual warming trends that have increased in recent years, as depicted in Figure 1. When compared to data collected since 1880,"October 2012 tied with 2008 as the fifth warmest October on record, at 0.63°C (1.13°F) above the 20th century average of 14.0°C (57.1°F) ((NOAA), 2012).

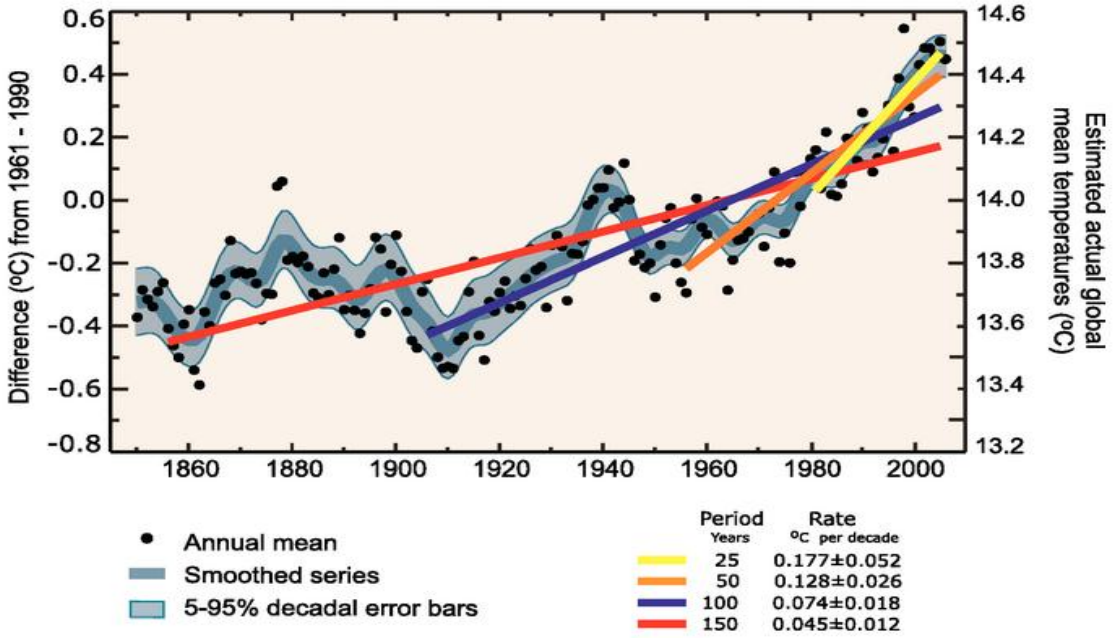

Figure 1: IPCC reports rising temperatures, displaying linear trends for the past 150, 100, 50, and 25 years ("IPCC Fourth Assessment Report: Climate Change 2007," 2007)

Climate change is projected to increase global temperatures and increase weather variability. Both temperature and precipitation changes can make areas that are currently ideal for agriculture unsuitable for growing (Wilfrid & Hsin, 2010). The corn belt of the United States and the rice fields of Asia could both be uprooted by changes in temperature and precipitation, affecting massive populations of people who rely on these staple crops. Some nations are more vulnerable to climate change then others due to factors such as location, development, economic stability, and ability to adapt to a changing climate (*Adapting to the Impacts of Climate Change*, 2010). Increasingly, the world will begin to feel disproportionate negative effects as a result of a changing climate.

2.2 Thailand's vulnerability to climate change

Thailand is particularly vulnerable to climate change. In considering Thailand's ability to cope with climate change, studies have concluded that "Thailand will likely be one of the most affected countries given its geography, economy and level of development" (Marks, 2013). Pollution, development, and social and political inaction are all issues that affect Thailand's capacity to cope with climate change (Marks, 2013). This section will examine how the impacts of a changing climate have already manifested in Thailand. It will then consider how well Thailand can cope with these changes before examining the regional vulnerability of Mae Mo, Thailand.

The temperature differences attributable to climate change may not seem very significant in size, but they have drastic implications for the environment, particularly in developing, tropical nations like Thailand. Annual mean temperatures in Thailand have risen by approximately one degree Celsius between 1981 and 2007, while the amount of precipitation in Thailand has decreased from 1961 to 2011 (Marks, 2013).

While overall precipitation has decreased, the intensity and frequency of flooding in Thailand has increased (Marks, 2013). The consequences of this simultaneous rise in temperature and increase in the severity of flooding are disastrous for the nation's agricultural sector. However, about 14% of global GHG emissions are produced by the agricultural sector (Wilfrid & Hsin, 2010). Fossil fuels are used in many aspects of farming practices, from the production of artificial fertilizers to the transportation of products, which contribute to the release of GHGs such as methane (Wilfrid & Hsin, 2010). Increasing temperatures and a decrease in precipitation resulted in droughts throughout Thailand in 2010. Water management problems have risen as a result of droughts as well as increasing water usage in cities (Marks, 2013). Ironically, in 2011, Thailand experienced incredibly devastating floods that can also be linked to climate change (Peterson, Stott, & Herring, 2012).

Thailand is also vulnerable to climate change when considering its adaptive capacity, or ability to adapt to and cope with the effects of a changing climate. The Institute of Southeast Asian Studies concludes that Thailand has a relatively low adaptive capacity and would need to make serious and immediate adjustments in order to properly mitigate the impacts of climate change (Marks, 2013). In the future, climate change will threaten food security, create tensions with neighboring countries over water resources, and increase health risks (Marks, 2013). Thailand's ability to adapt to these impacts in the present will have serious implications for how they will cope with climate change in the future.

2.2.1 Mae Mo's vulnerability to climate change

This section will explore how Mae Mo is particularly vulnerable to the negative effects of conventional energy use, especially pollution and climate change. We will then examine the ways in which the continued operation of the plants in Mae Mo has posed a serious threat to the region while furthering the effects of climate change. This section will conclude that the villages of Mae Mo, compared to other provinces in Thailand, are disproportionately affected by the pollution and climate changes that have resulted from national consumption of fossil fuels.

Mae Mo is located in Lampang Province, the third largest province in Northern Thailand. The Electricity Generating Authority of Thailand (EGAT) established 13 coal-fired power plants in this district due to the abundance of lignite (40,000 tons of lignite are mined per day) (Cohen & Buakamsri, 2006). Lignite has higher sulfur content and is less pure than other forms of coal, and it releases many more pollutants when it is burned. Industrial development in Thailand has resulted in the exploitation of natural resources in Mae Mo, which has contributed to environmental degradation and negative health impacts (Cohen & Buakamsri, 2006; Sanseverino et al., 2008).

The power plants in Mae Mo were constructed in 1958 and utilize lignite to produce electricity. A history of unsafe practices at the site of the Mae Mo power plants has continually had negative effects on human and environmental health (Forsyth, 2004). Air quality and pollution are serious issues for Mae Mo. Concentrations of particulate matter and other gaseous emissions are higher in Mae Mo than in other areas of Lampang ("The air quality in northern Thailand on February 20, 2556," 2013). In 1992, a failure of the sulfur scrubbing system on the plants resulted in the release of sulfurous dust (Forsyth, 2004). The leakage resulted in serious short- and long-term health problems as well as affecting surrounding agriculture (Forsyth, 2004). Incidents such as this have occurred throughout the process of mining in Mae Mo and continually harm the local people and environment. A mine in Mae Mo is depicted in Figure 2.

Figure 2: A lignite mine in Mae Mo, Thailand

Because the power plants use lignite, they emit more mercury than other plants in Thailand, contributing to greater environmental damage (Brigden, Santillo, & Stringer, 2002). Mercury is an extremely toxic heavy metal and can seriously impact human health at all stages of development (Brigden et al., 2002). Fly ash released from the plants contains other toxic materials that can spread into the environment (Brigden et al., 2002). A quality of life assessment conducted in the late 1990s found an increased death rate and increased occurrences of respiratory problems such as bronchitis and chronic sinus infections (Sanseverino et al., 2008). Villagers have also experienced psychological problems resulting from health issues as well as a general lack of security (Sanseverino et al., 2008).

The agricultural sector endures a large economic burden in response to even slight climate change, specifically variations in rainfall and temperature (Sherwood & Huber, 2010). Lower income rural areas, like Mae Mo, are less able to cope with the adverse effects of these weather changes financially and it can significantly lower their quality of life (Sherwood & Huber, 2010). Rice agriculture is particularly vulnerable to the changes in temperature and precipitation that result from a changing climate (Marks, 2013). Thailand is a major producer and exporter of rice and 40% of the population relies on agriculture for income (Marks, 2013). Reductions in rice

crops from climate change have resulted in major economic losses and rice's sensitivity to water and climate are expected to intensify these losses (Marks, 2013). Climate change has already affected rice yields as well as the livelihoods of farmers who depend on this crop. Mae Mo has a large agricultural sector (composed of rice and non-rice crops) that will be very affected by a changing climate.

Mae Mo could benefit from RETs as a means to reduce the area's vulnerability to climate change and fossil fuel consumption. RETs could be used to provide power to areas currently off the grid, increasing opportunities for agriculture in the area. Additionally, increasing the capacity of RETs would reduce the area's reliance on fossil fuels, working to reduce the energy insecurity that the area can experience.

2.3 Renewable energy as a solution to vulnerability to climate change

The IPCC states that "the technical potential of renewable energy technologies to supply energy services exceeds current demands" (Edenhofer, 2011). While there are many opportunities to utilize renewable energy and renewable energy technologies, they are not being implemented to their full capacity. Continued development of appropriate technologies is needed to help nations adapt to climate change (*Adapting to the Impacts of Climate Change*, 2010). The effective use of RETs is essential to moving towards energy security and a more stable climate. Renewable energies and renewable energy technologies (RETs) are versatile systems that can benefit society in many ways. This section will examine some of the benefits that RETs can provide and how these benefits can reduce a nation's vulnerability and susceptibility to changes in the climate and fossil fuel economy.

Renewable energy technologies such as solar, biomass, and hydro power use inexhaustible and natural resources to generate electricity. These sources of power can be used to reduce conventional energy consumption, thereby limiting the emission of GHGs and mitigating climate change (*Adapting to the Impacts of Climate Change*, 2010). RETs can be used to pump and purify water, provide electricity, and reduce reliance on conventional energy sources.

There are economic, social, and environmental benefits that can result from utilizing renewable energies. The price of renewables is almost completely independent from other fuel costs; they have close to unlimited production potential; and do not emit harmful pollutants such as carbon dioxide and heavy metals (Pflüger, 2010). These advantages are appealing to many nations that are seeking solutions to rising energy consumption and demand.

Decentralization of power systems can be a technological advantage that reduces transmission costs as well as vulnerability (Pflüger, 2010). Areas with renewable energy systems do not have to rely on the grid and are less likely to experience other vulnerabilities that come with grid-power, such as unreliability and power outages. Decentralization of power supply through RETs can also electrify isolated systems that previously lacked grid access (Edenhofer, 2011).

Dwindling fossil fuel supplies are already affecting economies around the world. Not only can the use of RETs improve social and environmental health, they can also "reduce [a nation's] vulnerability to supply disruptions and market volatility" (Edenhofer, 2011). The utilization of RETs can also reduce environmental effects such as pollution and land degradation (Ocak, Ocak,

Bilgen, Keleş, & Kaygusuz, 2004). RETs utilize non-polluting sources and emit minimal (if any) pollutants. As RETs are still being developed, they are very versatile and can be adapted to many geographic locations.

RETs can provide many benefits to particular economic and societal sectors, including agriculture. Sustainable agriculture is described as the "balance of maximizing crop productivity and maintaining economic stability, while minimizing the utilization of finite natural resources and detrimental environmental impacts" (Chel & Kaushik, 2011). Using renewable resources can satisfy the first principle of agricultural sustainability, developed by Gerber in 1992. This principle states that renewable and recyclable resources and practices should be utilized to indefinitely sustain agricultural practices (Chel & Kaushik, 2011). Renewable energy can meet both of these goals by reducing the use of finite natural resources while increasing the sustainability of agricultural practices. Renewable energy can benefit agriculture further by reducing transportation and fuel cost, noise, and maintenance (Chel & Kaushik, 2011).

2.4 Renewable energy options

There are many different renewable energy technologies that can be utilized for various applications and benefit different sectors of society and the economy. This section introduces three renewable energy options, solar, hydro, and biomass that are feasible for rural communities throughout Thailand and comparable nations. First, each technology is briefly introduced and explained. Next, we seek to understand the uses of each technology and their benefits to the environment, society and the economy. We will identify further insights by investigating and examining case studies pertaining to the application of these three classes of RET.

2.4.1 Solar technologies

Solar energy is an alternative energy resource that utilizes radiation, in the form of light or heat from the sun, to generate energy. Since this form of energy absorbs radiation from the sun, it is a cleaner energy resource than fossil fuels and has minimal environmental impacts (Solangi, Islam, Saidur, Rahim, & Fayaz, 2011). Globally, solar energy has the greatest potential as an alternative energy source because "the sun radiates more energy in one second then people have used since beginning of time" (Solangi et al., 2011). However, solar energy is not easily implemented into all communities due to its high initial costs and more advanced technical requirements.

There are two main types of solar energy systems. Solar photovoltaic (PV) cells capture the energy of the sun on a thin film surface that then converts the energy into electricity. These systems can be connected to the grid (centralized systems) or generate electricity off-grid (decentralized systems) (Timilsina, Kurdgelashvili, & Narbel, 2012). The other method of harnessing solar energy is through solar collectors, which use the thermal energy of the sun for heating, cooling, and the generation of electricity (Timilsina et al., 2012).

2.4.1.1 Solar photovoltaic cells

Solar PV utilizes a sustainable energy source and is now the third most important renewable energy source in terms of installed global capacity (Pearce, 2002). Solar panels are used to generate power and are composed of solar cells containing photovoltaic materials such as silicon,

which works to turn the energy of the sun into electrical energy. Photovoltaic materials have advanced in recent years because of an increase in demand for renewable energy technologies (Pearce, 2002).

Solar energy is a widely available and clean source of energy. In most regions of the world, solar energy has more potential than current primary energy consumption methods in those regions (Timilsina et al., 2012). Although solar powered systems are adaptable and relatively reliable (Solangi et al., 2011), cost frequently inhibits the implementation of this technology. Additionally, the cost of solar electricity per unit can still be higher than the cost of conventional energy per unit (Timilsina et al., 2012).

The Population and Community Development Association (PDA) implemented Solar Powered Water Systems (SPWS) in Nakhon Ratchasima Province, to provide water for eight villages. This system consists of a solar panel used to pump water from either a surface or groundwater source, to storage tanks (Figure 3).

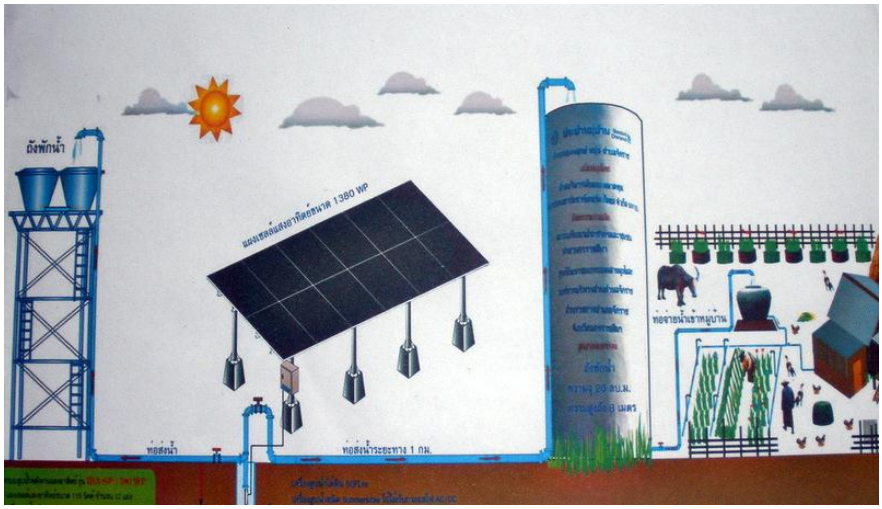

Figure 3: Diagram of solar powered water systems at the Chakkarat learning center

In 2012, these systems were evaluated to assess the impact the SPWS had on the villages. Overall the systems received positive feedback; however a few villages had experienced negative impacts on their community (Kimmel et al., 2012). The implementation of the technology was successful because many of the villagers felt PDA provided them with the information and resources necessary to implement. The success of many of the systems motivated villages to expand the system (Kimmel et al., 2012).

2.4.1.2 Solar thermal technology

Solar thermal collectors are classified into three categories: low-, medium-, and high-temperature collectors. Low temperature collectors are flat plates generally used for heating, cooling and ventilation. Medium-temperature collectors are also flat plate and are used for heating water or air for residential or commercial use. High-temperature collectors concentrate sunlight using mirrors and lenses and are used for producing electricity (Smith, 2010). Solar thermal energy can be used in many applications, including drying wood for construction, and heating water for household use (Punter, 2002).

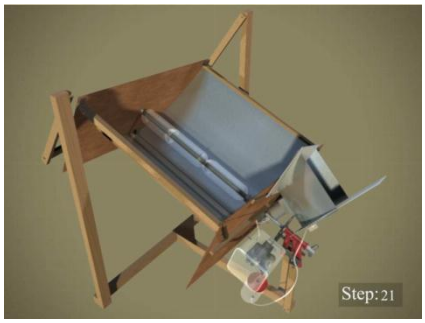

Figure 4: Solar collector from SolarFlower.org

Solarflower is a publicly accessible solar energy collector that is capable of tracking the sun's path automatically (Figure 4). It can be made from common recycled materials using basic tools, and can produce up to 500 Watts/hour in full sunlight at a low cost (less than $100 USD or 3000THB approximately). Potential uses include electricity production, oven with integrated water system for temperature regulation and water heating, steam distillation for removal of chemicals and heavy metals from waste, and food processing. Additional electricity produced can also be sold to consumers ("Solar Flower,").

2.4.2 Hydroelectric technologies

Hydroelectric power converts the potential energy of water into mechanical energy with the use of a turbine (Selin, 2012). The moving water rotates a turbine, which in turn drives a generator to convert the mechanical energy into electricity. Hydroelectric systems can utilize various scales of damming techniques to increase and control electrical output, or they can use the free flowing nature of the water (on a small scale) to generate electricity through micro-hydro systems.

Damming technologies are used to control the flow of water through the turbines and can increase the height of the head by increasing the level of water behind the dam, creating a higher potential power (Selin, 2012). The dam can cause many different changes to the water flow and levels downstream as well as flooding of land upstream (Pascale, Urmee, & Moore, 2011). This technology requires a large initial financial investment and large reservoirs of water, making it impractical to implement on smaller scales with limited resources ("Microhydropower Systems," 2012).

Micro-hydro systems are a more feasible option for rural communities (West et al., 2002). Micro-hydropower works by using the force of flowing water to turn a turbine, pump, or water wheel in order to generate electricity ("Microhydropower Systems," 2012). Micro-hydroelectric systems maintain the natural flow of the river and ecological balance and therefore have no major environmental impacts. However, the system relies directly on the river flow and power output will reduce or increase accordingly (Razan, Islam, Hasan, Hasan, & Islam, 2012). Micro-hydroelectric energy has been used as a standardized technology for off-grid and remote villages with a reliable running water supply. Electricity generated can be used for a specified task in the homes, including lighting, cooking, or heating water. Micro-hydro systems are also able to

replace diesel generators and decrease reliance on grid power, and can improve the socio-economic stability in the area of implementation (Razan et al., 2012).

The Border Green Energy Team (BGET) is a non-governmental organization that has worked throughout Thailand to implement RETs. In a village in the south of the Mae Hong Sorn Province, Thailand, BGET investigated the need for a reliable source of renewable energy (BGET, 2010). The village has a year round availability of water from two separate valleys. Micro-hydro systems were chosen to be used in the villages because of their user-friendly and reliable technology. The micro-hydro system includes a concrete dam to divert the water flow, a settling basin to reduce wearing on the technology due to sedimentation, as well as the power house that includes the generator to convert the mechanical flow of water to electricity.

The electricity generated from the project was sought to power 10-watt fluorescent light bulbs in every home in the village and an electricity outlet (BGET, 2010). The lowest flow rate during the dry season was measured at 27 liters/second, and the system works to reduce the environmental impact by utilizing no more than 50% of the dry season flow. The technology used for the pump system is low in cost, parts are locally available, and with education there was a local knowledge of the pump maintenance (BGET, 2010). This project demonstrates an environmental, societal, and economical technology that is feasible for implementation in rural Thailand.

2.4.3 Biomass technologies

While biomass is arguably the world's most traditional fuel source, recent advances in biofuel and biomass technology have improved this type of energy production (Prasertsan & Sajjakulnukit, 2006). Biomass is a renewable resource which can be used to generate biofuel. This can include gaseous or liquid fuel that can be used to produce clean electricity or natural gas. The material obtained from organic waste – including agricultural waste and animal manure – is high in carbon content and can be converted into carbon dioxide (waste) and methane (natural gas) by microorganisms ("What is biomass?," 2011). Micro scale biomass systems utilize surplus raw and waste materials, including animal and agricultural waste, that would otherwise have little to no utility (Nersesian & Ebrary Academic, 2010). After processing in a biomass digester, the system will produce useful products such as natural gas and fertilizer (BGET, 2010).

Biomass plantations have been criticized for taking up land that could otherwise be used for commercial agriculture, industrial development, or residential expansion. At such a large scale, the costs can outweigh the benefits. Collecting biomass through recycling or using items that are deemed waste, however, generates fewer products and may in fact reduce waste (Nersesian & Ebrary Academic, 2010). Utilizing agricultural waste in the form of stalks, stems, and husks, for example, serves to use waste that would otherwise have no utility. Biomass emits no net releases of carbon dioxide and has minimal sulfur content. The economic viability of biomass could increase if fossil fuel prices continue to rise (Demirbas, 2008). Like many renewable energies, biomass is readily available worldwide. However, biomass is unique in its ability to produce solid, liquid, and gaseous fuels (Demirbas, 2008). The production of biofuels offers benefits such as "sustainability, reduction of greenhouse gas emissions, regional development, social structure and agriculture, security of supply" (Demirbas, 2008).

Biomass has been recognized in some developing nations, such as isolated areas throughout Indonesia, as having high potential to be used on a micro-electricity-generation scale (Nersesian & Ebrary Academic, 2010). Biomass systems implemented in small communities can help mitigate negative environmental, social, or economic costs compared to large scale plants. A study in Mexico revealed that integrating the needs of cooking stove users with the designers of the cooking stove drastically increased the benefits received as well as its acceptability in the community. The new cooking stove is more efficient, reduces emissions, and decreases environmental and health impacts (Pine et al., 2011). Additionally, the stove can cut down on the time it takes to cook and gather fuel, allowing time for other important activities (Pine et al., 2011).

2.5 Barriers to renewable energy implementation

It is clear that renewable energy technologies can present a multitude of benefits to a variety of communities. However, non-governmental organizations (NGOs), national governments, organizations of the private sector, and other actors have faced barriers while attempting to address growing global energy demand with renewable energy. In many cases, renewable energy projects are unsuccessful due to an assortment of barriers (Reddy & Painuly, 2004). The barriers that this section will address are economic, policy, social, technology and knowledge.

Economic and policy barriers themselves tend to be regulated by national and local governments. Systemic action to address these barriers can only happen as a result from changes made by government. In contrast, social and technology barriers can be addressed more locally for they each result from a lack of understanding about how and why renewable energies should be implemented into a community. As a result of misinformation, miscommunication, or misunderstanding, knowledge barriers act as the most fundamental roadblock to successful implementation of RETs (Richards et al., 2012). Unfortunately, knowledge barriers usually result from simply inadequate access to reliable information (Richards et al., 2012).

There have been many projects that failed because actors working towards renewable energy technology (RET) implementation did not acknowledge and address these barriers. This section will serve to analyze these various barriers and put them in the context of Thailand. Although knowledge barriers cannot mitigate all the barriers that exist they are the fundamental roadblocks to RET implementation.

2.5.1 Economic barriers

All around the world, nations face economic barriers which prevent the development of renewable energy. Financial barriers, such as high initial costs, usually result in fewer incentives for communities to utilize renewable energy technologies. For developing countries, the frequent issue is the availability of capital to start a project in the first place (Mondal, Kamp, & Pachova, 2010)

In general, renewable energies such as solar PV and biomass are known to be expensive to implement (Parikka, 2004). Implementation projects have had difficulty getting off the ground due to lack of investment. For example, in India, projects with biomass are often not pursued due to financial reasons (Parikka, 2004). Banks are frequently reluctant to invest in biomass projects

because they require high investments and are not known to be as profitable as other types of energy production. The combination of high initial costs for biomass and the low costs of conventional energy have formed a roadblock to the implementation of renewable energy. Many rural communities in India lack the funding and budgets needed to support a renewable energy system (Parikka, 2004).

In a Maharashatra, India case study, the various barriers to systematic barriers of RET implementation were addressed. It was examined that the major economic incentive for RET implementation that was being supplied to consumers were subsidies from the government. Providing subsidies for projects relating to RET implementation are not uncommon. However, this study examined that even though subsidies are meant to stimulate the RET market, "the fact is that the burden is shifted from the consumer to the tax payer" (Reddy & Painuly, 2004). The study concluded that in developing countries such as India, financing options for RET projects must be adapted to local needs and traditions.

Frequently, there is little incentive for communities to switch to renewables when the cost of conventional energy is so low (Reddy & Painuly, 2004). Economic barriers such as the ones discussed above, must be addressed in order for renewable energy to be considered as an electricity generation option.

2.5.2 Policy barriers

"Even after governments' best efforts to promote RETs, they have failed to emerge as prominent competitors to the conventional energy technologies" (Reddy & Painuly, 2004). Energy policy is a major factor that contributes to the accessibility of RET. Policy types can range from national to provincial based on the location and implementation level. Developing countries usually have a renewable energy support policy as an incentive for investors to help renewable energy commercialization (Sawin, 2012).

A case study that took place in Bangladesh identified that most of the RET implementation programs are government and donor-funded and focus on research and development as opposed to promotion and implementation (Mondal et al., 2010). The study examined five aspects of policy barriers that limit incentive to utilize RETs:

1. Lack of financial incentive policies to encourage private sector investments in RET development
2. Lack of regulations for purchase incentives of RETs by consumers
3. Lack of coordination between actors behind RET implementation (ex. Various ministries, agencies, and institutions)
4. A complicated and lengthy project approval process
5. Reliance on national budgets for financing as well as delays associated with decision making

As a result of this study, it was determined that an umbrella organization for "monitoring, regulating, capacity building through research and training, and evaluating impacts of RETs projects" should be established (Mondal et al., 2010).

Thailand's electricity sector was once a government monopoly but now has turned into a semi-unbundled structure called the Enhanced Single Buyer model. This model consists of the Electricity Generating Authority of Thailand (EGAT) owning about 50% of generation assets and the other half is owned by private companies (i.e. Independent Power Producers (IPPs), Small Power Producers (SPPs), and Very Small Power Producers (VSPPs)) (Amranand, 2008). IPPs and SPPs produce and sell power to high voltage transmission systems owned by EGAT while VSPPs sell power through the state owned distribution systems such as the Metropolitan Electricity Authority (MEA) and the Provincial Electricity Authority (PEA) (Amranand, 2008).

Thailand's energy policy, including electric power and renewable energy, is drafted and proposed by the Ministry of Energy (MoE) while policies regarding electric power and natural gas transmissions are regulated by the Energy Regulatory Commission (ERC). This causes problems pertaining to the regulation of the emerging renewable energy sector. The renewable energy policy in Thailand is a hindrance to the growth of renewable energy use because there is no cohesive policy, therefore affecting RET accessibility to community members. The feed-in tariff program in Thailand has been implemented since 2006. This program is supposed to provide incentives for investment in the renewable energy sector. Although the strong policy on renewable energy has been successful in attracting interest from investors and project developers, weak regulatory support and lack of public communication about a renewable energy policy has been a problem with the Feed-in Tariff (FiT) program (displayed in **Table 1**) (Tongsopit & Greacen, 2012).

As of 2012, many energy plans have been proposed, each of which corresponds to different government divisions. Some of the current energy plans include the long term Power Development Plan (PDP 2010-2030), the 15 year Renewable Energy Development Plan (REDP 2009-2022), and the 20 year Efficiency Development Plan (Amranand, 2008). However, unlike many other countries, Thailand lacks a cohesive renewable energy law. The absence of a unified energy plan means that the Power Development Plan and Renewable Energy Development Plan, instead of complementing each other, could compete with each other in the future (Amranand, 2008).

Table 1: Thai VSPP feed-in tariffs

Fuel	Adder	Additional for diesel offsetting areas	Additional for 3 southern provinces	Years effective
Biomass				
Capacity <= 1 MW	$ 0.015	$ 0.030	$ 0.030	7
Capacity > 1 MW	$ 0.009	$ 0.030	$ 0.030	7
Biogas				
<= 1 MW	$ 0.015	$ 0.030	$ 0.030	7
> 1 MW	$ 0.009	$ 0.030	$ 0.030	7
Waste (community waste, non-hazardous industrial and not organic matter)				

Fermentation	$ 0.074	$ 0.030	$ 0.030	7
Thermal process	$ 0.104	$ 0.030	$ 0.030	7
Wind				
<= 50 kW	$ 0.134	$ 0.045	$ 0.045	10
> 50 kW	$ 0.104	$ 0.045	$ 0.045	10
Micro-hydro				
50 kW - <200 kW	$ 0.024	$ 0.030	$ 0.030	7
<50 kW	$ 0.045	$ 0.030	$ 0.030	7
Solar	$ 0.238	$ 0.045	$ 0.045	10

(assumes exchange rate 1 Thai baht = 0.029762 USD)

2.5.3 Social barriers

Community opposition is often a barrier that prevents renewable energy from being successful. Further, there exist examples of blatant reluctance to accept a new system (Reddy & Painuly, 2004). Lack of social acceptance of technologies usually occurs when there is misunderstanding or misperceptions about renewable energy and its implementation possibilities (G. Baldwin, Childs, Hunter, & Urrea, 2007).

A paper analyzing the Maharashtra State, India, as a case study found that "data reveal[ed] that the adoption of RETs is influenced by the consumers' perceptions of the quality and usefulness of technologies when compared to the conventional ones" (Reddy & Painuly, 2004). This exemplifies how community perceptions affect the successful implementation of RETs. The study determined that too frequently, consumers take the advice of their friends rather than obtaining information from experts (Reddy & Painuly, 2004). In order to gain acceptance from the community, correct information about all aspects of the RET must be available.

In a farming community of Thailand, the Thai government started a project to use rice husks as fuel for generating electricity through a biomass power plant (Prasertsan & Sajjakulnukit, 2006). The communities were just recently educated on the negative environmental impacts of coal-fired power plants, such as acid rain. As a result, communities refused to accept this technology, because they believed any power plant would result in acid rain and destroy their crops (Prasertsan & Sajjakulnukit, 2006).This presented another type of social barrier of RET implementation. Although education efforts were made previously, the information was not appropriately transferred to the villagers. Misperceptions of renewable energy by the community led to a lack of public support of the biomass power plant (Prasertsan & Sajjakulnukit, 2006).The government failed to address this barrier, which resulted in the failure of renewable energy efforts (Prasertsan & Sajjakulnukit, 2006).

2.5.4 Technology barriers

Technology barriers to renewable energies frequently develop as a result of the complexity of renewable energy systems. "Solar photovoltaic and biomass technologies have a much steeper

'learning curve' compared with fossil-based technologies" (Uddin et al., 2006). Solar PV and Biomass technologies are typically more complex, which makes it more difficult to simplify for communities of lower education levels to understand (Uddin et al., 2006).

During a case study in Saskatchewan, Canada, interviews were conducted from a multitude of actors behind a wind energy implementation project. Individuals were asked to categorize the magnitude and effects of various barriers the project faced. Technology as a barrier was the most frequent identified problem. It was concluded that to address barriers involving technology, deliberation to uncover what is actually known about the technology first, is essential.

Another dimension of technology barriers pertains to the performance and reliability of RETs. The amount of technical risk is specific to each RET in particular. The development of RETs over the past few decades has worked to gradually advance and stabilize technologies. While the technologies are more sophisticated than they once were, site-specific limitations and considerations can increase the technical risk of implementation, reducing the success and sustainability of the RET (Reddy & Painuly, 2004).

In Thailand, there have been several examples where renewable energy systems fail due to a lack of knowledge on how to maintain the technologies. These failures present a knowledge barrier that manifests in a technology barrier because community members may not have the available technical skill to maintain systems. In 2004, the Thai government donated 200,000 Solar Home Systems (SHS) to rural villages in the Tak Province (G. Baldwin, Childs, Hunter, & Urrea, 2007). Within one year of implementation, the SHS started to experience failures such as manufacturing defects, installation errors, and user errors (G. Baldwin et al., 2007). Community members were not trained on how to properly maintain the system after installation. When problems with the system developed, the SHS became useless to the community (G. Baldwin et al., 2007). For the long-term success of this project, extensive training on the technology could have prevented the renewable energy systems from failing. This knowledge would allow community members to identify installation, manufacturing, and maintenance errors involving the system.

2.5.5 Knowledge barriers

An example of wind energy implementation in Canada addressed how knowledge barriers played a role in addressing other barriers to the project. "Results show a number of perceived barriers to wind energy investment, however, these barriers can be explained in large part by knowledge barriers" (Richards et al., 2012). This study exemplified how economic, policy, social, and technology barriers can all be identified as knowledge barriers. It is not to say that acknowledging these barriers alone will result in mitigation of the issues, but knowing about them is essential to enable successful implementation of RETs.

In the case study from Saskatchewan, Canada mentioned above, the government and non-governmental organizations, which play major roles in the development of renewable energy, were asked to identify the barriers of RET installation. When asked about possible barriers of implementation, the majority of actors denied their existence. In the past, when NGOs and the Canadian government have failed to acknowledge that barriers exist, the projects frequently

failed (Richards et al., 2012). In general, when possible economic, policy, and knowledge barriers are not acknowledged by NGOs and the government prior to implementing a renewable energy system, the projects usually result in failure ((Reddy & Painuly, 2004; Richards et al., 2012).

Another example occurred near the Mekong River in Thailand where the national government was working to build a hydroelectric power plant (Wongruang, 2012). Despite the economic and environmental benefits to this project, public support remained an issue because surrounding communities only understood the negative impacts the dam would have. Communities felt that hydropower projects would change their living styles and take their land away (Wongruang, 2012). While these negative impacts are important for the government to consider, they did not educate the communities on the positive effects hydropower can have. Transferring the knowledge about the positive impacts of hydropower could have helped gain more public support and make the hydropower plant a more successful project (Wongruang, 2012).

Frequently in the United States, collaborative extension services are provided by the university system. This arrangement allows for research and outreach to be provided by one organization. In contrast, developing countries are often faced with a disconnect between the technical knowledge and community outreach efforts (J. R. Anderson & Feder, 2003). This issue is prevalent because research institutions and extension managers are not frequently aligned. The outcome of this disconnect is detrimental to the effectiveness of extension services since the education provided to communities in need may not be relevant or accurate. To remedy this, it is essential for communities, researchers, knowledge transfer agents and governmental sectors to be in communication (J. R. Anderson & Feder, 2003).

From this analysis, it is essential to note that addressing knowledge barriers is the fundamental step to successful implementation of renewable energy technologies. Knowledge barriers can manifest in a variety of ways depending on the actor being addressed. For example, if experts have incomplete or contradictory ideas about a RET compared to each other, flawed assumptions can be repeated or even validated (Richards et al., 2012). Further, if knowledge is widely available but not entirely reliable, political decisions to endorse increased investment in RET programs will be less efficient. The study performed in Canada determined that much of the perceived technology, and political barriers were rooted in knowledge barriers (Richards et al., 2012). When local people do not have knowledge about RETs, they do not have the ability to successfully implement RET technologies. On a community scale, it is important to acknowledge that political and economic barriers cannot be met and overcome; rather, they can be addressed in a sustainable way to accommodate the community. In contrast, technology, social, and general knowledge barriers can be addressed on a community level through successful knowledge transfer methods.

2.6 Opportunities to overcome knowledge barriers to renewable energy technology implementation

This section will serve to develop an understanding of the framework of how to sustainably address knowledge barriers. One way to do this is in rural communities is through learning centers. PDA has cultivated successful knowledge transfer methods that are utilized at their learning centers through a variety of media. Knowledge transfer in the context of PDA and our project consists of education that supplies community members' information from collaboration between experts and researchers. PDA will utilize their community-based knowledge transfer methods in a learning center to assist the community in addressing their energy problems.

2.6.1 Knowledge transfer as an opportunity

Renewable energy efforts have been unsuccessful because there is a lack of information and proactive outreach about renewable energy's applications and benefits in Thailand (Uddin, 2013). "These are important issues because effective knowledge networking and effective communication between government institutions and local people are seen as a first step to encourage further market penetration of renewable energy systems" (Reddy & Painuly, 2004). In order for renewable energy systems to be understood and promoted, it is important to establish a way of transferring knowledge from the experts to the end-users, which the end users need and believe is relevant and credible. Utilizing learning centers as outreach facilities is an option for transferring knowledge from actors such as the government, NGOs, and other experts to the communities in which renewable energy can be beneficial. Providing communities with information on the technology, the benefits, its applications, and financing options will help overcome knowledge barriers that have prevented installation of systems in the past (Pokorny, Cayres, & Nunes, 2004; Reddy & Painuly, 2004).

The role of government and non-governmental organizations (NGOs) in promoting renewable energy includes aiding this transfer of knowledge. In the past, NGOs that have successfully implemented renewable energy have also acknowledged barriers. NGOs like The Border Green Energy Team (BGET), have considered the various knowledge barriers that exist. While BGET specializes in renewable energy projects, their process of implementation and knowledge transfer has resulted in successful projects (BGET, 2010). In many of their projects, they utilize a participatory approach to understand the needs and desires of the community in order to transfer knowledge about renewable energy in a way fits the villagers needs and desires.

For example, after the 200,000 Solar Home Systems (SHS), mentioned in the previous section, started to malfunction, BGET focused their attention on improving the long-term sustainability. While the government was helpful in addressing the financial barriers, they failed to acknowledge the knowledge barriers. BGET has a participatory approach that helped involve the community on making these improvements and transferring knowledge about the SHS (BGET, 2010).

A study conducted in low-income rural areas of the Brazilian Amazon assessed the role of knowledge transfer services in the implementation of strategies for development of sustainable management of natural resources. The rural areas were restricted in their endeavors by limited

financial and human resources. Short-term facilitation visits (monthly; each a few days long) by external researchers, governmental programs, and NGO's were introduced to establish planning and learning programs about how to reduce the village's dependence on açaí (a species of palm tree frequently cultivated for its fruit) for nutrition and income (Pokorny et al., 2004).

By utilizing participatory action research, a model for extension and knowledge transfer was created to increase the efficiency and relevance of external support for local farmers. The model utilized practices and recommendations established by villagers and for villagers (Pokorny et al., 2004). Community members identified two standout advantages of the development initiative. First, the control that the community had over decision-making and information gathering was empowering. Second, the absence of external obligations lifted the usual pressure that the community faced by industry desiring açaí. At the end of the study, groups communicated that they could manage future problems and felt able to continue programs even without external support (Pokorny et al., 2004).

When addressing the barriers to renewable energy implementation, it is important to involve the community in the methods of knowledge transfer in order to ensure the information will be understood and accepted by the community. Therefore, when the government and NGOs are involved in promoting renewable energy, it is important that they use knowledge transfer methods that work for the communities in which they are working (Pokorny, Cayres, & Nunes, 2004; Reddy & Painuly, 2004).

2.6.2 Designing a learning center with successful knowledge transfer

Learning centers have proven to be a successful method of knowledge transfer in rural communities across the world. To establish a successful learning center, the needs and aptitudes of the community must first be assessed. Next, in a collaborative way, the community and the actors installing the learning center must come to a common understanding of the problem that is faced by the community. Then through communication with members of the community, appropriate knowledge transfer media must be identified. These media involve various methods and materials by which knowledge transfer is executed to previously identified target groups. Lastly, with the knowledge of the problem and potential solutions, the community must construct their own solutions to problems they face (Pokorny et al., 2004).

The Population and Community Development Association (PDA) utilizes a community-based approach to sustainable poverty mitigation, which has been successful in rural Thailand. Projects in rural communities frequently work to address gaps in knowledge through the use of learning centers that focus on educating and empowering locals on ways to increase their quality of life. Through PDA's community-based approach, they work to involve community members in decision-making processes and address the knowledge barriers that hinder sustainable development ("The Population and Community Development Association (PDA)," 2012).

PDA uses learning centers to educate villagers on different ways to improve their quality of life. The community that the learning center is designed for is first analyzed to determine the most useful information to be covered at the site. Each learning center built by PDA works to ensure that the education that community members receive is relevant to their daily lives. Topics covered in a learning center could range anywhere from income generation to agriculture to

renewable energy technology. PDA has established several learning centers located in various districts of Mae Mo which cover topics that cater to specific communities ("The Population and Community Development Association (PDA)," 2012). PDA utilizes this framework in their learning centers to ensure sustainable solutions are put in place by the community, for the community. This method has successfully addressed knowledge, technology and social barriers in that knowledge transfer is provided through community members with information supported by experts.

One of PDA's most prominent learning centers in Mae Mo is based on the Royal sufficiency initiative. The creation of this center was driven by His Majesty King Bhumibol's promise to improve the living conditions of Thai citizens. To achieve this goal, Royal Projects have been underway that frequently take place in rural areas of Thailand (Rachawadi, 2005). The center in Mae Mo has a simple water treatment system that utilizes treatment pools to clean water runoff from the village. At the learning center villagers are educated about farming practices through informative hands-on workshops. The center has plots of land owned by the village that the community members can use to grow crops for consumption or to sell. PDA has created a small market at the front of the learning center that can be utilized by villagers to sell their crops for personal income generation. This center has substantially impacted the villagers' lives by empowering them with education and a stable source of income.

2.6.3 PDA's renewable energy projects

In 2011, PDA worked with eight villages of Nakhon Ratchasima Province to implement Solar Powered Water Systems (SPWS). PDA was working to address the rising cost of energy which was exacerbating debt in the communities. In 2012, these systems were evaluated to assess the impact the SPWS had on the villages. Overall, the implementation of the technology was considered successful because many of the villagers felt PDA provided them with the information and resources necessary to implement the systems (Kimmel et al., 2012). Through their community based approach, PDA successful overcame the knowledge barriers that the communities faced.

Recently, a learning center has been created in the village to educate about various renewable energy technologies. This center has worked towards further transfer of knowledge to villagers to encourage the use of these technologies. The success of many of the systems motivated villages to expand their system (Kimmel et al., 2012). This learning center helps to further address knowledge transfer.

Another example of successful knowledge transfer in the context of renewable energy projects is PDA's completed project in the province of Krabi. After the 2004 tsunami, farmers and fishermen suffered from costly diesel prices (Shapiro, 2006). The purpose of the project was to implement a village-scale biodiesel reactor that utilized vegetable oil to help generate income and meet energy needs of the community. The goals of the project included constructing the bio-diesel plant, creating a user guide for PDA, and training PDA workers to use the reactor. The project leader, Andrew Shapiro, designed, constructed, and tested the reactor. However, PDA participated in every aspect of the project. After Shapiro finished the construction and testing of the reactor, PDA took full ownership of the project. PDA continued to work on optimizing the process before they educated local villagers on the production of biodiesel (Shapiro, 2006).

PDA's involvement in this project demonstrates their innovative approaches to conventional problems as well as their community-based expertise (Shapiro, 2006). In this project, PDA successful overcame the technology barriers by using a community-based approach to knowledge transfer. PDA had an expert implement a complicated technology and teach it to PDA representatives, who simplified the training materials to a community level of understanding.

PDA has worked to implement learning centers to educate rural communities on these issues and provide them with tools to create their own solutions ("The Population and Community Development Association (PDA)," 2012). By providing effective knowledge transfer methods that are established by community members, knowledge barriers can be sustainably eliminated within communities. As learning centers provide more access to reliable information, economic, policy, social, and technology barriers can also be addressed. The reduction of these barriers does not mean that they will disappear, but that actors working towards RET implementation will be aware of the barriers that exist which will enable them to look to experts and other resources for solutions to these issues.

2.7 Conclusions

Our background research has examined how Mae Mo's 13 coal-fired power plants make the district more vulnerable to climate change. The negative environmental, health, and social implications of reliance on coal have already begun to affect the residents of Mae Mo. Renewable energy technologies (RETs) have been identified as a sustainable solution to mitigate long-term effects of climate change and short-term issues involving the health, environment and social fabric of community members in Mae Mo. Unfortunately, economic, policy, social, technology, and knowledge barriers have been identified as preventative issues to the successful implementation of RETs all around the world. Knowledge barriers are the most fundamental roadblock to successful RET implementation and if they can be sustainably addressed, these technologies have much potential for success in rural areas throughout Thailand.

PDA, our sponsor, has recognized the knowledge barriers that exist in Mae Mo about RETs. To work on addressing the barriers of potential RET implementation in Mae Mo, PDA plans to transfer knowledge through a community-based method. Successful methods of knowledge transfer utilize community members as leaders and collaborators for projects. To make this knowledge reliable and accessible, PDA plans to establish a learning center in Mae Mo. This learning center will serve as an educational facility that will address the gap in knowledge of the community members and will work to provide them with the knowledge and skills to close that gap. Determining effective methods of knowledge transfer are central to the success of learning centers. Our project worked to provide recommendations to increase the effectiveness of the learning center and increase the successful implementation of RETs.

3 Methodology

The goal of our project was to provide recommendations to PDA Mae Mo to develop a learning center about renewable energy technology and its applications.

This project was pursued between the months of October 2012 and March 2013. Our project was located in Northern Thailand, in the district of Mae Mo, of Lampang Province. The learning center will serve the five districts of Mae Mo, shown in Figure 5, Baan Dong (blue), Na Sak (purple), Chang Nua (green), Mae Mo (yellow), and Sop Pat (red).

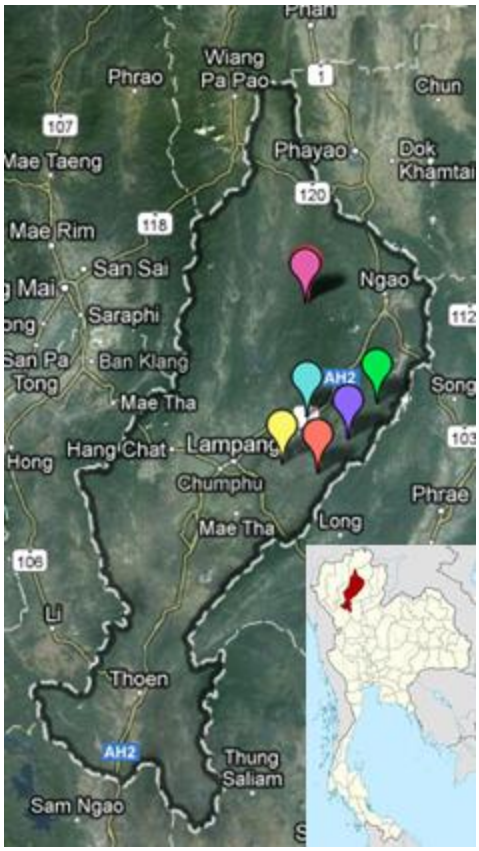

Figure 5: Map showing perspectives of Lampang Province, Mae Mo, and the five districts of Mae Mo

In order to accomplish our goal, we adopted a framework developed around PDA's community-based approach to problem solving. This community-based approach has allowed PDA to become a highly successful NGO in Thailand. PDA's approaches are similar to the social science research method of participatory action research (PAR) (Ozanne & Saatcioglu, 2008). This method works to incorporate community members into the research processes of outside investigators. A pillar of PAR is that "the researcher and the worker must forge a common understanding of the problem and its solution and implement change" (Ozanne & Saatcioglu, 2008). Since its inception in 1974, PDA has utilized a "community-based" approach that seeks to develop relationships with community members. PDA believes that villagers are not only beneficiaries of community projects but "partners, planners, managers, and leaders" ("The Population and Community Development Association (PDA)," 2012). The community members are considered the primary stakeholders in the "shaping and sustaining [of] their own development" ("The Population and Community Development Association (PDA)," 2012).

We identified three target groups within the community that will benefit from information provided by the learning center. Each target group will utilize the learning center for slightly different purposes. PDA representatives will be using the learning center to carry out our recommendations and act as liaisons between the learning center and community members. The representatives could bring knowledge from the learning center back to the villages they represent and/or teach sessions within the learning center and organize transportation for community members to visit. Mae Mo community members were another target group, comprised of small businesses and villagers. The small businesses we addressed were projects sponsored by PDA in Mae Mo to support community members with a way to generate income, and the villagers represent members of the community who own land for agricultural use. The villagers do not necessarily farm as their only profession; some have other occupations and farm separately. It was important to make this separation because both groups exemplified differing needs and uses for the RET.

To achieve our goal we executed four objectives:

1. Determine criteria of a successful learning center to determine the location, design, and educational media to be used in the PDA learning center for Mae Mo
2. Assess the energy usage, energy needs, and the cost of electricity for community members of Mae Mo
3. Determine affordability, user-friendliness, and local availability of renewable energy resources to evaluate physical and social feasibility of renewable energy technologies for the communities of Mae Mo
4. Develop recommendations and materials about renewable energy technologies that will be made available in the Mae Mo learning center

Through site visits and interviews, we determined the criteria for a successful learning center. These criteria resulted from interviews with learning centers as well as our target groups. Interviews with our target groups helped ensure that we developed a list of criteria for the learning center in Mae Mo according to their needs and preferences. We were then able to evaluate the potential sites for a learning center in Mae Mo to determine which site met the most criteria. Our questions worked to ensure that the input of community members were carefully integrated into the ideas and recommendations that we developed, which will work to ensure that their needs will be addressed in the learning center.

After we gained an understanding of the criteria to make the learning center in Mae Mo successful, we assessed how Mae Mo community members use energy. Evaluating the energy needs and uses was important in developing an understanding of what renewable energy technologies would be useful in the districts of Mae Mo. Through interviews, we investigated the current energy problems communities are facing and began to develop an understanding of different useful RET applications that should be exemplified in the learning center.

Through background research and interviews with experts of renewable energy technologies we developed criteria to assess feasibility of implementation of RETs as user-friendliness, local availability, and affordability. Through our site assessment we gained understanding of the technologies that can be supported given the geography of Mae Mo. Finally, interviews were conducted with our target groups to test the feasibility criteria. We used the three steps of our feasibility study to then compare the costs and benefits of each energy type. The economic, social and environmental costs and benefits determined the most suitable technology.

Once we had the learning preferences of the community members, we worked to develop recommendations for the learning center on way to educate target groups on renewable energy and its applications. Through interviews, we identified gaps in knowledge about renewable energy and topics relating to it. We developed recommendations for PDA's future expansion of the learning center.

Content analysis was used to analyze all of the interview responses. We analyzed the responses of the target groups and identified themes among the answers we received through open coding. The results of the open coding performed on these responses can be found in Appendix E. The

themes that we identified allowed us to develop ideas about resources that should be included in the learning center based on the preferences of the various target groups.

3.1 Determine criteria of a successful learning center to determine the location, design, and educational media to be used in the PDA learning center for Mae Mo

Understanding the criteria that make a successful learning center determined what PDA could put into their new learning center in Mae Mo. We conducted interviews at existing learning centers to develop a list of criteria that has made them successful. To cater the learning center to meet the needs and preferences of the communities of Mae Mo, we interviewed residents to develop a list of criteria they would like to see in the learning center. Interviews were completed with the following groups to gather information on what each group views as criteria of a successful learning center:

a. Learning center staff
b. PDA representatives
c. Villagers
d. Small businesses

3.1.1 Site visits to existing learning centers

Site visits to existing learning centers allowed us to develop criteria of a successful learning center. When visiting a learning center, we observed the accessibility, the materials used, and the programs offered. To understand the features typically seen, we visited the following learning centers to determine the criteria that have made them successful:

1. Baan Dong, Mae Mo: Baan Dong is currently a learning center in Mae Mo that provides information to surrounding communities about farming, livestock, textile, and a biogas digester.
2. Na Sak, Mae Mo: Na Sak is currently a learning center in Mae Mo that provides information to surrounding communities on mixed use agriculture.
3. Royal Thai Project Site, Mae Mo: The Royal Project Site is currently a learning center for community farming started by PDA and the local government. It is a community farm where villagers are given plots of land to farm and sell crops.
4. PDA Learning Center, Chakkarat: The PDA learning center in Chakkarat is a center that provides information to surrounding communities on income generation. This learning center demonstrated how renewable energy can be used to save money. Our purpose in visiting this learning center was to understand how they taught community members about renewable energy and if their methods were effective in educating a community similar to our target groups.
5. Sunny Bangchak, Bangkok: Sunny Bangchak is a learning exhibit in Ayutthaya that focuses on renewable energy. It is home to the third largest solar farm in Southeastern Asia. This facility focuses on solar energy but has dioramas, models, and displays on several other types of renewable energy.

We conducted interviews with the staff to gain a better understanding of the services provided by the learning center. Questions were asked about physical characteristics such as the layout of the

site, features, and location. Further, questions were asked about the purpose of the learning center and its target group to gain an understanding of what services and features are used to cater to the needs of the target group. In order to assess whether the learning center is successful, we asked questions about how they measure their success (questions can be found in Appendix A).

3.1.2 Interviews with the target groups

Since the learning center will be located in Mae Mo as a resource for the surrounding communities, it was essential to involve the communities when developing recommendations for PDA. It is important for long-term sustainability that the learning center reaches all the target groups. Interviews were held with PDA representatives, small businesses, and villagers to gain an understanding of their preferences for types of knowledge transfer methods to be utilized at the learning center and can be viewed in their entirety in Appendix A. Through interviews we developed a list of criteria based on the responses from our target groups.

Since PDA representatives will be the first to use the learning center, questions were asked about their preferences for the learning center. We asked them about their preferred location of the learning center, since they can determine how location may affect their communities. Questions were asked about their opinion on media for the learning center to ensure that features are included that will be useful for them. PDA representatives will be transferring the knowledge provided by the learning center to the community members. Through interviews, we gained an understanding of the different criteria that would be useful to PDA representatives and the community members.

Interviews were conducted with community members (small businesses and villagers) to gain an understanding of what they see as characteristics of a good learning center. Our questions were based around the methods of PAR which helped ensure the needs of the community will be addressed in the learning center. In asking questions about the community's experience with learning centers, we gained a mutual understanding of what would be useful to them to include in the learning center, such as educational media and services (Ozanne & Saatcioglu, 2008). All of the questions sought to cater the resources available in the learning center to the members of the community based on their preferences.

3.1.3 Developing educational materials for the target groups

After determining the criteria that make a successful learning center, we focused on developing preliminary educational materials to recommend to PDA. These materials had to be formulated by considering the needs of our different target groups and the future applications of RETs. When we interviewed PDA representatives, small businesses, and villagers, we gained insight into how they would like to learn, recognizing that PDA representatives may want different types of information than villagers. PAR methods were applied by working with these target groups to understand their needs before generating materials.

PDA representatives will use the learning center first and then pass information on to community leaders and members. By having PDA representatives continue to teach others in the community,

we believe that the community will be more likely to accept and maintain RETs. This also forms a strong base for continued community-based education, where community members teach other. PAR will again be utilized to allow community members to become primary leaders and planners for the future implementation of renewable energy technology. PDA's community-based approach to community building and education will also work towards the long-term sustainability of the learning center.

We asked the target groups questions to determine what they understood about renewable energy. We then asked questions about how they would like to learn about renewable energy or how they would like to learn in general (see Appendix A). This allowed us to gain insight into learning styles and how knowledge could effectively be transferred from one group to another.

3.1.4 Evaluating the possible locations for the learning center

PDA gave us options for the location of the learning center. The four possible locations were:

1. Cabbages and Condoms, Mae Mo
2. Royal Project Site, Mae Mo
3. Na Sak, Mae Mo
4. Baan Dong, Mae Mo

The Royal Project Site, Na Sak, and Baan Dong are already learning centers that can be expanded to educate on renewable energy. Cabbages and Condoms is not a learning center, but PDA plans to make it into a learning center in the future. Through site visits to each of the possible locations, we evaluated the locations based on the criteria determined from existing learning centers. Through interviews with community members, we were able to confirm the location of the learning center, to make sure it is accessible to them.

After we determined the criteria that would make a learning center in Mae Mo successful and chose the location, we were able to propose a design. Based on interviews with existing learning centers and community members of Mae Mo we developed recommendations for the layout of the site.

3.2 Assess the energy usage, energy needs, and the cost of electricity for community members of Mae Mo

In order to fully understand the problems and needs of the target groups, a preliminary assessment was made to determine energy use, needs and cost for community members of Mae Mo. Understanding energy needs is important to developing an understanding of potential technologies that will be useful for each target group. Our method of obtaining data was based on PDA's community-based approach because during the site assessment and interviews, we worked to include as much community input as possible. The methods we used to gather the information are as follows:

1. Initial background research about the sites
2. Site assessment: includes site visits and evaluations
3. Interviews with target groups: PDA representatives, small businesses, and villagers

The research was conducted using a set of tools, which included: background research using journals, newspaper articles, participant observation during site visits to multiple villages, and interviews with villagers in those villages and other target groups (such as PDA representatives). Initial background research about Lampang and Mae Mo was completed prior to the first site visit. Research topics included geography, climate, and the population, demographics, education levels of different target groups, local jobs and sources of income, daily activities, exposure to energy sources and/or renewable energy, customs and culture, amongst other various social indicators. Background research is crucial to understanding the characteristics of the target groups and area that we will be working with. In particular, our background research showed that geothermal energy was not feasible in the Mae Mo area.

An initial site assessment was conducted consisting of site visits to the various rural villages as well as potential learning center locations. All of the five districts of Mae Mo, shown in Figure 5 were visited: Mae Mo district, Sop Pat district, Na Sak district, Chang Nua district, and Baan Dong district. A total of 11 sites were examined. We encountered different types of communities and leaders throughout. The descriptions of the different communities that we visited can be found in Appendix C. By visiting each site and thoroughly assessing the capacity of the land, village leaders, and villagers we discovered some of their energy needs and views on renewable energy technology. We interviewed 3-5 people on average at each site. Every site had a variety of people from different target groups composed of: at least one villager whose responsibilities were to maintain the site that we were visiting, an additional village/learning center leader whose responsibilities were either governing the community (district) that we were visiting and/or leading the learning center, a PDA representative who was an expert in each of the districts they represented, and a PDA leader whose vision oversaw Mae Mo.

We started the interviews by asking informal questions because it would ease the target group into familiarity and allow the interviewee and interviewer to become comfortable with each other. We were then able to ask PDA and community members about their energy use and gather information about how they viewed renewable energy options. PDA representatives were able to provide us with a big picture of the problems communities face while community members told us about how they view electricity access and potential changes to renewable energy from conventional energy production. This method worked to provide us with an understanding of the social, economic, and environmental problems the communities face.

3.3 Determine the affordability, user-friendliness, and local availability of renewable energy resources to evaluate physical and social feasibility of renewable energy technologies for the communities of Mae Mo

After assessing the energy usage and needs of the communities in Mae Mo, we used this information to determine the most feasible renewable energy technology. The technology will be demonstrated in the new learning center, and will be implemented into communities and surrounding districts in the future. The technologies under consideration include solar photovoltaic (PV) cells, solar thermal, micro-hydropower, and biomass. Renewable energies were examined through the use of feasibility criteria including affordability, user-friendliness, and local availability. We organized the information about feasibility as a result of three stages to the project: research and preparation, site visits, and interviews with the target groups.

3.3.1 Research and preparation

Prior to the first site visit, we developed information about feasibility criteria of renewable energy technology. We organized the information gained according to physical and social aspects of feasibility. We defined physical feasibility as the ability for a renewable energy technology to be sustained in a certain geographic location. Social feasibility focused more specifically on the community members can support technically and financially.

First, we studied the physical features of the district of Mae Mo and which technologies it can sustain with available local resources. To further our knowledge of physical feasibility, interviews were conducted with experts from non-governmental organizations, BGET (Border Green Energy Team) and Palang Thai and Prof. Naebboon Hooncharoen from Chulalongkorn University. The goal of the interviews was to understand the process of implementing renewable energy technologies, and form criteria of feasibility for implementation in rural Thai communities.

The Border Green Energy Team has successfully completed renewable energy projects in rural Thailand. These projects have included technologies including solar PV, solar thermal, micro-hydropower, and biomass. BGET focuses more on rural areas of Thailand located out of reach from grid connection (BGET, 2010). We gained insight on the process of their projects, and their knowledge on the feasibility of renewable energy technologies, not just the projects specifically and therefore recognized BGET as an expert. Palang Thai partners with BGET on many projects but works to ensure that changes in a regions energy sector are economically feasible and augment social and environmental justice (BGET, 2010). For the interview with BGET and Palang Thai, we focused on geographical and seasonal considerations to ensure the renewable energy technologies fit our criteria of local availability.

To meet the criteria of user-friendliness and affordability (our study of social feasibility), we asked NGOs about their experiences working with communities with less knowledge of renewable energy to predict what barriers we might encounter on site.

We identified Prof. Naebboon Hooncharoen as an expert on renewable energy technologies. His work is focused on small scale renewable energies as a solution for Thailand's energy plan. Our project focuses on renewable energy technologies specifically on a smaller scale, which parallels his concentration. The focus of the interview with Prof. Naebboon Hooncharoen was to gain information of the technical aspects of the renewable energy options we considered for the project, solar PV, solar thermal, biomass, and micro-hydropower. This interview catered to the renewable energy technologies specifically and their potential use in Thailand.

3.3.2 Site visits

The first trip included site visits to different districts of Mae Mo and gather information regarding the physical feasibility of RET's in the communities. It was important to narrow the choices of renewable energy technologies to those that can be supported by the geography of the region. Observational data gathering (i.e. areas with a steady water flow, a large supply of biomass and possible obstructions to direct sunlight) was the focus of our first site visit, while also being aware of opportunities to interview community members or leaders. There are five

villages in the district of Mae Mo and we visited all five districts to reduce bias in our data collection.

3.3.3 Interviews with the target groups

Interviews were conducted with our three target groups, PDA representatives, small businesses, and villagers. The interviews conducted with these groups between our first and second site visit were set up by PDA. We followed a semi-structured interview format which does not enforce strict adherence to the set of questions. Instead the interviewers are reactive to the answers and clarify any confusion and allow a chance to gain new information we had not thought of prior to the interview (Berg, 1998).

Interviews with PDA representatives and community members focused on two categories of questions. First we confirmed criteria of feasibility of RET and understood what feasibility means to the community. Second, we sought to gain local opinions of renewable energy projects implemented in the community. To form the feasibility criteria, we sought to understand the factors that may prevent or encourage their use of renewable energy technologies. The questions were open ended to encourage the target groups to freely express the advantages and disadvantages they see of local renewable energy technologies.

The knowledge gained from the interviews helped us to determine which renewable energy technologies can best suit the needs and desires of Mae Mo community members and PDA representatives. This step encouraged an alignment between our project and PDA's community-based approach. It allowed a balance between our knowledge of feasibility with the community's knowledge and abilities, and it allowed them to be a part of the decision process. All questions for the interviews with PDA representatives and community member can be found in Appendix A.

3.4 Develop recommendations and materials about renewable energy technologies that will be made available in the Mae Mo learning center

After determining the criteria of a successful learning center, energy needs, and feasible renewable energy technologies, we focused on developing recommendations for the learning center about renewable energy. After conducting interviews, we performed content analysis on our data to discover what knowledge the target groups were lacking about renewable energy as well as how they would like to learn. We were able to evaluate which educational materials the target groups preferred as well as notice themes in their responses to questions about renewable energy technology.

We were then able to develop educational materials that will address the gaps in their knowledge. These materials were designed based on the responses we heard about learning styles and methods preferred. Each technology recommended was supplemented with background information, benefits of the technology, justification for our recommendation, and specifications for the technology (i.e. diagrams, building materials, maintenance schedule). We were able to form recommendations about how PDA can teach community members based on how our target groups expressed that they would like to learn.

Additionally, we provided PDA with recommendations for future projects and expansion. These recommendations were based on the needs and desires of community members and included future renewable energy projects, applications, and expansion of the learning center. Finally, we compiled a list of renewable energy experts—including NGOs, private companies, professors, and other learning centers—so that PDA would be able to consult with experts on renewable energy technologies about potential expansion and improvements to their learning center.

4 Results and Discussion

By evaluating the data collected through interviews and site assessments, we were able to identify trends in our data about issues concerning energy, learning centers, renewable energy feasibility, and gaps in knowledge. In this chapter we will present our findings related to the following topics:

1. Criterion of a successful learning center
2. Proposed learning center sites
3. Gaps in knowledge to be addressed in a learning center
4. Energy needs and the applications of renewable energy technologies in Mae Mo
5. Feasible renewable energy technologies
6. Future expansion of the learning center

4.1 Criteria of successful learning centers

Through evaluating the information gathered from interviews and site visits, we were able to identify the criterion of a successful learning center.

4.1.1 Finding #1: Successful learning centers should address an educational need, be in a location that is accessible and in neutral territory, have appropriate facilities, have a variety of educational media, and evaluate the effectiveness of the learning center

In order to determine the criteria, we visited existing learning centers and interviewed the staff to gain an understanding of what makes the centers successful. We visited the following learning centers:

1. Baan Dong, Mae Mo
2. Na Sak, Mae Mo
3. Royal Thai Project Site, Mae Mo
4. PDA Learning Center, Chakkarat
5. Sunny Bangchak, Bangkok

Through interviews with the communities of Mae Mo, we found site-specific criteria that members of the community identified as making the learning center successful. We asked community members about their experiences with learning centers. As seen in Figure 6, below, 13 out of 17 community members have been to a learning center. We acknowledge that not all community members have been to a learning center, so we asked those who had not visited one to explain their reasoning for not attending. To make certain their preferences are still addressed in the learning center, we asked them about what they would like to see in a learning center if they were to attend.

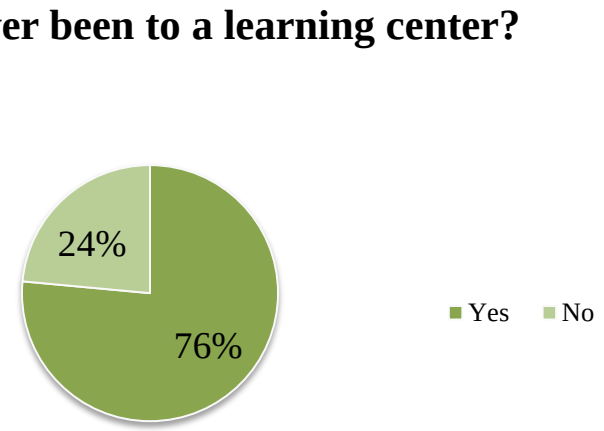

Figure 6: Percentage of villagers that have/have not been to a learning center

The list of criteria we developed through our visits to existing learning center and interviews with PDA representatives and community members is shown below in Table 2.

Table 2: List of criteria

Criteria
Address an educational need
The location should be accessible
Located in neutral territory
There needs to be appropriate facilities
A variety of educational media
Evaluate the effectiveness

Address an educational need

Successful learning centers address issues relevant to nearby communities. Many learning centers address educational needs of the surrounding communities. It's important for the target group to benefit from the information provided by the learning center.

We were able to identify the educational needs being address in the learning centers we visited. When visiting surrounding communities, we understood why the issue was being address. The PDA learning center in Chakkarat sought to help with income generation. The learning center provided trainings on job creation, renewable energy and agriculture to teach the community members on ways how to increase their income. When we visited a community outside of the learning center, we saw that many of the trainings about increasing income were being used by community members, such as farming cantaloupe.

Other learning centers such as Baan Dong, Na Sak, and Royal Project Site provided information to communities on agriculture. Many of the surrounding communities' are based on agriculture.

These learning centers helped in providing information on ways to improve their farming techniques.

The location should be accessible

In examining other learning centers, we found that the location of the learning center should be accessible to the target groups. The PDA learning center in the Chakkarat District was located off of a main road, which made it easy to find and travel to. The learning center is located near their target group, which makes it an accessible resources for community members. The Baan Dong, Na Sak, and Royal Thai Project learning centers were easily accessed by the communities. However, for community members of other districts, these learning centers are not as accessible. Unfortunately, the Sunny Bangchak learning center was not open to the public, which made it difficult to determine whether it was easily accessed.

Should be located in neutral territory

Another criterion was neutral territory. The PDA representatives are from different districts in Mae Mo. They believed that choosing a location of a learning center to reach all communities of Mae Mo should be unaffiliated with any particular district. Implementing a renewable energy technology into one community to be used as a demonstration could show favoritism. However, PDA representatives could also be biased sources of information.

There needs to be appropriate facilities

We observed that demonstration sites and lecture rooms were commonly used at the learning centers we visited.

In all of the learning centers we visited, we found that demonstration sites were frequently used for educating villagers. At the Royal Project site, there is 15 rai (24000m^2 or 5.9 acres) of land, which was initially used to train people about agriculture. The Na Sak site was a pilot project started by PDA to demonstrate a self-sustaining farm. All areas of the land are used for demonstrations on this mixed use agriculture. This learning center has a fish pond, rice paddies, a pig farm, and a chicken coop. Baan Dong has various demonstration sites within the learning center. There was an animal farm, farmland, and a biogas digester. The site director informed us that all of the sites were used in training sessions for demonstrations.

The PDA learning center in Chakkarat had various demonstration sites used for educating the community on a variety of ways to generate income. Sites included solar panels, a water purification system, mushroom farm, a cantaloupe farm, factories, and greenhouses. Through interviews with the staff, we found that lecture rooms were commonly used in learning centers for presentations. The PDA learning center in Chakkarat had a conference room which they used for lectures. Baan Dong and Na Sak had areas where presentations could be given for training.

Use a variety of educational media

Through interviews with the staff of learning centers we determined options of educational media for the learning center in Mae Mo. In order to cater the educational media to the communities of Mae Mo, we interviews PDA representatives and community members to determine their preferred media.

Educational media determined by existing learning centers

The Royal Thai project site had *interactive trainings* given by the local government. The farmers were taught about agriculture, making fertilizer, and livestock. The trainings were hands-on where the farmers were taught how to plant. We asked some of the villagers that have attended this training, and many were pleased with the interactive and hands-on nature of this training. Sunny Bangchak utilizes *visual aids* about several types of renewable energy that used examples of the technology as well as videos, shown in Figure 7 and Figure 8. Through interviews with the staff, we found that visitors liked the way the information was presented. Visitors found these demonstrations to be entertaining and engaging.

Figure 7: Solar panel display at Sunny Bangchak

Figure 8: Renewable energy video at Sunny Bancghak

At the Baan Dong learning center in Mae Mo, a biomass system is used for demonstrations and trainings. As seen in Figure 9, a complex diagram of the inside of the system is located next to it. However, the site director explained that in his experience with teaching communities, diagrams may have too much technical detail for community members. This type of *visual aid* may be too technical for learning centers and inappropriate to show as general information.

Figure 9: Biomass diagram at Baan Dong

We found that PDA's learning center in the Chakkarat uses a *combination of lectures, visual aids, and an interactive training to teach their community members*. Since villagers have different learning preferences, the learning center has catered this program to the various needs of the community by having both a lecture and an interactive training. Visitors will spend a full day at the Chakkarat center. The morning will involve lectures with hand-outs and visual aids and the afternoon will have an interactive training. The staff of the learning center informed us that this is their most effective program for teaching.

Educational media determined by PDA representatives and the community members

To cater our recommendations for the learning center to the various target groups, interviews were conducted to determine the target groups' preferences for materials, services, and features of the learning center. Figure 10 shows the results of our interviews with community members on their learning preferences.

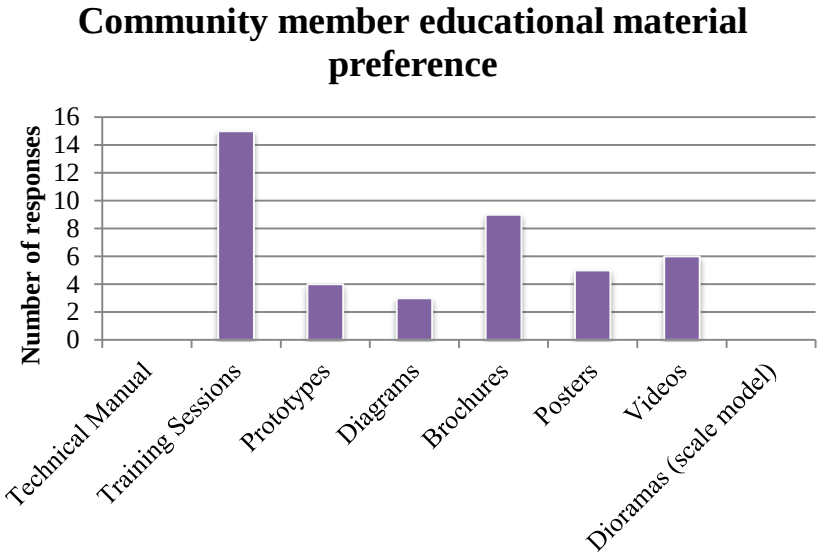

Figure 10: Educational material preferences of the community members

As seen in Figure 10, many community members and small business owners would like to learn through *training sessions that present verbal information and hands-on demonstrations*. Through interviews with community members who have attended learning centers in the past, we found that many community members liked learning through a hands-on training session. Many of the

community members have been to learning centers about hydroponics vegetable systems, agriculture, mushrooms farms, and livestock which all included a hands-on training. The majority of the villagers whom have learned through a hands-on training session enjoyed it. We do acknowledge that since not all of the community members have been to learning centers they might not know how they would prefer to learn, but the responses we received overwhelming indicated interest in training sessions.

Through interviews with PDA representatives, we found that technical information is not always helpful to the community members. This information can be too confusing and complicated. However, PDA representatives believe that they can learn best through technical information such as prototypes, training programs, diagrams, and technical manuals. They will be able to gain knowledge about renewable energy technologies and can then seek to educate other community members.

Through interviews with community members we confirmed that visual aids with technical information would not help them or engage them. As shown in Figure 10, none of the villagers wanted to learn through technical manuals. One villager stated that she wants "an easy way to understand the technology." Many villagers preferred to learn through *visual aids* such as posters, videos, and brochures. Community members also indicated that these visual aids could be in the form of brochures/pamphlets that they can take home with them upon leaving the learning center. A *combination of teaching, hands-on learning, and follow-up in the form of take-home materials* would be an effective way to educate community members.

Evaluate their own effectiveness

In order to measure whether the new learning center in Mae Mo is successful upon opening, we interviewed the staff at other learning centers to understand how they measure success. Two out of the five learning centers we visited had evaluative processes. Over time, these learning centers can adapt and determine new ways to present information. We found two different methods for evaluating the learning centers.

The PDA learning center in the Chakkarat District measures success rather than the quality and usefulness of the services they offer. Since their center focuses on income generation, they measured success based on the percentage of visitors of the learning center that saw an increase in income after attending the learning center by utilizing what they learned. Interviews with the staff told us that their success rate is about 7 or 8 out of 15 villagers per training session. Sunny Bangchak learning center had a different kind of evaluation process than the learning center in Chakkarat. Upon leaving the center, visitors are asked to fill out a short survey ranking their impressions of some features of the learning center. The survey asked visitors to rank their impressions of some features of the learning center and leave them suggestions for improvement.

Through interviews with the communities of Mae Mo, we found site-specific criteria that members of the community identified as making the learning center successful. We asked community members about their experiences with learning centers. As seen in the pie chart below, 13 out of 17 community members have been to a learning center. We acknowledge that

not all community members have been to a learning center, so we asked those who had not visited one to explain their reasoning for not attending.

4.2 Proposed learning center sites

Initially, PDA gave us options of different locations for the learning center in Mae Mo. These options include:

1. Cabbages and Condoms Restaurant and Resort, Lampang
2. Royal Thai Project Site, Mae Mo
3. Na Sak, Mae Mo
4. Baan Dong, Mae Mo

Figure 11 shows a map of the possible locations for the learning center (Cabbages and Condoms-yellow, Baan Dong-green, Royal Project Site-pink, Na Sak- purple).

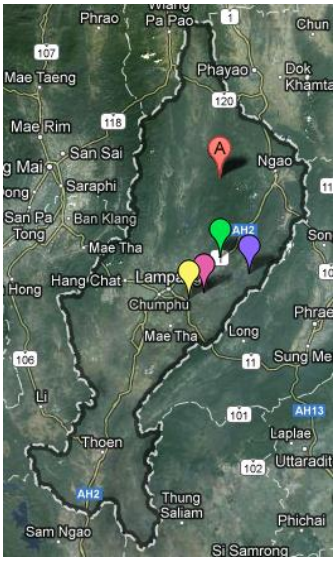

Figure 11: Map of learning center locations

Once we determined the criteria of a successful learning center, we were able to narrow down the location of the learning center. The results of our interviews with existing learning centers and with PDA, villagers, small businesses and leaders provided us with further information that supported the development of a learning center at a specific site. Table 3 shows the results of evaluating each site based on the criteria.

Table 3: Results of evaluating possible learning centers

Possible Locations	Cabbages and Condoms	Royal Thai Project Site	Na Sak	Baan Dong
Criteria determined by learning center visits				
Address an educational need	√	√	√	√
The location should be accessible	√			
Located in neutral territory	√			
Have appropriate facilities	√	√	√	√
A variety of educational media				√
Evaluate their effectiveness				

4.2.1 Finding #2: The Cabbages and Condoms site ranks highly in the criteria identified by finding 1

We evaluated four possible locations for the learning center which were Cabbages and Condoms, Royal Thai Project site, Baan Dong and Na Sak. The Royal Thai Project site, Baan Dong, and Na Sak are already learning centers, so our project would work to expand on what they already have to meet all communities of Mae Mo. PDA is hoping to make Cabbages and Condoms into a

learning center in the future, however we were to evaluate whether it was a suitable location for a learning center about renewable energy.

As seen in Table 3, Cabbages and Condoms meets more criteria of a successful learning center than the other locations. The criteria Cabbages and Condoms restaurant and resort do not meet can be added into the learning center in the future.

Evaluating the expansion of existing learning centers:

The *Royal Thai project* site is already a learning center about agriculture, so it did contain some of the criteria for a successful learning center. Since this learning center already reaches farmers, a renewable energy system that promotes sustainable farming would address a similar educational need. We found that this site was easily accessed by the current target group. However PDA would like this learning center to reach all five districts and this location is far for residents of other districts. Since this site is within the Mae Mo district, it is not located in neutral territory.

We found that the Royal Project Site did have some of the demonstration areas such as a water tank and water treatment pond on site which could utilize a renewable energy powered water pump. This site does not currently have a varierty of educational media or evaluations.

Na Sak is currently a learning center about mixed use agriculture to show a working example of a self-sustaining farm. The learning center's target group is farmers. Since the learning center already addresses educational needs about agriculture, adding in demonstrations about sustainable farming through renewable energy would still benefit the surrounding communities.

This location offers a variety of demonstration areas that can use renewable energy. There is a water pump which can be powered by renewable energy along with water storage tanks that can hold the water. There is a pig farm, which produces waste that can show how energy can be generated from biomass. Along with suitable demonstration areas, Na Sak does have an outdoor area appropriate for giving presentations and lectures. Currently, Na Sak does not have a variety of educational media or evaluations for trainings. However this site isn't in neutral territory and it's not accessible to all of the communities of Mae Mo.

Baan Dong is already a learning center that targets community members interested in biogas, pig farms, and agriculture. Since this learning center already contains renewable energy demonstrations, surrounding communities will continue to benefit from the information about renewable energies. However this learning center is not in neutral territory and far from other districts making it less easily accessed.

We found that Baan Dong has appropriate facilitates already on-site such as a biomass system and a lecture hall for presentations. This learning center contains a variety of educational media on renewable energy, such as the biomass system diagram found in Figure 9. This learning center does not currently have an evaluative process for measuring the success.

It is important to note, that the possible locations for the learning center on renewable energy are already, or soon will be, learning centers. Looking at what they currently have is how we determine how each center meets the criteria. However, much of the criteria can be met if changes are made to current practices of the learning center.

Evaluating the option to create a new learning center

Cabbages and Condoms is accessible by the communities of Mae Mo. This site is located off of a main road which makes it easy to see and access. A PDA staff member estimated that each morning 400 cars pass Cabbages and Condoms. Since other possible locations for the learning center were more remote, planning learning center where there is more traffic and easier access would help reach all communities in Mae Mo. PDA representatives saw Cabbages and Condoms as a good option for demonstrations to reach all districts of Mae Mo, not just certain villages. Cabbages and Condoms is located just outside of Mae Mo in neutral territory and not affiliated with any particular district.

Cabbages and Condoms is not currently a learning center, however it contains many of the criteria of a successful learning center. The location already contains important features for a learning center such as conference rooms for presentations and lectures and areas for demonstrations. As shown in Figure 12 and Figure 13, two storage tanks and farmland are available on-site for demonstrating a renewable energy powered water pump. Adjacent to the storage tanks is a pond where water can be pumped from.

Figure 12: Water storage tank at Cabbages and Condoms

Figure 13: Farmland at Cabbages and Condoms

Since there is farmland, storage tanks, and a pond, renewable energy can be applied to demonstrate sustainable agriculture. This will address some of the educational needs of the community regarding agriculture. Since the site is large, a learning center in this location could provide information and demonstrations on other applications of renewable energy to meet education needs of different communities. Since this site is not currently a learning center, educational media and evaluations have not been created yet.

4.2.2 Finding #3: The Cabbages and Condoms site is accessible to many people

Cabbages and Condoms Restaurant and Resort matched more criteria than other options. To ensure this would be a suitable location for community members, we asked 17 community members from various villages they would visit a learning center at Cabbages and Condoms.

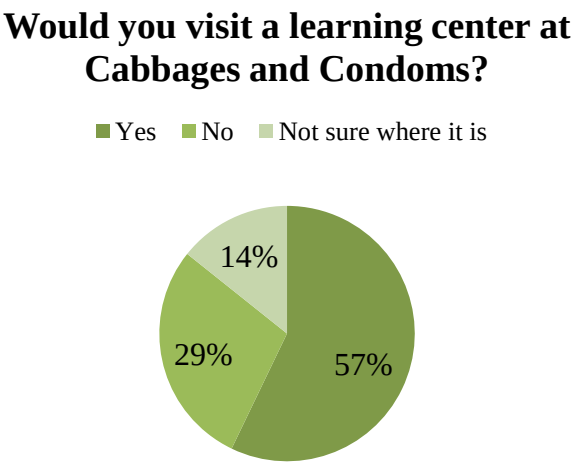

Figure 14: Response to interviews about Cabbages and Condoms as a learning center

The majority of villagers thought that Cabbages and Condoms was a suitable location for a learning center, as shown in Figure 14. Other villagers said they would only go if they could be in a large group. The main reason villagers answered no was because the location was too far for them to travel to. We acknowledged that the responses will vary from village to village based on its distance from Cabbages and Condoms. Due to time constraints and the location, our findings are limited to a small sample of opinions. Many of the responses that we received about drawbacks of the learning center location can be addressed by working to increase the accessibility of the learning center. The physical site is suitable for a learning center.

4.2.3 Finding #4: There are additional benefits to creating a learning center at Cabbages and Condoms

The features discovered during our site assessment confirmed that Cabbages and Condoms was a suitable site for a learning center. Cabbages and Condoms, Mae Mo has an area of 28 rai (11,200 m^2 or 11 acres), which is an appropriate amount of land for demonstrations about renewable energy.

Another factor that affects the layout of the site is maintainability. The Cabbages and Condoms site is located in the capital district where PDA staff are most comfortable. PDA headquarters are located about 7-8 kilometers from the proposed site. With the learning center located closer, the staff can maintain and fully integrate themselves into the site. The learning center site is quite large and would need constant maintenance by staff. Different prototypes have different maintenance schedules and level of difficulty that the staff would have to be familiar with before they can teach villagers or give demonstrations.

For future renewable energy applications, we observed areas of the site that may support other technologies. We were told that the groundwater is slightly alkaline, and in the future this could be an ideal site to demonstrate a water purification system that utilized renewable energies. A stream also runs through the property, which may be utilized by a hydroelectric powered system. However, since we were not able to visit during the rainy season, we could not properly evaluate the potential for a hydroelectric system.

4.3 Gaps in knowledge to be addressed in the learning center

Our research led us to identify several gaps in knowledge that can be addressed through the new learning center in Mae Mo.

4.3.1 Finding #5: Community members are unaware of how electricity is generated

Analysis of our field research has shown that many community members do not understand or are misinformed about how conventional energy is harnessed. This results in a lack of knowledge about the negative health effects of conventional energy. To study how prevalent this misunderstanding was in the community, we asked community members "do you understand how electricity is made through conventional sources?"

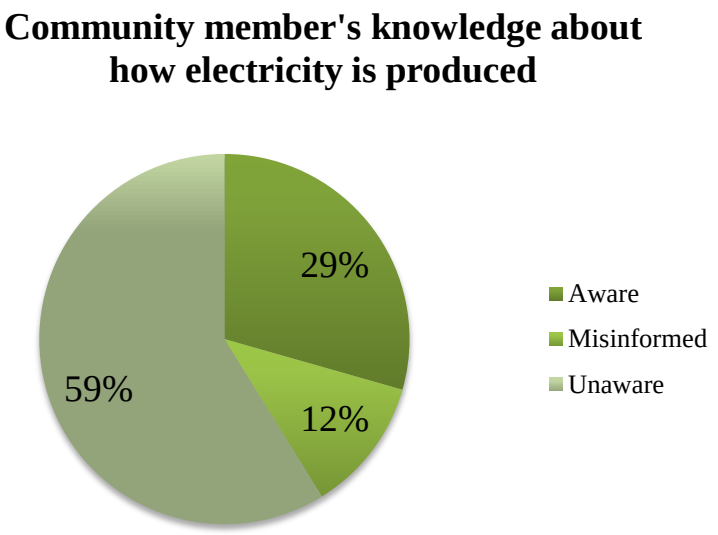

Figure 15: Results of interviews with villagers about electricity production from conventional methods

As displayed in Figure 15, the majority of villagers that were interviewed were either misinformed or unaware of how conventional energy methods produce electricity. Some examples of how community members were misinformed about production of conventional energies are as follows:

One community member believes that coal is transported out of the district of Mae Mo and generated elsewhere. Another community member states that the electricity comes from the city. These two are examples about how community members are misinformed about the production of their electricity. The group who was unaware did not have an answer to the question but simply stated that they did not know where or how their electricity is produced.

4.3.2 Finding #6: Community members are unaware of the costs of conventional energy

As displayed in Figure 16, the majority of villagers interviewed by our team were unaware of the variety of costs or negative effects from conventional energy production. These findings display a gap in knowledge about the risks that community members are faced with every day.

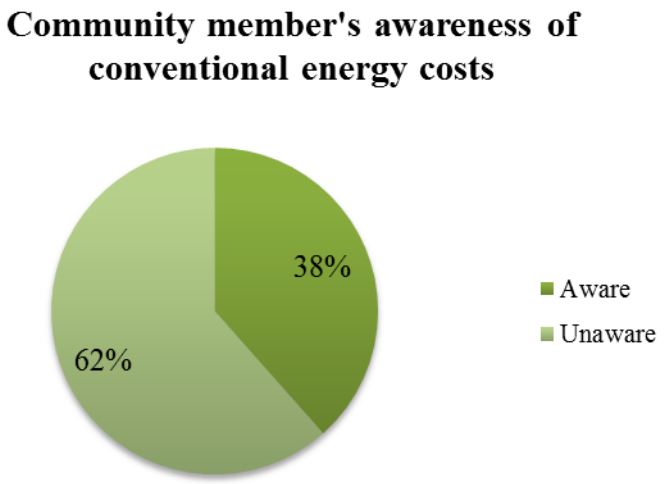

Figure 16: Results of interviews with community members about social and environmental costs of conventional energy use

Through analysis, we have found that to increase the success of the implementation and promotion of renewable energy technology, community members should be well informed about how conventional energy is produced and what the variety of costs include. Along with a lack of knowledge about negative impacts of conventional energy, many community members didn't understand how renewable energy is a good alternative from their current source of electricity.

Two community members understood that there have been protests in Mae Mo about the coal-fired power plants but did not understand why they occurred. Some understand that conventional energy is bad, but could not specify what is bad about it. Another stated that she has never had a problem with pollution and didn't think the coal mine or power plant was an issue. Without a clear understanding of the costs of conventional energy it makes it difficult to understand the benefits of renewable energy technologies.

4.3.3 Finding #7: Community members have limited knowledge about renewable energy technologies

To determine the knowledge gap of community members, we investigated what individuals knew about renewable energy technology. We asked whether community members:

- Knew the term "renewable energy"
- Could identify specific technologies
- Needed further explanation but then could name at least one technology

- Still did not know what we were discussing after clear explanation

The majority of community members we interviewed did not have any knowledge about renewable energy technologies and their applications. As displayed in Figure 17, below, the majority of community members interviewed either knew little to nothing about renewable energy technology or could only identify solar after an explanation of the term "renewable energy". After a brief explanation of what the term encompassed, these villagers recalled hearing about or seeing solar panels and frequently understood that electricity could be generated from the sun.

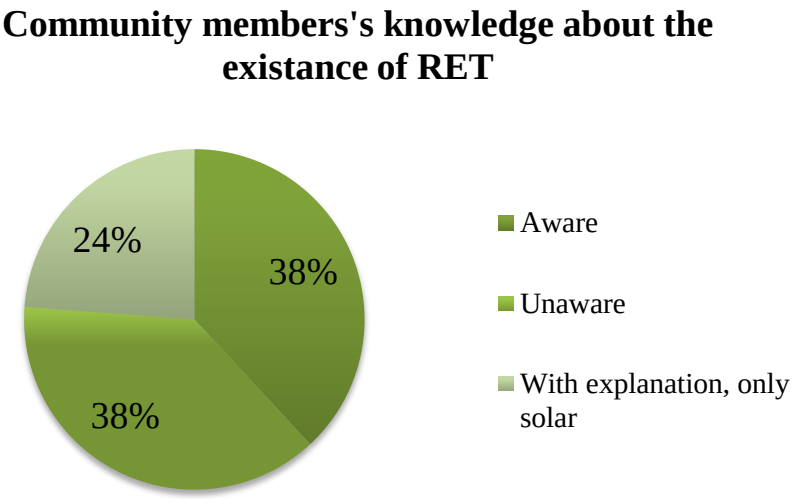

Figure 17: Knowledge of villagers about the existence of renewable energy technology

Community members who were unaware stated so, even after an explanation of what renewable energy technology was with examples. Several community members had heard of renewable energy and believe that it is "better" but cannot quantify why. Another community member explained that he was not familiar with the technical term renewable energy but did understand what solar cells were.

One of our interviews led to contradictory results to the trends we saw. We interviewed a group of women who make fish pastries in the district of Mae Mo who were all personally affected by the power plants. The women were relocated due to their home's vicinity to the coal-fired power plants. Even though all of their husbands work for EGAT, they do not have a substantial understanding of how conventional energies are produced or their costs.

During an interview with another small business in Mae Mo, we learned that these women were more informed about renewable energy technology and were personally affected by coal mining in Mae Mo. These women could name solar, hydroelectric, and biomass systems when we asked about their knowledge of renewable energy technologies. They seemed to have a good understanding of how renewable energies can be utilized. These women understood how the lignite mines worked and that the coal-fired power plants produced electricity from the abundant resource. Unfortunately, the women have also experienced the coal mines and power plants on a personal level. Their children have developed asthma due to the dust particles they grew up around.

4.4 Energy needs and the applications of renewable energy technologies in Mae Mo

We developed a lot of information about the current energy demand of Mae Mo community members while observing potential applications of renewable energy technology.

4.4.1 Finding #8: The main concern of community members is the cost of electricity

Through interviews with community members we gained information on their electricity usage at home, for their farm, and in their business, as well as a potential use of renewable energy technology. It was immediately apparent that community members recognize economic benefits or costs from these renewable energy technologies but do not demonstrate an understanding of social or environmental costs and benefits. From our interviews we learned that the household cost of electricity is an economic burden for many community members, and they have seen renewable energy technology subdue these high costs elsewhere. On the other hand, the cost of water for many villagers is not significant and many do not have a high need to reduce the costs and therefore do not see a need for renewable energy technology. The lack of knowledge about renewable energy needs to be addressed to encourage the use of the RET in the community.

During interviews with community members we asked what they paid for their electricity in their homes. The electricity costs vary greatly depending on the commodities they have, for example the use of air conditioning. We gathered average costs of community member's electricity usage at home to expand on potential applications for renewable energy technology and compiled it in Figure 18. Individual villager's electricity usage is approximately 77.5 kWh – 155 kWh (calculation shown below) per month for household purposes and they perceive this to be very expensive especially because of the tax.

12 baht/ unit = 930 (tax excluded)/ x unit = 77.5 kWh
12 baht/unit = 1860 (tax excluded)/ x unit = 155 kWh

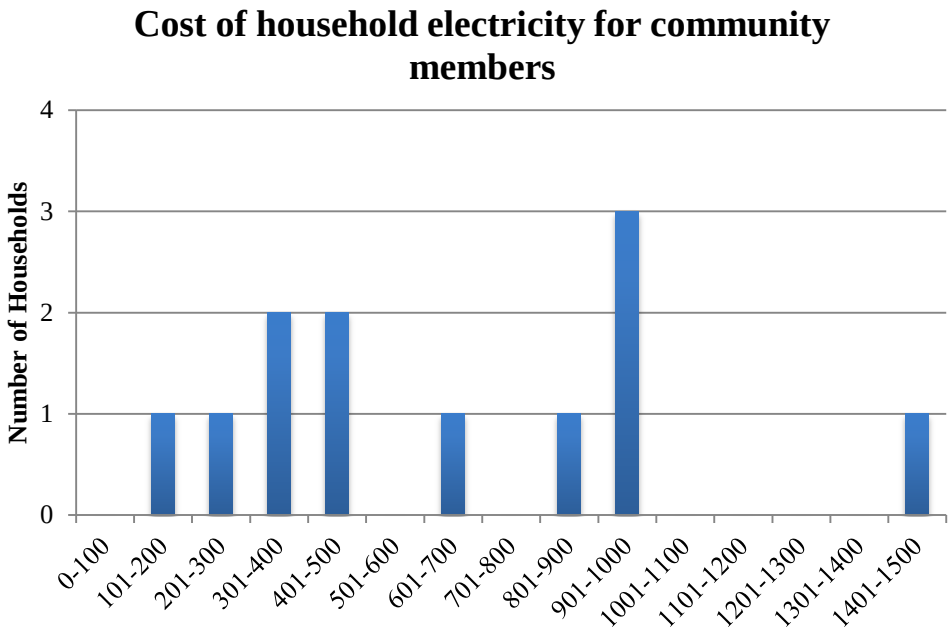

Figure 18: Graph showing the cost of household electricity for community members

Even with this wide variety of electricity cost throughout the community, it was common for the costs to be viewed as too high. We analyzed community member's opinion on renewable energy technology by asking what benefits they see from the technology. For those who were familiar with the term "renewable energy" expressed its economic benefit and ability to reduce electricity costs. They have heard other community members experience with renewable energy technology and that it reduced their monthly cost and therefore that was the most significant benefit in their opinion.

Through discussion with PDA representatives, they explained the economic benefits surrounding communities have gained from the implementation of renewable energy technologies. In an agricultural community outside of Mae Mo, the use of solar panels to pump water reduced the cost of electricity by 50%, from 8 baht/unit to 4 baht/unit.

During a site visit to the PDA center in the district of Chakkarat, we visited a community with a solar panel that pumps water from the ground water source to storage tanks (Figure 19) (refer to Appendix C for additional information). This district received a donation from Ida Hi-Tech Corporation Co., Ltd., a company in Thailand that manufactures solar panels. The company supplied the solar panels, and training on the operation and maintenance of the solar panels for community members. The use of solar power instead of grid power, the cost of electricity to pump water reduced from 5 baht/unit to 2 baht/unit. This project demonstrates the opportunity for renewable energy technology to economically benefit rural communities.

Figure 19: Diagram of Solar Powered Water System in Chakkarat

Next, we interviewed the agricultural sector of Mae Mo to determine the potential uses of renewable energy technology and its benefits for villagers. Through interviews with the villagers, we examined the current cost of water and what benefits villagers recognize from use of renewable energy. Community members were not aware that when they were paying for water, they were paying for the electricity to pump the water to their fields. Therefore they considered it their water bill, and for the purpose of this report, we also referred to these numbers as the cost of water.

Villagers at both sites where interviews were conducted, pay for water through either a flat rate payment or are determined by individual water meters. The cost of water is on average 25-50 baht per plot of land (approx. 10 m^2). Mainly, they use water for about 2 hours of the day (4.00 pm - 6.00 pm) to water their crops. In Figure 20, we summarized the cost of the water that villagers pay to maintain their gardens.

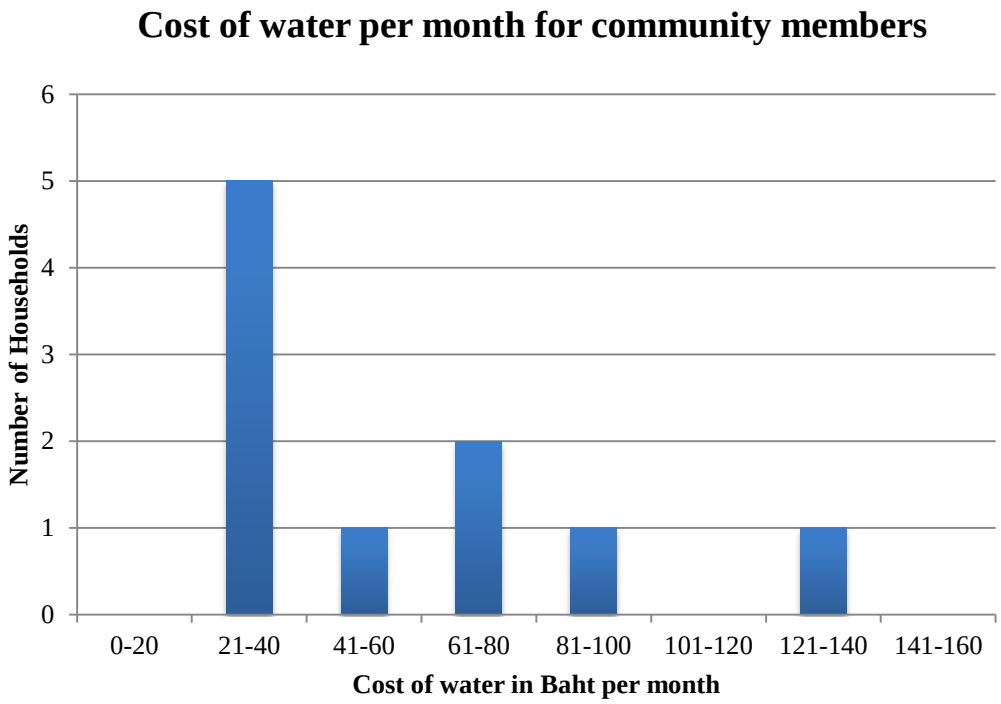

Figure 20: Graph showing cost of water per month for community members

During discussion with villagers about their cost of water, they did not express a need for their water bill to be reduced. Without a need for reduced cost, community members did not understand how they could benefit from using renewable energy technology. This exemplifies the importance of improving the villagers' knowledge of the many benefits of renewable energy including social and environmental benefits. This knowledge will be transferred through materials in the learning center that explain the costs of conventional energy, and how renewable energy can benefit the community.

4.4.2 Finding #9: Renewable energy technologies can benefit Mae Mo

Site visits to five districts demonstrated how communities use and value energy in different ways. Information provided in the learning center should address the different ways that community members can use renewable energy technology to meet and possibly exceed their current energy usage and needs. In addition to agricultural applications, renewable energy technologies can supplement electricity and decrease the financial burden on a household. As a result of our findings, we were able to identify the problems and determine how renewable energy can help improve the quality of life for villagers.

We visited a pig farm in the district of Chang Nua that utilizes the pig waste to fuel a biogas system (Appendix C). The digester can be seen in Figure 21. Although the digester was not currently in use, it had been used to generate gas for cooking. The family members we interviewed want to connect their biogas system to a generator to produce electricity for their home and possibly neighboring homes. The benefits of this renewable technology installation are that the cost of electricity per household would be decreased. This allows income to go towards other things that can work to improve the community members' quality of life.

Figure 21: Biogas digester in Chang Nua

PDA's learning center in Mae Mo that is based on the Royal sufficiency initiative is working to improve the quality of life of community members through a multitude of programs. Water for agricultural sites is controlled on site and filtered using a surface water multi-pond sediment system. The site advisor would like to implement a solar panel to provide electricity for the water pump to transport water to the water tanks. He acknowledged that this system is less taxing on the environment than relying on conventional energy.

We visited small businesses in Mae Mo to understand all of the applications of renewable energy in the community. These businesses were typically sponsored or funded by PDA, and most were located at the owner's home. Some businesses were run by homemakers and the business served to generate supplemental income. It was important to understand their energy usage and needs to ensure the learning center caters to all sectors of the community of Mae Mo.

A textile industry in Mae Mo, which was initially funded by PDA, has been facing issues involving desired expansion. Their electricity bill has increased from 1,000 baht to 2,000 baht with their increased use of machinery. Although more products are great for the business, their increased electricity bill has been limiting their ability to purchase top-quality materials. Further, they hope to purchase a badge-making machine and computer that would enable them to make badges they attach to many of their products. The industry currently travels to get these badges and having the machine where they work would increase their productivity. Unfortunately, this system is very expensive and would increase electricity usage and is therefore not feasible for the business. RETs could help alleviate some of their electricity costs so their profits could be saved and put towards things to improve their business.

We then visited Baan Baibua (House of the Lotus Leaf), we learned about their system of drying out lotus leaves to make decorative products. The process takes half a day to air dry the leaves in the dry season but they have a 50% decrease in production during the rainy season. Through

interviews, the owners expressed to us their desire to buy an oven to make their leaf drying process more efficient. By utilizing an oven that runs on renewable energy technologies, the business can make more products and thereby increase their profit without increasing their electricity bill. The owners understood this concept during our interview and seemed very intrigued by the idea.

Our interviews with community members showed us how important it is to them to save any money they can. Frequent responses we received when mentioning that utilizing renewable energies could save money consisted of immediate brainstorming of how they could utilize their saved money. Community members would start listing how their extra money can be put to expand their small businesses or bettering their life in another way.

The main method used while formulating this finding was interviewing community members, small business owners, and PDA. Due to time and location constraints, we only received a small sample of opinions. There is a possibility that if we interviewed more individuals from more demographics, we would have gathered varying results.

These businesses are limited by their current supply of electricity because they cannot afford to increase their usage or expand their business. They each saw a chance to expand their business if provided with a renewable source of energy and they could increase the profits of their business. Out of the five businesses that were interviewed, three of them mentioned the benefit they saw behind renewable energy utilization was to save electricity costs. Two of these were more specific and explained certain uses for their renewable energy. They identified that RETs could provide them with a greater variety of products from their business and then hopefully increase profit.

4.5 Feasible renewable energy technologies

This section analyzes the feasibility of the renewable energy technologies to be included in the learning center at Cabbages and Condoms in Mae Mo. We determined the criteria of feasibility to analyze the options of renewable energy technology. The renewable energy technologies in consideration include solar PV and thermal technology, micro-hydro, and biomass systems. We completed this analysis based on information gained from interviews with renewable energy experts and our target groups as well as a site assessment of Mae Mo.

4.5.1 Finding #10: Criteria for analyzing feasibility of renewable energy technology for Mae Mo should be expanded to include familiarity and reliability

Our feasibility criteria were expanded to include reliability and familiarity, which was added to affordability, local availability, and user-friendliness. Reliability and familiarity allowed us to provide a better description about what makes a technology user-friendly. The criteria were expanded through our interviews with renewable energy experts, and with our target groups in Mae Mo.

To expand on our knowledge gained from background research, we interviewed renewable energy experts to clarify how to analyze feasibility. The experts we interviewed included the Border Green Energy Team (BGET) and Palang Thai, both non-governmental organizations

familiar with renewable energy projects in rural Thailand; their interviews were conducted together. Our second expert interview was with Professor Neabboon Hooncharoen, who specializes in electrical engineering at Power Systems Research Lab, Faculty of Engineering, Chulalongkorn University.

BGET's projects involve the implementation of renewable energy projects in remote communities without access to grid connection. They have been working since the 2000s with different technologies and have had their experience with failed projects and have made the adjustments necessary to increase the success of the project. Recently, they have adapted a community-based approach similar to PDA's by engaging the community in discussion and resolution of issues ("The Population and Community Development Association (PDA)," 2012).

To further our understanding of feasibility, we asked about criteria to consider when introducing renewable energy technologies in rural communities. In the interview with Professor Neabboon, he explained that the technology must be low maintenance and simple for community members to operate. BGET and Palang Thai identified four factors to ensure a sustainable project including a strong community, long-term financial support, reliable technology, and assessment of project and checking in with progress. The first factors will be completed by PDA with the introduction of a learning center in Mae Mo. PDA will also provide financial support the communities and find sponsors for these projects to ensure long term success.

From the interviews, we recognized criteria that were important for consideration include user-friendliness, reliability, and affordability. To obtain an affordable technology the resources must also be local available to the community. PDA representatives also expressed a list of criteria which was important to the Mae Mo community when considering feasible renewable energy technology. The first was for the technology to be cheap and easy to use. Other criteria mentioned were durability (reliability) and an easily maintainable system. Both PDA and renewable energy experts have expressed a concern about reliability of the technology, and this was added to our list of criteria to analyze feasibility.

Another criterion was uncovered through the interview with BGET/Palang Thai. An important criterion of feasibility of renewable energy technology is familiarity. They explained that the feasibility of the technology will be increased if community members are familiar and comfortable with the technology. We also examined that many community members expressed an interest in RET, but specifically solar PV, because they have either seen or heard of solar cells. Out of the community members interviewed, 38% were able to name solar energy as a renewable energy technology, even if they did not understand what RETs were.

Renewable energy technologies were only deemed feasible for demonstration in the learning center in Mae Mo (in the present and future) if they met most, if not all, of the criteria. We were able to confirm our initial criteria developed through background research, user-friendliness, affordability and local-availability. Then we expanded our criteria and analysis to include familiarity and reliability.

4.5.2 Finding #11: Cost-benefit analysis supports our findings of feasibility

In this section we will discuss the cost-benefit analysis of the different renewable energy technologies to discover which ones to recommend. The renewable energy technologies that we will consider are:

1. Coal
2. Solar PV
3. Solar thermal
4. Biomass
5. Micro-hydropower
6. Wind

While doing the cost-benefit analysis on each technology, we will focus on economic, environmental, and social factors. Economic cost-benefit analysis was made based on market indicators. These indicators usually predict the advancement of a project based on market prices and conditions. This economic cost-benefit analysis was made considering these internal cost factors:

- Capital costs (including waste disposal and decommissioning costs for nuclear energy) - tend to be low for fossil fuel power stations; high for wind turbines, solar PV; very high for waste to energy, wave and tidal, solar thermal, and nuclear ("Open Energy Info - Apps," 2012)
- Fuel costs - high for fossil fuel and biomass sources, low for nuclear, and zero for many renewables ("Open Energy Info - Apps," 2012)
- Factors such as the costs of waste (and associated issues) and different insurance costs are not included in the following: Works power, own use or parasitic load - that is, the portion of generated power actually used to run the stations pumps and fans has to be allowed for ("Open Energy Info - Apps," 2012)

4.5.2.1 Economic cost-benefit analysis

The *levelized cost of energy* estimates total electricity cost including payback of initial investment and operating costs. In other words, the price at which a plant must sell electricity in order to break even ("Open Energy Info - Apps," 2012). The overall trend of each of the renewable energy technologies decreases but the most significant technology was solar PV as seen in Figure 22. Decreasing levelized cost means that it will be easier in the future for electricity producers to break even. This cost includes the initial investment cost which is relatively high for solar PV.

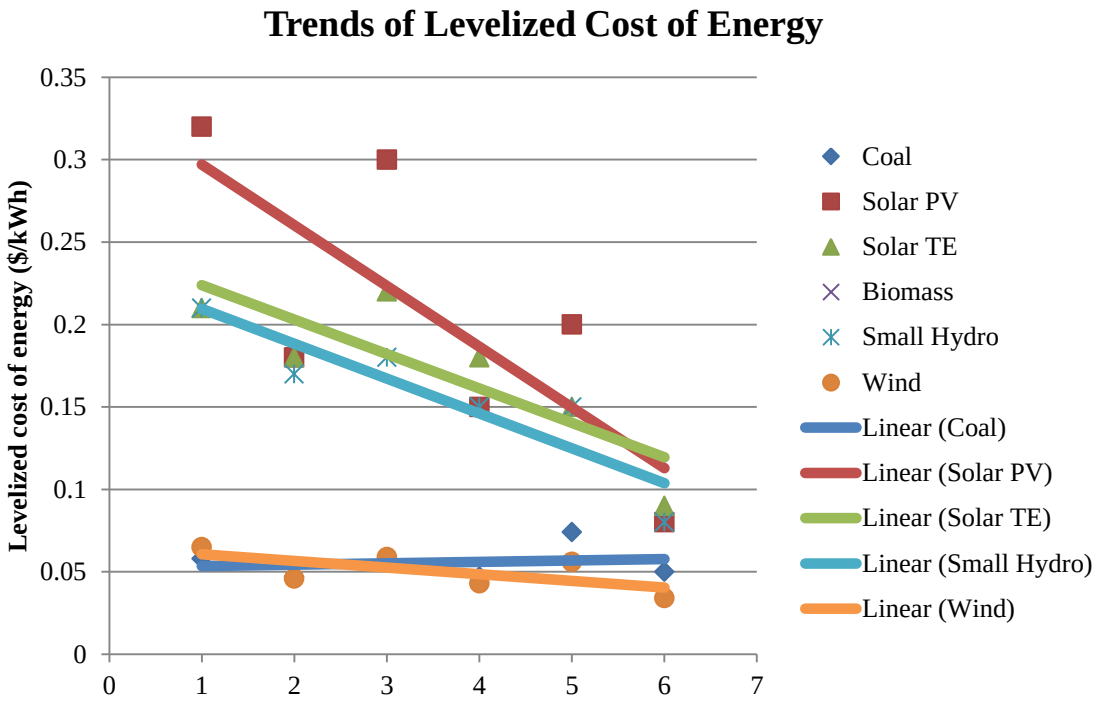

Figure 22: LCOE for coal, solar PV, solar TE, biomass, small hydro, and wind (Biomass n/a) ("Open Energy Info - Apps," 2012)

Overnight capital cost describes the initial cost of a generation technology per kilowatt of capacity, if it could be conducted overnight ("Open Energy Info - Apps," 2012). Figure 23 describes the overnight capital cost of each types of renewable energy technology. OCC is useful to compare the economic feasibility of each technology.

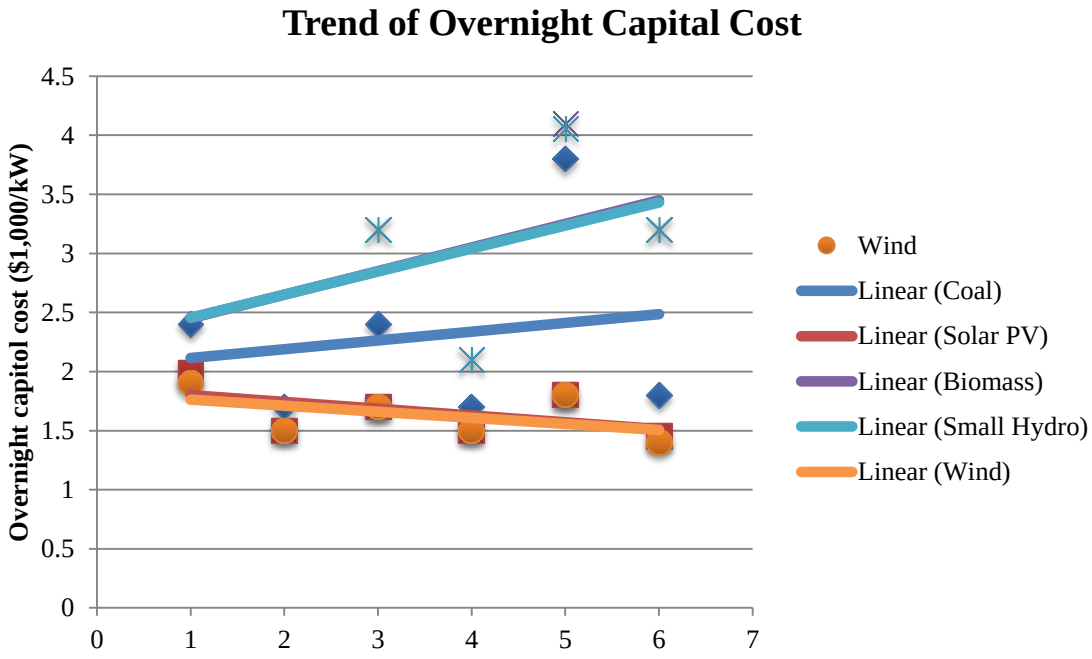

Figure 23: OCC for coal, solar PV, solar TE, biomass, small hydro, and wind ("Open Energy Info - Apps," 2012)

Fixed operating cost examines maintenance costs for generation paid regardless of the total amount generated ("Open Energy Info - Apps," 2012). Figure 24 shows the trends of fixed operating cost for different types of energy technology. The trends that are shown vary from increasing to decreasing to leveled.

The trend of fixed operating cost for each technology differs vastly. Coal power tends to stay at the same range as time goes by because the technology is at its peak and is stable. Contrary, Solar PV and solar TE will experience a decreasing trend in the future. This is because there are many innovations emerging every day that lowers cost for these technologies. Another factor that helps stabilize the operating cost of solar technology is that solar radiation is free and readily available. When supply in infinite, the demand can be met no matter high it is. The technologies that will face an increasing operating cost are biomass and small hydropower. This is because of the resources that are used in these technologies are location specific. For example, as the demand for biomass technology rises in the future, there will have to be an allocation for land for agriculture and land for biomass supply. There is a limit on the amount of land that can be used therefore driving the price up for the same amount of biomass supply.

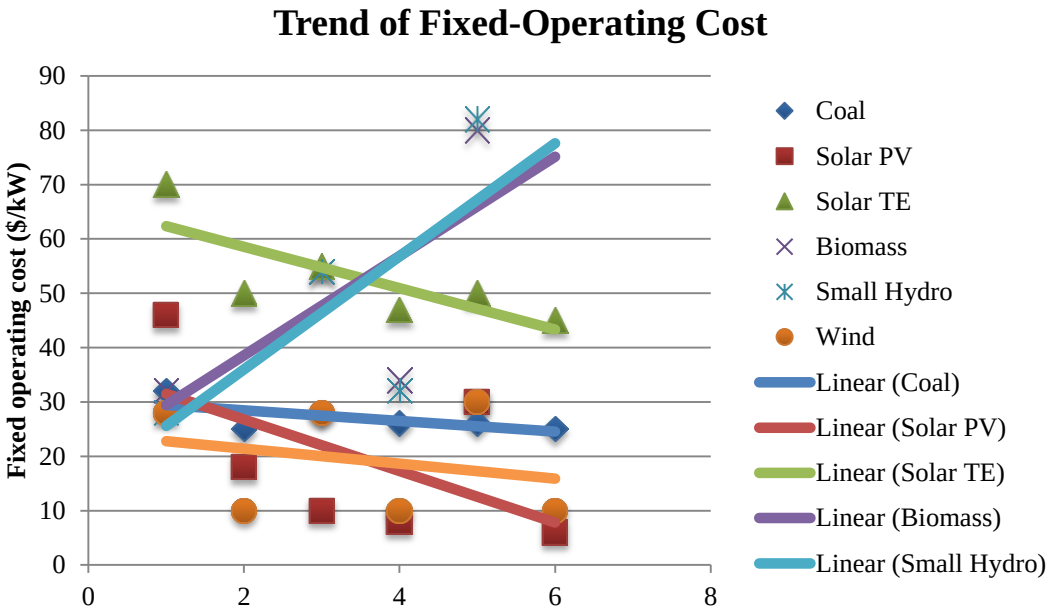

Figure 24: FOC for coal, solar PV, solar TE, biomass, small hydro, and wind ("Open Energy Info - Apps," 2012)

Variable operating cost describes the maintenance costs for generation paid per unit of energy produced ("Open Energy Info - Apps," 2012). Figure 25 shows the trends of variable operating cost for the different types of energy technology. This information shows the maintenance cost per unit of energy produced. The variable operating cost does not increase or decrease over the years. Solar TE, biomass, and small hydropower have the lowest cost (upper bound) and it also diminishes to zero (lower bound). This indicates that these renewable energy technologies require the lowest maintenance cost and could be suitable for systems where maintenance cost is an important factor. Meanwhile, coal and wind have a significantly higher variable operating

cost in both upper and lower bound. Wind energy technologies would have to improve significantly for the system to be maintainable without high cost.

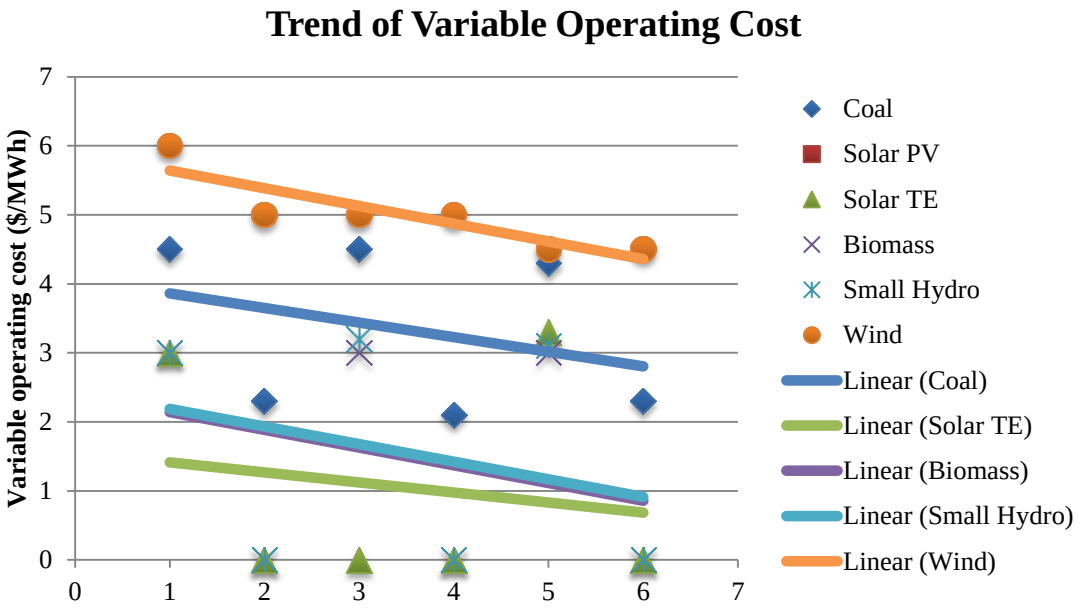

Figure 25: VOC for coal, solar PV, solar TE, biomass, small hydro, and wind ("Open Energy Info - Apps," 2012)

Capacity factor is the ratio between average power and peak capacity ("Open Energy Info - Apps," 2012). Figure 26 demonstrates the trend for capacity factor is relatively stable for every technology. This means that every type of technology presented is reliable. The reason that solar PV, solar TE and wind power have a low capacity factor is because the availability of source of energy is limited (sunlight/day and fluctuating wind speed). This does not mean that they are inconsistent.

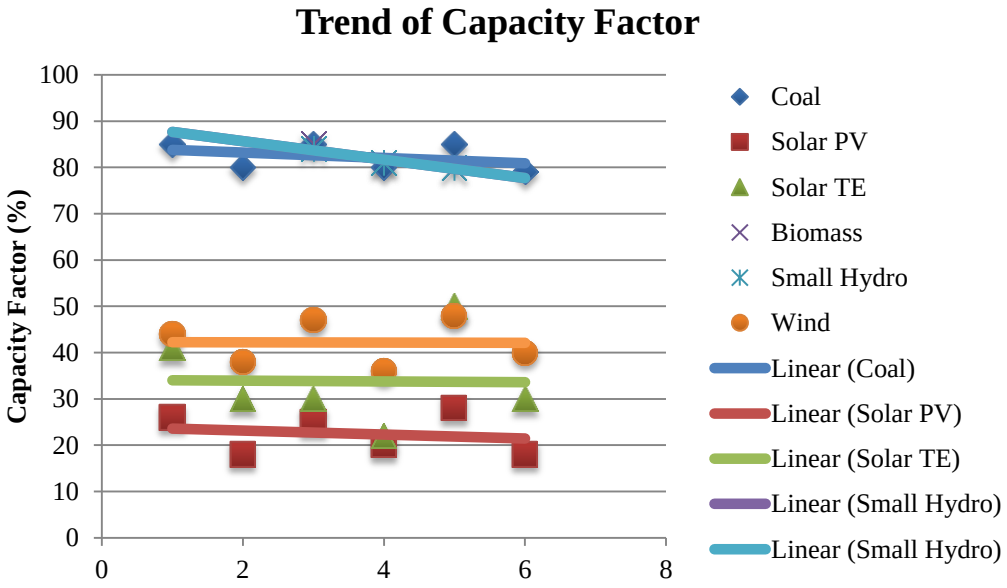

Figure 26: CF for coal, solar PV, solar TE, biomass, small hydro, and wind ("Open Energy Info - Apps," 2012). A plant running at full capacity for exactly one the year would have a 100% capacity factor

4.5.2.2 Environmental and social cost-benefit analysis

A social and environmental cost-benefit analysis was made based on the specific impact indicators. These indicators are identified as externalities that are important to a particular society but are not particularly valued in the market. Social factors include relocation, education, politics, and tourism. Environmental factors include damage to natural and built environment including air, noise, and visual pollution, deforestation, global warming, and health effects. Social and environmental cost-benefit analysis, unlike the economic analysis, will be qualified in Table 4.

Environmental impact indicators are concerned with the impact of the technology on local and regional emissions of greenhouse gas, local landscape, and natural conservation and risk abatement (Intermediate Technology Consultant, 2002). Although some of these factors can be quantified, some indicators are subject to individuals or community perception and are difficult to quantify. These factors include:

Visual impact: the visual impact of a renewable energy is highly particular to perception. Two impacts were considered:

- Objective impact: image of technology to observers in line of sight (those that depend on land form and visibility)
- Perceived impact: depends on attitude to existing land and scenery and general opinions about technologies

Land use: effect on wildlife, biodiversity, soil and local water sources.

Pollution: by-product from operation.

Emission: emissions during operation stage as well as manufacturing, constructing, transporting technologies. These emissions include SO_2, NO, CO_2 and others.

Noise: noise from the technology when in operation.
Fuel: fuel cost to operate each technology.

Resource availability: the scarceness of source of energy.

Landscape: includes:

- Planning process cost
- Effect on land use
- Other purpose of land

Risk abatement refers to the risks that could be averted if a renewable energy technology

Social impact indicators consider the social aspect to gain local support and acceptance of a project. They are used to evaluate the implications of implementing a particular strategy. These could be quantified (local employment gain and income generation) however some are

individual perceptions and are difficult to quantify (Intermediate Technology Consultant, 2002).

Relocation: health hazards related to the technology that can force communities to relocate.

Tourism: future opportunities from renewable energy that can be used to develop green tourism.

Political: local government support or objections.

Employment: how well the renewable energy can provide a source of employment and opportunity to locals.

Education: having opportunities for locals to learn, first hand, about renewable energy sources/ technologies and its applications

Self-reliance: the benefits of not relying solely on conventional energy (grid power). It also concerns the variety of options and security of other sources of energy

Community cohesion: community benefits that could arise from these technologies. These include involvement of the communities in diversification of rural income, financial gains, increase in local employment, contribution to environment, potential for green tourism, and community satisfaction.

Economic cost is the cost at which users will have to pay for electricity generated from each technology.

Table 4: Environmental and social cost-benefit analysis (Intermediate Technology Consultants, 2002)

Renewable Technology	**Specific Environmental Impact Indicators**	**Specific Social Impact Indicators**	**Specific Economic Costs (with assumptions)**
Coal	Visual Land Use Pollution CO_2 Emission	Relocation Tourism Political	Economic: 5.4 c/kWh
Solar Photovoltaic	Visual Use of Land	Employment Education Self reliance	Economic: 75 c/kWh
Solar Thermal Energy	Visual Use of Land	Employment Education Self reliance	Economic: 17 c/kWh
Biomass	Noise Visual Use of land Fuel	Community cohesion Political Education Employment Self reliance	Economic: 14 c/kWh (Electricity only) Economic: 56-98 c /kWh (Heat and Electricity)

Hydropower	Resource availability Visual	Community cohesion Maintenance Education Self reliance	Economic: 8 c/kWh
Wind- on shore	Noise Visual Impact on landscape Effect on birds Planning process Use of land	Community cohesion Tourism Political Employment Education Self reliance	Economic: 7 c/kWh

4.5.3 Finding #12: Solar photovoltaic and biomass technologies are feasible technologies for the learning center site as well as the communities of Mae Mo

Solar photovoltaic and biomass technology are the most feasible technologies to be successfully implemented in the community of Mae Mo, and therefore should be demonstrated in the learning center. In the surrounding districts of Mae Mo we visited three sites who have already utilized renewable energy technologies. These include Baan Dong, Chang Nua and Sop Pat. PDA has another site location in the district of Chakkarat with a successful solar powered water pump system. We studied these projects to determine their success and address improvements that can be made to the system. It was determined that the solar panel, and water pump systems were reliable, easy to maintain and clean, and feasible for the community. Biomass technology was also useful to the community to provide a different type of energy need, and with increased education, it will increase the success rate of the projects in the community.

Renewable energy technologies implemented in surrounding communities of Mae Mo included solar panels and biomass systems. The biomass system uses animal waste to produce gas which is attached directly to the kitchen to be used for cooking. It provided more than enough fuel for one home, and could be expanded to serve multiple homes in the surrounding area. Unfortunately, it was not active because the community member in charge no longer had time to utilize the system. At Chang Nua, there was a similar biomass system, used for cooking but was also not in use. Other biomass systems in the community faced similar issues. The technology was not too complicated to understand and it was user-friendly, according to the community members, but time and effort put into maintenance was lacking.

The Sop Pat was the only site in Mae Mo utilizing solar powered water pump system. The system was sponsored by EGAT and replaced the conventional energy source originally used to pump the water. The solar panels required minimal maintenance and provided a reliable function to the community. PDA also studied the cost of the solar panels would found that they reduce electricity costs by 50% per unit.

From our site visit to PDA Mae Mo, we were able to determine potential renewable energy projects for the surrounding communities. Through observing the 5 districts in Mae Mo, we were able to recognize renewable energy technologies that would suit the community's physical

needs. The needs of the community ranged from water pumps for agriculture, electricity for their household or gas for cooking.

We visited three communities that demonstrated a need and potential use for renewable energy technology. The three community sites include Baan Na Kheam, Nak Sak and the project site based on the Royal Initiative. Baan Na Kheam includes 5 rai, or about 2 acres of agricultural land. Their supply of water is a pond located across a road from the agriculture site. PDA has initiated the building of pipes to transfer water across the road, but still need water tanks and a water pump to transfer the water from the pong to the tanks. Similar to Baan Na Kheam, the other two sites have a water pump and storage system but relied on conventional sources to power their pump (see Figure 27 below).

Figure 27: Diesel powered water pump in Nak Sak

These three sites each demonstrated a potential for the use of renewable energy technology. We only visited sites already reaping benefits from PDA support. There may be a higher potential for renewable energy than is typical in the surrounding communities of Mae Mo. From our physical observations from the sites and information gained from K. Chainarong, the two systems that are useful and practical in the communities are solar PV cells for a water pump system and biogas systems. These two technologies were chosen because there were water pump systems in place but they ran on conventional energies. Other sites acquired a high concentration of bio waste from plant and animals and were able to support a biomass system. Therefore they should be considered as highly feasible to include in a learning center to teach community members about renewable energy technology they can apply to their daily activities.

4.6 Expanding the scope of the learning center

PDA has a large vision for the potential of this new learning center. We noticed several notable trends from our interviews with PDA representatives and community members that can be applied to accomplish this goal.

4.6.1 Finding #13: Advertisement about Cabbages and Condoms is important to reach a broader audience

The Cabbages and Condoms site is located on a main road that many people use every day. This site location is part of the criteria for a good learning center. Khun Chainarong, the Regional Coordinator of PDA Mae Mo, and other PDA representatives in Mae Mo envisions that a learning center about renewable energy will one day attract visitors from other districts and provinces throughout Thailand. In much of our background research, we noticed that PDA did not advertise other learning centers in a way that was accessible to outsiders. Increasing public access to information could work to increase the visibility and accessibility of the learning center.

4.6.2 Finding #14: Solar thermal and micro-hydro technologies are potential future expansions

Two technologies considered during our analysis of feasibility are solar thermal technology and micro-hydro. Preliminary research led us to believe these technologies would fit our feasibility criteria best because the technologies are simple, easy to make and maintain, and initial costs are low. Further understanding of the feasibility of the technology specific to Mae Mo led us to encourage the technology as part of the future expansion of the learning center but not feasible for community members for daily use.

It was immediately apparent in our site assessment that a constant flow of water is not available to many communities in Mae Mo. The Cabbages and Condoms site has a strong flow from a river, but only during the five months of the rainy season. As a result of our interviews with experts, we noticed that micro-hydro systems do not best fit our criteria. Micro-hydro is a very affordable technology but according to BGET/Palang Thai, the technology is more difficult to maintain over time. Therefore it is not reliable for the community of Mae Mo, but could be used in the future as a general demonstration of RET in the learning center.

Solar thermal technology, specifically a simple system called SolarFlower was initially considered for the learning center. Through an interview with the SolarFlower expert, it was discovered that the technology is still in testing phases and would not be reliable for the community. This technology was also not able to use simple technologies to convert solar energy into electricity, and therefore is not user-friendly. However, SolarFlower can easily be used to heat and purify water. As the community of Mae Mo has high alkaline water, this system could be useful in water purification. Thus, this technology could be utilized by the learning center in the future as a demonstration technology. The technology uses locally available resources, as well as simple technology that community members could assemble their own system.

4.6.3 Finding #15: There are gaps in knowledge of community members about issues of climate change

Our interviews with renewable energy experts such as NGOs, organizations, learning centers, and professors revealed that there are gaps in PDA's knowledge that other groups can help fill. PDA has some experience with implementing renewable energy technologies and they have been successful in their past endeavors by involving the community in decision-making and implementation processes. PDA also has highly developed and functional learning centers ("The

Population and Community Development Association (PDA)," 2012). Organizations like BGET, on the other hand, have been working on renewable energy projects for a long time and are only recently beginning to develop learning centers (Appendix B). Generating a contact list for PDA will help them in expanding their learning center. Drawing on the advice and help of other experts will be beneficial to the long-term development of the learning center at Mae Mo.

Our background research has informed us that climate change has and will continue to affect Thailand, particularly the agricultural sector (L. Anderson & Geary, 2010; Marks, 2013; Peterson et al., 2012). Through interviews with community members, we noticed that they know very little about the effects of conventional energy use, and have little to no knowledge about climate change. Climate change is a very important and prevalent topic throughout the world and its ties to renewable energy are also significant (*Adapting to the Impacts of Climate Change*, 2010). After PDA establishes an understanding with community members about the negative effects of conventional energy, they should consider offering education about climate change. It is significant that community members gain a larger understanding of the nature of the problem of conventional energy and how renewable energies are part of the solution.

4.6.4 Finding #16: Water conservation is an important issue for the learning center to address in the future

Our recommendations for a renewable energy powered water pump could lead to an increase in the availability of a cheaper water supply for agriculture. A potential increase in water usage could result in the need for education about water use and conservation techniques. When visiting the Learning Center based on the Royal Initiative in Mae Mo (Appendix C), we saw water purification systems that were used to provide water to the gardens. The system consisted of three ponds that filtered and cleaned water before it was ready for use, as seen in Figure 28.

Figure 28: Water purification system at Learning Center based on the Royal Initiative in Mae Mo; pond 1 allows waste to settle while ponds 2 and 3 treat the water

An additional pond was built to supplement water supply. Building these ponds can be difficult because of the nature of the landscape. Ponds are dug out and filled with clay to line the pond. However, the volcanic rock in the area is very porous and it takes a long time (~ 2 years) for the clay to settle before the pond can be filled. Supplying renewable energy technology to pump water could serve to increased water usage as a result of pumping. Coupled with the expansion of agriculture in the area, these factors could lead to water shortages. These shortages will be compounded by the effects of climate change (Marks, 2013). Consequently, PDA could consider expanding the learning center to include education on issues of water use and conservation.

Our recommendations for the future of the learning center are limited to the information that we were able to gather in only 8 weeks of on-site work. While we believe that these recommendations will become significant for PDA to consider in the long-term development of the learning center, we will be unable to monitor if they will be applicable. Ideally, the evaluative process that we recommend will help PDA adjust to the needs and desires of visitors to the learning center.

5 Recommendations and Conclusions

The Population and Community Development Association (PDA) asked for our assistance in choosing a suitable site for a learning center and developing information about renewable energy technologies (RETs) to address a lack of information and important skills for the community members of Mae Mo. Our findings and background research have allowed us to meet our goal and provide recommendations and preliminary design to PDA Mae Mo to develop a learning center about renewable energy technology and its applications. These recommendations were developed as a result of several major conclusions, which are as follows:

1. Cabbages and Condoms Restaurant and Resort in Mae Mo is an appropriate site for a learning center about renewable energy technology
2. PDA can benefit from increased communication within branches of PDA as well as through contact with other experts in renewable energy and RETs
3. A learning center in Mae Mo should address issues of conventional energy use as well as the benefits and applications of renewable energy technologies
4. The learning center can be expanded in the future to include new topics and programs and reach a broader audience

As a result of these conclusions, we were able to develop many recommendations to PDA. These recommendations include a site layout and design for the learning center as well as ideas for educational materials based on the preferences of the communities. Our findings revealed gaps in knowledge about renewable energy that the learning center can also work to address. We have also included recommendations regarding the content of the learning center which includes feasible renewable energy options and ideas for promoting renewable energy. For the future expansion of the scope of the learning center, we have provided a list of recommendations.

5.1 Cabbages and Condoms Restaurant and Resort in Mae Mo is an appropriate site for a learning center about renewable energy technology

We recommend that PDA create the learning center about renewable energy technology and its applications at Cabbages and Condoms in Mae Mo. This location is a suitable and an easily accessible site for many people in Mae Mo. It meets many of the criteria of a successful learning center as it addresses a specific target group that could benefit from learning about new information and skills; it contains useful conference rooms; it can be easily maintained by reliable staff.

We recommend that PDA utilize existing features of the Cabbages and Condoms site to train community members on applying renewable energy for agricultural use. PDA can use some of the features already available, such as the water tanks and the farmland for demonstrating how renewable energy can be used to pump water for agricultural use. The conference rooms on site can be used for the lecture portion of the training. We developed a site layout (pictured in Figure 29) that describes the location of several of the features of the future learning center.

Figure 29: Recommended site layout and description of features

We recommend that the Cabbages and Condoms site contain the following additional features to develop into a successful learning center about RETs:

1. *Prototypes of renewable energy systems for demonstrations and interactive trainings*

We recommend that PDA have prototypes of renewable energy technologies available for demonstrations and interactive trainings. These prototypes will provide community members with a hands-on experience so that they may learn about the technology, how to construct it, how to maintain it, and how to teach others about it. Prototypes can either be constructed by PDA or donated through other organizations for use at the learning center site.

After a thorough analysis of the our fieldwork, we determined the most feasible renewable energy technology to be utilized in the learning center that best fits the uses and needs of the community. **We recommend that PDA utilize solar powered water pump systems (solar PV cells) and biogas system in the learning center at Cabbages and Condoms.** With an increase

in community knowledge these renewable energy technologies can then be provided to community members to be used themselves.

2. *Educational materials about renewable energy technologies that cater to the different target groups that will be using the learning center*

We recommend that technical information be provided to PDA representatives so they can learn about the renewable energy technologies on site. We recommend that PDA utilize different educational methods for PDA representatives and community members. Our results indicated that not every target group desires the same educational materials. **We recommend a combination of lecturing, hands-on learning, and follow-up in the form of take-home materials in order to effectively educate community members.** Once PDA representatives learn about the technologies, they can use the training schedule (proposed below) as a model for developing educational sessions about renewable energy technologies. Villagers and small business owners would like to learn through training sessions that present verbal information and hands-on demonstrations. These sessions should be followed up with brochures/pamphlets reviewing the information learned during the training session.

3. *Offer services to increase the convenience and accessibility of the learning center*

We recommend that PDA provide food and transportation as part of the program offered by the learning center. As a result of our findings, we believe that PDA can offer additional services to increase the accessibility of the learning center. In order to address issues of distance, PDA could offer transportation services to bring students and visitors to the site. This could help overcome some of the resilience that community members had about travelling to the Cabbages and Condoms site. Additionally, we would recommend that PDA consider providing lunch or other food to visitors participating in training sessions. The Cabbages and Condoms site contains a restaurant that could easily cook for visitors. Additionally, the food could be cooked using the biogas or electricity generated through the RETs on site. Thus, eating could also be used to show the benefits and applications of renewable energy.

4. *Surveys and evaluations to measure the success of the learning center*

We recommend that PDA use an evaluation method to ensure that the learning center is reaching the community and make improvements accordingly. As a result of our findings when visiting learning centers, we found that learning centers use different methods for measuring their success. One method is to have visitors fill out a survey to have them reflect on their experience in the learning center and leave the center with any questions, concerns, or comments. Another learning center evaluated success based on the number of villagers that effectively used methods learned in the center. We would recommend that PDA give a written survey that assesses the learner's satisfaction with the center and their confidence in the skills that they learned. A sample form is included in Appendix F.

As a result of these recommendations, we conclude that the following schedule is appropriate for a training session about RET.

Proposed schedule

9:00 am – pick up students in central location

10:00 am – morning session

This morning session could include a combination of lecture strategies such as a presentation with supporting materials including posters and pamphlets.

12:00 pm – break for lunch, provided by Cabbages and Condoms

1:00 pm – afternoon session

This afternoon session could include interactive tours of the prototypes or a hands-on demonstration about construction, applications, etc. Community members can see how the technologies work and interact with the prototypes or complete a task to learn through action.

3:30 pm – conclusions and take-away points, evaluations

Have students complete the evaluation form (see Appendix F) before leaving the learning center. This will allow you to collect feedback about how the session went, what the students liked or disliked, and how materials and contents can be adapted to the needs of the visitors.

We recommend that an informational brochure be provided to villagers before they leave. The brochure can be catered to the session that they just attended and will serve as a tangible reminder about what they learned that day. In this brochure, you can provide contact information so that villagers may follow-up with a PDA representative/renewable energy expert at a later time. This will work to ensure that the learning process is continued outside of the learning center. The support of outside experts could work to encourage villagers to implement the ideas that they learned.

4:00 pm – bring students back to village

5.2 PDA can benefit from increased communication within branches of PDA as well as through contact with other experts in renewable energy and RETs

We recommend that PDA increase communication between the various PDA offices throughout Thailand. We found that some PDA representatives were misinformed about the educational programs and facilities that different learning centers offered. Additionally, there is a

lack of a clear and comprehensive website/networking system that is easily accessible to outside researchers and viewers. PDA can benefit by increasing communication between their regional offices and learning centers and be more prepared to direct visitors to specific information through websites and informed contacts.

We recommend that PDA contact other experts in renewable energy and RETs. While PDA has some experience with renewable energies and RETs, our recommendations are very preliminary. There are a multitude of other NGOs, industries, and organizations that PDA can contact to gain more information about this area of knowledge. These experts can guide the development of the learning center, offering means for improvement and technical knowledge about renewable energy technologies.

5.3 A learning center in Mae Mo should address issues of conventional energy use as well as the benefits and applications of renewable energy technologies

We recommend that PDA educate community members about the costs of conventional energy and the benefits of renewable energy. After analyzing our fieldwork, we discovered that several members of the population of Mae Mo lack an understanding about how their electricity is produced. Additionally, community members were unaware of some of the harms of the mining and combustion of lignite. In order for community members to understand some of the benefits and usefulness of renewable energy technologies, it is important that they first understand the consequences of conventional energy production and its effects on health and the environment.

We have concluded that in order to explain to community members that renewable energies should be utilized, it is essential to convey the benefits that they would receive as a result of renewable energy technology implementation. We suggest that PDA use a variety of media to transfer knowledge to visitors of the learning center at Cabbages and Condoms. These educational materials should provide clear and concise information on:

- How electricity is harnessed through conventional energy methods
- Why conventional energy is harmful to the environment and human health
- What renewable energy options exist
- How renewable energy production is cleaner and safer than conventional energy, can save community member's money on electricity expenses, and can supply electricity to areas not connected to the grid

We recommend that PDA develop an understanding of the potential applications of renewable energy in Mae Mo. Our preliminary findings show that there are a number of applications for renewable energy technologies, both at the learning center and throughout the districts of Mae Mo. The districts of Baan Na Khean, Na Sak and the project based on the Royal Initiative sites can all support solar PV systems to pump water for agricultural use, and Na Sak also can support a biogas system. We suggest a new design for the biogas system be included in the learning center to provide a more reliable and user-friendly technology to community members.

We recommend that PDA install a micro-hydro system and solar thermal system at the learning center in the future. Based on our preliminary findings, we believe that these two technologies would be feasible and useful for some of the districts and community members of Mae Mo. Micro-hydro power can be utilized at the Cabbages and Condoms site during the rainy season. This site can be used as a demonstration of renewable energy technologies and enough water power may also exist in other areas during the rainy season. This technology could provide seasonal energy. Our preliminary assessment also led us to conclude that community members could benefit from different applications of solar thermal technology.

5.4 The learning center can be expanded in the future to include new topics and programs and reach a broader audience

These recommendations are long-term suggestions that can be considered after the learning center is established and running. These suggestions will serve to increase the scope, credibility, and function of the learning center. The learning center at Cabbages and Condoms has great potential to expand and develop into an institution with a variety of learning opportunities. In order for PDA to achieve this long term goal, **we recommend that they consider taking the following actions in this general order**:

1. Create an informational website to inform other communities about the learning center and increase the accessibility of the learning center
2. Utilize the knowledge and resources of other NGOs, organizations, and community members to improve the knowledge of the learning center
3. Expand the scope of the learning center to include education about climate change and water conservation

We recommend that PDA consider expanding the learning center to include education on issues of water use and conservation. Our recommendations about renewable energy technologies will be used by PDA in order to pump water for agriculture. A potential increase in water usage could result in the need for education about water use and conservation techniques. This will make the scope of the learning center more comprehensive and sustainable.

Conclusion

Through our recommendations, we believe that PDA can adequately address the gaps in knowledge of the community members of Mae Mo. Through this learning center, community members will be able to gain new knowledge, skills, and insights about their lives that will empower them to increase their quality of life. For some, access to renewable energy technology will allow them to expand their business operation. For others, it can cut the cost of electricity or power remote systems. Still for others, renewable energy technologies can allow them to develop a greater understanding of the significance of energy usage. All of these impacts will serve to decrease the vulnerability of Mae Mo to the effects of climate change and a fossil fuel economy. Additionally, the learning center has many opportunities to grow and expand. The learning center can gradually expand the scope of the concepts and materials that it teaches about. One day, the ideals in this learning center will be able to spread to other communities, reaching a greater audience and having a wider impact.

Appendix A – Interview questions for objectives

Objective 1 Interview Questions

Questions for existing learning centers:

- What are the features of this learning center? [Layout of the site, similarities/differences with other PDA learning centers?]
- What issue is being addressed by PDA in this learning center?
- Who is your target audience?
- Who visits this learning center? (i.e. community members, leaders, visitors from other communities, travelers?)
- How many visitors do you receive per week, month and year? Do these numbers reflect the success of the learning center? If not, how do you measure success in this learning center?
- How were the community members involved in the making of the learning center? How are they involved now?
- What materials/services (ex: learning sessions, take-home materials, prototypes or examples) do you provide to your target audience?
- What was the most effective tool for educating community members or leaders? What services or materials did you try that did not work, and why?
- Do you have an evaluation process for this learning center?

Questions for PDA representatives, community leaders, and community members:

- Have you ever been to a learning center?
    - If so, what did you do there?
    - What do you think the purpose was? (i.e., was it even clear to them?)
    - What did you like/dislike about those activities or information sources?
    - What was the best part of the learning center? The most useful? Least useful?
    - Was one visit enough?
    - What do you wish was there or that you did? Why?
- What do you believe are characteristics of a good learning center (location, accessibility, materials)? Why?
- Where do you think the Mae Mo learning center on renewable energy should be located? Why?
- Would you visit a learning center at Cabbages and Condoms? Why?

Questions for visitors/travelers:

- Is this your first time at this learning center?
    - If not, what programs have you attended? What was the purpose if the session you attended?
    - What did you learn?
    - Do you feel like the session prepared you to use this information?
    - If not, what additional information would you need?

- Have you visited other learning centers? How many times?
- What attracted you to this learning center?

Questions about educational media for the target groups:

- How would you prefer to learn about renewable energy? I.e. through a learning center, friends, PDA representatives
- What materials would help you learn about renewable energy? Please order your response from helpful to unhelpful.
    - Diagrams
    - Dioramas (scale model)
    - Technical manuals
    - Videos
    - Training sessions
    - Prototypes
    - Posters

Objective 2 Interview Questions

Questions for community members:

- What energy problems do you face?
- Do you have electricity? How much does it cost?
- What are some difficulties you face in your daily activities?
- Do you believe renewable energy can support your energy needs?
- Do you take any steps to decrease your electricity use? If not, are you aware of ways that you could?

Questions for PDA representatives included:

- What do you see as a main problems that the district you represent face?
- What benefit do you think your community can receive from electricity or renewable energy?
- What is your opinion of renewable energy? And have you ever had any experiences pertaining to renewable energy (for households or communities) before?
- What are the characteristics of good learning center? In terms of location, accessibility, materials, and demonstration?
- What learning materials about renewable energy would you prefer to see?

Objective 3 Interview Questions

Questions asked to the NGOs:

- What geographical considerations should be made when visiting a site (Lampang is a mountainous region)?

- What are the steps that (specify NGO or company name) takes in deciding on renewable energy systems? On implementing renewable energy systems?
- What types of renewable energy have you encountered that work well with rural communities with limited knowledge and income?
- Have you had any success with hybrid systems that utilize more than one type of renewable energy?
- What seasonal considerations (i.e. rain or fog) should be made in developing renewable energy systems?

Questions asked to professors:

- What are the factors of choosing a renewable energy based on location?
- Which type of renewable energy is the most suitable for Amphoe Mae Mo area (northern) in your opinion? Why?
- Is it possible to integrate different types of renewable energy (hybrid systems) for a better output?
- Which type of renewable energy is most suitable for villagers with low knowledge about renewable energy technology and their maintenance?
- Which type of renewable energy resources is the most affordable?
- Are there any alternative ways cheapen a renewable energy resource technology?

Interviews with PDA representatives:

- What renewable energy projects have been successful in the past? Unsuccessful? And why?
- What are seasonal considerations of the community to consider when studying renewable energy options?
- Have you had experience with renewable energy technologies in the past?
- If yes, were they easy to understand and maintain?
- What prevented maintenance of the renewable energy system?
- Have they been less expensive/ more expensive than electricity from the grid connection?

Questions for community members:

- Have you had experience with renewable energy technologies in the past?
- Do you think renewable energy can support your energy needs?
- What do you know about the benefits and cost of conventional energy/ renewable energy?
- If yes, were they easy to understand and maintain?
- What prevented maintenance of the renewable energy system?

Objective 4 Interview Questions

- What do you already know/understand about renewable energy?

- Follow-up question: Are there specific types of renewable energy you would be interested in learning about?
- If you have had experience with renewable energy, what benefits do you see from using it?
- What do you find interesting about renewable energy?

Appendix B – Interviews with renewable energy experts

Interview with BGET and Palang Thai

17 January 2013, 2 PM
Chulalongkorn University
Attendees: Chris, Salinee, Chanica, Ashley, Maddie, Julia, Tom, Giovanna

Questions to us:

- Are you actually building anything?
    - We would love to implement a technology
- Previous IQP suggested micro hydro and it was built later
- Will community be able to make conclusions and implement something themselves?
    - Yes, we hope so
    - PDA engages the community , they can use the learning center to do it themselves

Our questions:

- Geographical considerations – what should we look for?
    - Not very far from the power plants
    - RE will be more expensive than provincial electricity authority
    - Economics of RE systems cannot compete with retail price of electricity from PEA
    - Areas far enough away from the national grid are more likely to want this type of electricity
    - Grid connected projects are more viable when they're big (millions of dollars)
    - More rural area might experience extreme lack of
    - Solar – anywhere
    - Hydro – stream in mountainous area
    - Wind – isn't particularly viable at household scale
    - Biomass – huge supply of manure
    - Project for learning center – can set up any system for people to learn and implement a project that would fit
- What steps do NGOs take to determine feasibility of renewable energy?
    - Talk to community before talking about our ideas
    - What do they need?
    - Didn't do that at the beginning of NGO
    - Setting up learning center – surveying needs of people (what would be useful?)
        - Volunteers are surveying villagers on needs
        - Learn more about work, income, money spending
        - Focuses on RE and sustainable agriculture
        - Develop training around knowledge, needs, desires of community members
    - Provide information about options (water can give you… animals can give you…)
    - How is the project going to continue years later? Need strong community and financial support in the long term, reliable technology
    - Failure years down the road without financial planning for maintenance creates a crisis

- What RE work well with limited knowledge and income?
    - Different communities and different technologies are different
    - Solar energy
    - Many people are already familiar with the technology
    - Other technology (micro hydro) is more difficult to maintain over time
    - BGET has been working since 2000s with different technologies and have experienced failed projects
    - Solar-electric is slightly more developed and less likely to see extreme forces of nature
    - If community works, then the project can work – include ideas of community from beginning
    - Any project that becomes sustainable has to consider four factors
        - Strong community
        - Long term financial support
        - Reliable technology
        - Assessment of project and checking in with progress
- Designing hybrid systems?
    - PV and solar?
    - Not all other options are practical
    - Not always economically feasible
    - Solar wind hybrid systems? Solar diesel battery systems
- Seasonal considerations
    - Look at what happened during seasons
    - If water source is enough during rainy season, is it enough in the dry season?
    - Sun in the valleys – might not have as much sun
    - Solar – small amount of shading severely reduces output of module
        - Failures occur when there's partial daily shade
        - Before or after the panel is built! Avoid obstructing panels
    - Lead acid batteries – discharged and left, the battery can fail
    - Watch out for electricity use during rainy season when there isn't a lot of sun
- Thermal solar
    - Use for showers and heating
    - Can be used for demonstration in learning center

Take away points:

- Money for repairs, maintenance is very important
- Micro hydro can get damaged in floods
- Account for climate change, seasonal/geographical changes
- Make forms for community to work on their own site assessment
- Education about use of electricity during the rainy season
- Type of technology with several uses (i.e. heating water, generating electricity) would be ideal for multiple uses and applications
- Be more aware of availability of sun in communities (more important than we thought)
- Have to be aware of availability of grid electricity and price of electricity consumed

Interview with Aj. Naebboon Hooncharoen

Chulalongkorn University, Power Systems Research Lab
24 January 2013
Attendees: Chanis, Chanica, Maddie, Ashley, Julia, Kenny, Giovanna

Background:

- Chula is a national university and focuses on the national agenda
- Other universities may have more regional focuses
- Aj. Naebboon does not know the specifics of Mae Mo
- Can speak of power plant in Mae Mo and national development

1. What are the factors of choosing a renewable energy based on location?

    - Potential of renewable resource in each area – some resources are free, some are not
    - You have to survey a potential for each renewable energy resource, not particularly limited wind power due to geographical, wind power is limited.
    - Highly focus on solar power and biomass/biogas related.
    - MaeHongsorn – Green province → mini hydro is available there.
    - Biomass/garbage – agricultural residue, rice husk, wasted related (how they process wasted and agriculture residue.

2. Which type of renewable energy is the most suitable for Amphoe Mae Mo area (northern) in your opinion? Why?

    - Northern area
        - Wind is limited
        - Mini hydro (lots of rivers)
            - Quite complex, and specific location and also government and land issue)
            - Micro-hydro, for few 3-4 kilowatt for remote area people, may be highland
        - Biomass/Biogas
            - In Chiangmai – agricultural residue causing smog and dust
            - Must first give a knowledge to community with appropriate tech, also logistic management
        - Solar power usage is expected to increase all across country, convenient to utilize solar power to set up solar farm, recently due to Thailand policy
        - Rooftop solar, solar farm will take over the land.
    - Energy crop vs. food crop – energy crop like some species of grass somehow it might affect biodiversity

3. Is it possible to integrate different types of renewable energy (hybrid systems) for a better output?

    - Possible and also a trend
    - Pair intermittent energy sources that fluctuate (solar and wind)

    - We can predict solar and wind but uncontrollable
    - Design a good combination between these 2
- Not very easy to maintain now, maybe in the future
- "Hybrid renewable technology/energy" can be apply in small – large scale
- In Germany, see light intensity in different regions, study investigate correlation between wind speed and light intensity

4. Which type of renewable energy is most suitable for villagers with low knowledge about renewable energy technology and their maintenance?

    - Simple like micro hydro, solar PV [clean up solar panel only]
    - Don't think about hybrid yet
        - Need to maintain system but balance generation and load {electrical appliance} second by second, otherwise system will lose stability it will collapse
    - Only single source of generation first for villagers.
    - Solar can predict between 7am – 6pm
    - Biogas – at least you need one technician to check and maintenance, lubricant or ventilation [same engine as car engine]

5. Which type of renewable energy resources is the most affordable?

Generally speaking, Grid parity/priority – cost of renewable energy is comparable due to conventional generation [Solar and biogas energy will be comparable to conventional]

6. Are there any alternative ways cheapen a renewable energy resource technology?

    - PV – 5 years ago, investment cost of 150 M Thai Baht / [1W = 150 Baht]
    - PV is DC system need converter into AC to connect to the house
    - PV and invertor cost 50 :50 price
    - Japan, China and others are promoting renewable,
    - 2030 with clear-cut policy, achieve economy of scale
    - Cost will keep decreasing since people start to interest in renewable energy more and more [Solar PV]
    - CHS – combined heating/cooling and power system, 80+ efficiency
    - Conventional is 50% efficiency generation [coal, and natural gas]
    - Renewable energy to replace the conventional [main focus]

Interview with Daniel Connell (from SolarFlower.org)

29 January 2013, 8 PM, Reno Hotel
Interviewer: Maddie
Attendees: Julia, Ashley, Maddie, Giovanna, Daniel

- Can you tell us about the SolarFlower technology and applications in Thailand?
    - Do you offer this technology to those interested
    - 2004 – building shade structures
    - Ways of keeping something turned towards the sun
    - Came up with technology
    - Guiding a shade structure
    - Concentrated solar
    - Sterling engines?
    - Concentrate sunlight on highly efficient PV panel
    - Didn't do anything about it until 2007 or 2008
    - Only recently been building things – made prototype based on original design
    - Copenhagen, Spain, Germany
    - Track sun, made from recycled materials without advances tools or skills
    - 2011 in Paris – online documentation on website (tutorials)
    - Does 3D animation for a living
    - Workshops in New Zealand and Spain
    - Travelling through Australia, Asia, middle east – making and designing infrastructure
    - SolarFlower is pretty easy, but still demanding – small team of people takes a couple of days to build
- Do you have any experience with renewable energy technology in Thailand?
    - Been through Asia and Thailand (2-3 weeks)
    - not very familiar with the area in terms of needs and design
- Do you have experience working in rural communities?
    - SolarFlower is in beta testing phase in New Zealand and Spain
    - Device in Spain is in the process of being plugged in
    - Similar technologies – most infrastructural building is done under the NGO/university model – brought in and diluted to people
        - Good, but not quite the same
        - He works to adapt materials to their needs
        - Not a very common model
        - Reverse engineering to make projects catered to community members – not a very common model
- Can SolarFlower be used with batteries?
    - Doesn't generate electricity
    - Tracks sun
    - PV panel
    - Need to plug heat into steam engine (sterling engine) and then have that drive an alternator to generate current
    - Difficult to generate electricity from heat in a simple way

    - Working on ultra-simple electric generator
    - Uses: Heat, purify water – using heat directly
- Are there technical manual or blueprints available? Physical copy to use when building
    - Tutorials contain all the information necessary to build – sees it as an online course
    - Information on the process
    - Has a 3D model of the device – can give it to us
    - Animation – seeing all the pieces coming together helps resolve any ambiguity
    - Expressing that on paper would be difficult
    - Text on the website aligns with the videos
    - Workshops would model this type of animation; paper is difficult
    - Better for one person to understand the tutorials and then have one person teach others
- Will it work?
    - Efficiency is still unknown
    - It tracks – doesn't know how accurately
    - Collects heat
    - Boils water (140 C in Spain)
    - Doesn't currently generate electricity
- Water purification?
    - Should be ideal
    - 140 will pasteurize
    - Steam distillation
- Denmark, Copenhagen – don't need much energy, but do need direct sunlight
- Can throw off the optics
- If not casting a clear shadow, the tracking system won't work (i.e. diffused by haze or smog)
- When the ethanol or water is turning the wheel – connecting it to a generator?
    - SolarFlower works off low power, low efficiency heat engine
    - Wheel does 1/3 of turn every few minutes
    - Water is used to counterbalance
    - Works because it is very easy to turn the system slowly

Appendix C – Notes from site visits

Learning Center Site Visits

PDA Learning Center

5 February 2013
Chakkaran district, Nakhonrachisma Province

This site offers three services

1. Family Planning/AIDS prevention
2. Job Creation/Income Generation
    a. Keep jobs local
3. Renewable Energy
    a. Solar cells for water movement and water purification

Agenda:

Visit community
Lunch
Tour of C&C learning center
Final questions

Community Information (notes from initial meeting):

- Initially connected to the grid
    - Costs were too high
- Contacted a sponsor (Standard Charter) to provide these solar cells for electricity created and implemented by Ida Tech
- Use of solar cells for agriculture (now 3 years in place)
- 5 baht per unit for grid→ 2 baht per unit to pay for maintenance of solar
- District includes 40 villages (8 sub-districts)
- German Technical Cooperation (GTZ)- NGO for developing countries, monetary support
    - Stan was familiar with them
- DTEC- government organization, connection b/t the NGO's (PDA/GTZ)
- Agriculture in the community→ sugar cane, rice cassava (4.6,4.6,5.6 (Baht per square meter) respectively)
- Problem: Low income, 2 options for making money- move to Bangkok for work or expanding area through deforestation to grow crops
    - Only one season for the agriculture
    - PDA wants to prevent them from moving away from the community., it breaks up families as well
        - Father moves away, may sleep around, stay in Bangkok, or bring back AIDs
    - GTZ supported the program until 10 years ago, PDA is trying to sustain it independently
- We were given a diagram of SPWS***

Site Visit-Interviews President of the Water System (he does all the maintenance)

- Old tank too small, and this was connected to grid power (caused a negative income)
- With solar panels- serves 106 homes (for water for daily use)
    - 120 homes in total
- Drinking water is collected from rain
- 35m deep piping, well is 68m deep
- Pump to holding tank 1 km away from the pump/solar panel system
- No water supply issues, could dig deeper if need be
    - Also water was delicious!!! Tried it☺
- System (ball) to regulate water level in the tank (similar to that of a toilet tank) can break
    - Other than that maintenance is minimal
- Solar system runs 7am to 5pm
    - Other than that they use grid electricity
    - Promoting to only use water between these times
- Batter storage?
    - No access of electricity to store…
    - 1.8 HP water pump

- **How was the president of the system trained? How did he pass on the information he learned?**
    - Company specializing in the technology (Ida-tech) comes in to train the specified member of the community (one-time)
    - After this first system they implemented 2 others and training was similar
    - Other smaller techniques in cleaning panels and what not to do are shared between community members who are in charge of the panels.
- Easy maintenance
    - Mop/ wash down the panels with dish soap
    - These panels have a 20 year guarantee
- **What benefits does he see from using renewable energy?** (We asked if he knew about climate change and if he understands why renewable energy can help)
    - Marshalls law of hierarchy- money first, then environment
    - Connection made with the PDA about climate change- it's understood that it helps climate change
    - For community members it was simply income related (cheap supply of energy)
- Does the low cost of electricity increase in demand in the system?
    - Yes if they can pay for more, because it's cheaper than they will use more – money restricts their use
    - 1.5 units for small individual storage
- Standard Charter is the bank that donated money for initial costs
- PDA is the middle man-connects community, funding, technology
- Cantaloupe
    - Resting period 2 months (harvest = 3 times a year) with water supply
    - Water usage 100 units a month (200 baht/month)
    - 20,000 baht for initial piping costs
    - 50/60,000 baht for the harvest of the fruit
- Water storage tank on community leader's property

    - He provided the land to hold the tank, also it was highest ground to allow for gravity flow to supply to members
    - Same size tank as in Lampang, only maintenance is that water level regulation system
    - When talk was implemented, he tested a 2 hr/day drip system trial
        - 10 ton per rai (before drip system)- 28 ton per rai (after drip system)
    - Do you see the benefits of using RE? Do you know what climate change is?
        - Money related, nothing about climate change
- C&C Learning Center (**What are the features of the learning center?**)
    - 8 (companies) Factories, Agriculture (job creation, income generation)
    - Employ 1,500 workers
    - Solar Pump/Water Treatment process
        - Water is pumped from a nearby river to a man-made pond (solar)
        - Water pumped again from the pond to this treatment system
            - Alum added, settlement system where it slowly moves through a maze like structure to a filter (sand, gravel, rocks, pebbles), then chlorine is added to drink
        - Solar panels sponsored by EEP
        - Excess power= cooling/roof system and a fountain in the pond
    - Factories: Shoes, Sportswear, Helmet, Doll factory..etc.
    - Other aspects
        - Agriculture
            - Crickets
                - C&C raises crickets to sell to community members for (20baht/kg??)
                - They can deep fry these crickets and sell for more (100baht/kg??)
            - Catfish pond (show them how to utilize little space to raise catfish)
            - Chickens
            - Mushrooms
        - They also grow fields of cantaloupe, chives, asparagus
        - They sell smaller plants to any community member that goes through their training process
            - 15 farmers each, presentation and handouts with less words and some pictures
            - ½ of theory in the classroom, ½ on hands training in the training center
        - Income generated from this entire place is 10,000 baht
        - PDA talks to companies to fix prices for these crops to ensure constant income to farmers and they can't experience any lack of income
        - 7/15 gain almost 100% but all farmers gain profit from their harvest

What issue is being addressed by PDA in this learning center?
This learning center focuses on income generation with parts dedicated to family planning/AIDS prevention and renewable energy

Who is you target audience?
Community members

Who visits the learning center?
Community members (whoever is interested in learning about agriculture), leaders, University students from Chula (teacher may take their students here), and companies that may want to invest (in PDA, the factories, villages)

How do they find out about your services/programs?
Word of mouth

How many visitors?
They have 2 visits per month and the number of people that attend varies. (could be as little at 10 and as much as 100-200)

Do these numbers reflect the success of the learning center?
No, they measure success based on the success of the farmers that attended. When farmers come to the center to learn about agriculture, they usually take the information and use it for farming. They don't just buy the seeds and plant them. The villagers learn how to make fertilizer, catch pests (avoid using pesticides), and about the different crops. Next they bring that information to the farm and if they learned how to do all of these things properly, they will be successful. Successful meaning they make a larger profit from the crops they sell. The site director said about half of the farmers are successful and make a larger profit than the remainder of the farmers. He used an example where 15 farmers come in to learn, and 7 out of those 15 will make a larger profit than the remaining 8. They usually sell more because the quality of the cantaloupe is better because they learned the techniques from the PDA learning center well.

How were the community members involved in the making of this learning center? How are they involved now?
They weren't involved, this was aimed to help them with income generation, but it was made for the communities not created by the members. Currently, members attend as sessions occur that they are interested in.

What materials/services do you provide to your target audience?
They have a full day training, the first half is spent in a conference room, listening and watching a presentation (Powerpoint), the second half is spent with interactive learning (a demonstration using the examples in the greenhouses, fields and such). The attendees are given a 3-4 page booklet with instructions, descriptions, figures and diagrams. (They didn't have any examples to show us)

What is the most effective tool for educating community members or leaders?
The interactive training where the Powerpoint makes sense to the villagers.

What services or materials did you try that did work or did not work?
No answer. It seems that they haven't really taught any other ways besides this type of training.

Do you have an evaluation process for this learning center?
No

INTERVIEW WITH WUTHICHAI (A VISITOR OF THE LEARNING CENTER)

What session did you attend and what have you learned?
He came to the learning center initially to learn about agriculture and ended up learning about the solar panels as well.

- He started a community where he hopes each household will have a solar panel (so far 10 homes have been built and have them and he is hoping to end up with 140-150 households
- He found a solar panel that costs 20,000 baht

How did you learn about solar energy?
The PDA way, full day training, half in classroom setting and half in demonstration

What did you like/dislike about it? Why?
He liked it.

What do you find interesting about renewable energy? What benefits or negatives did you see/have you seen from using it?
He said renewable energy, specifically solar, was interesting to him because it could help with income generation. That is also a major benefit he sees along with it helping address the issue of climate change. He said the major negative of using it is the initial cost.

Some advice from him:
He said people generally have a negative thoughts about Mae Mo. Mae Mo is known to have pollution and smog, not a very good place to visit. He believes renewable energy can change that because it doesn't harm the environment in the way that the coal-fired power plants and mines do. We (PDA and other NGOS, villagers, leaders) have to change their minds. Maybe if Mae Mo was a cleaner place to live and visit, more tourists would visit, meaning income.

SITE VISIT TO SUNNY BANGCHAK

8 February 2013
Sunny Bangchak Learning Center
Interviewees: Chanis, Chanica
Note-Takers: Julia, Giovanna

- 3rd largest solar farm in southeast Asia (500 rai)
- Clean energy exhibition of several types of renewable (natural) energies consisting of recordings, videos, dioramas, interactive sites, etc.
    - Wind
    - Solar
    - Kite
    - Algae
    - Wave
    - Biological
- Colorful animated displays with concise information about batteries, cars, future uses of RE, information about carbon dioxide emissions
- Dioramas of how natural energies can be used in a town
- Research currently being conducted about using algae to produce biofuel
- Life-changing 4D video about natural energy technologies
    - Cartoon and simplistic that could be used for a variety of audiences
- Bangchak produces their own fuel (biofuel) from algae
- 44.5 MW capacity of solar farm
- 38.5 MW of electricity currently being sold
    - 30MW to EGAT
    - about 8MW to PEA
- 8 baht per kWh bought from the government and sold to citizens for 3 baht
- Second phase of Sunny Bangchak's project is located somewhere else in the province
    - The other solar farm has a 50MW capacity but produces 32MW of electricity
- The initial startup cost of this solar farm was 4.2 billion baht and it was not subsidized
    - Currently produces around 200,000 kWh per day
    - By making about 2 million baht per day the site will break even in about 6 years
    - 70% of the cost went to the panels and the other 30% was for everything else (like converters)
    - The cost for the plant has improved to 50/50 for panels/inverters
- This solar farm has the capacity to produce 200,000 units/day which is can power 600 households for one month
- Learning center is not open to the public. Sunny Bangchak is wary that people could steal panels or wires since their CCTV system does not view the entire farm. Center is only open for reservation frequently by the military, schools, universities, and other companies
- No training takes place here, it is only an exhibition center
- Tour guide told us that for our learning center, it will be crucial to educate people on the maintenance of renewable energy systems
- Due to the climate, solar cells are the best option of renewable energy for the area

- Electricity can be produced at a maximum rate for 5.5 hours per day
- Suntech brand solar cells ← Chinese company
- Currently seeking interactive materials and more languages (currently written materials are only in Thai)
    - CEO has no vision to expand to reach NGOs or rural communities
- Online advertisements will be used to promote this center
- Suggested to contact Panasonic for potential donation of solar cell
- Tracking solar panel only produces 2% more electricity than the stationary cells
- Flat land is optimal for implementing several solar panels
- Many new perspective: safety (cells, wires, site, possibly the owner), professional teaching views, financial aspect of solar energy, interactive learning

BAAN DONG LEARNING CENTER

Background:

- Learning center:
  - Community bank
  - Arranges funerals
  - Drinking water
  - Community committee
  - Animal farm (pig in a hole, chicken, fish, frog farm)
  - Agriculture (veggies, fruit, trees [teak])
- Committees and other organizations come to learn from this site
- Multiple activities of this district
  - Pellet fertilizer, mushrooms, biogas digester (out of service), agriculture and textile
- Training programs held here
  - 2 or 3 times a month (in a certain season)
  - Upon request with the committee
  - Police and officials come to teach about policies and rules and regulations
  - Verbal class to teach them the information
    - Documents and lecturing both used
  - Difference in the materials available at this learning center, and the comm. Members home causes a discrepancy in their learning
    - He had an example of this but I didn't have it written down
  - No demonstrations/pictures also cause confusion
    - [Pig in the hole]
  - Simple **and even local language** needs to be used!
  - Improvements he would like:
    - Model or prototype
    - Medias and demonstrations to convey in a non-verbal manner

Site Specifics:

- Contains pigs, frogs and fish
- Biomass system
  - Needed to drain water from the system- then it can run again
  - Includes a diagram of the system to see the inner workings
  - Manure produced
  - This is used again for cooking (not to generate electricity)
  - Seemed complicated to the community
    - Needs a more simple system to teach
- Pigs (2 in 1 system):
  - Uses the pigs (and the way they constantly dig) to mix his fertilizer
    - Contains rice husk, low manure, natural antibacterial
    - Used in the gardens

Additional Information:

A learning center located in the Mae Mo district of Baan Dong holds a community bank, drinking water manufacture, community committees, and several animal and agricultural farms. Animal farms at this learning center include pigs, chickens, fish, and frogs. Different vegetables, fruits and trees are grown there. In addition, this learning center has a biomass system that uses manure from the pigs to generate gas used for cooking. There are two or three training programs held monthly at the learning center in Baan Dong. All of the courses taught at the center have a verbal and written component to ensure that information is being conveyed accurately. Pictures and demonstrations are also used as frequently as possible as to cause as little confusion as possible. The learning center in Baan Dong utilizes the participatory approach exemplified by PDA.

Mae Mo Site Visits

PDA'S PROJECTS AND REGIONAL OFFICE

Sop Pat:

- EGAT sponsored project
- Solar cell powering water pump
- Old generator in place- used as backup
- Tank: 6.60m x 2.30
- 1000 Baht extra/month
- 10 cells/ 2 tanks/ 15 rai of rice paddies

Bike water pump: 6000 baht/ unit
When running it waters the garden

DISTRICT: CHANG NUA

Background:

- Biogas
    - No time to keep filling the tanks
- Provide a better system- improved quality and quantity of electricity (use a generator)

Site Specifics:

- Pig farm
- Banana tree cutting machine (hand-made)
    - Makes food to feed pigs
- Biomass digester
    - Not in use (hasn't had time to take care of it and fix it) says owner
    - Gas used for cooking
    - Biomass from pig farm
    - Waste after gas is released, can be used for manure
    - Blue plastic tanks rise to indicate they are full
        - One tank is more than enough gas to supply one house hold

        - Can use this to connect to generator- provide electricity to one or expand the influence to other house holds
    - There is a lot of waste in the system right now

Additional Information:

- They learned about this specific system from a learning center (north of Lampang on the way to Chaing Rai) **Payao**
    - Choose it based on the small scale and seemed suitable for a house hold
- Does PDA have information on this learning center? Can we visit it?

DISTRICT: NA SAK

Background:

- Goal of this site
    - Provide an example of this mixed use agriculture to encourage villagers to take this back to their farms and use the technique
- PDA pilot project
    - Self sustaining farm (rice paddies)- first out of 9 villages
    - Mixed use agriculture
    - Fish pond, pig in a hole, chicken coop
    - Local villages will visit, uses the land

Site Specifics:

- Water line connects this site to the EGAT water supply
    - Water flows from the road (through pipe system) to a collection pond
    - Some continues through to the rice fields
    - Some is pumped to storage tanks- used for animal, household
    - Water amounts can be controlled from valve at the road
    - Many farms are below this water supply and can use a hose to connect
        - EGAT has only provided piping for this one
        - 2/9 villages have access to this water
- Storage tanks
    - 5 tanks total (some have leaks)
    - 2,000 L each
    - Government fills water tanks for drinking
- Water pump
    - 5 H.P (1-3L of diesel/week) to run
    - Cost 40-45 Bahn/L→Spends 500-600 per month
    - Only needs 1 H.P
        - Helps cut costs if we provide a renewable system
- Pigs
    - 50 Kilos of manure is produced
        - This will vary with the season (on average 4 to 5 at a time)
    - Future plans to have pigs all year round
    - Biomass system elsewhere in Mae Mo that they are interested in learning about

Additional Information:

- Villages in this area don't have electricity in their agriculture fields
- Gas (for their pump) cost 45 baht, in Bangkok its 30-35 baht
    - Rural-urban electrification
- Can also produce electricity to run their machines
- Biodiesel to power these machines

ROYAL PROJECT SITE VISIT

19 January 2013

Background:

- Learning center based on the Royal sufficiency initiative

Site Specifics:

- Water treatment system
    - Storm water flows into a pond
        - First pond allows waste to settle, 2nd for initial treatment, 3rd for final treatment
        - 4th pond recently dug (demonstrate the solar water pump)
- Small plots for different villagers (58 plots, 15 rai)
    - they maintain and water their own plants
        - 25 Baht/month cost for water (electricity for pump)
    - can sell or use the produce
- The water is not sufficient enough for the community
    - Water is controlled by the site, only turned on at certain times of the day
- Volcanic rock causes issues when creating ponds
    - This rock is porous and water seeps through when the pong is initially crated
    - Clay settles in after two years
- Water tanks (2)
    - Tank: 6.60m x 2.30 m, capacity 20m^2
- Water pump
    - 220V from electric line (this is enough)
    - 300 m from pump to tank

Additional Information:

- Grid power used for the pump(s)
- EGAT comes to this space to learn about how they negatively impact a community and how the community must overcome these impacts
    - Different target group to consider
- Additional sponsor for this site (may be dropping the site soon?)

BAAN NA KHEAM PATTHENA

19 January 2013

Background:

- Want to use water in the pond for agriculture across the road
- Area is very shaded

Site Specifics:

- Agricultural area at site = 5 rai = 2 acres
- Pond used for water supply located across road (small road)
- Pipes for the system are installed and ready
- Need to build a tank and a pumping system
    - Preferably with RE

Other Information:

- PDA did a cost analysis and renewable systems cut the **daily** costs of using electricity by 50%
    - Need more information about initial costs and maintenance
- Asked about relationship between committee and PDA (K. Chainarong answered)
    - Villagers and leaders trust PDA's decisions and usually go along with what they suggest

Appendix D – Interviews with target groups

Interview with PDA representatives

21 January 2013

Interviewers: Chanis, Chanica, Kenny (Ashley, Julia, Giovanna, Maddie)

Interviewees: Mr. Goson Leader of Mae Mo District (12 villages in Mae Mo +1 Village in Sop Pat), Ms. Un Leader of Nasak District (9 villages), Mr. Savut Leader of ChangNuea (7 villages + 1 community), Mr. Yong Leader of Sop Pat (7 villages)

1 district leader did not come for the interview (Baan Dong District (8 villages))

1. What do you see as a main problem that your community faces?
    - Generally, water is the main issue whether water for daily use as drinking, household, and agriculture. Water sources are far from some communities
    - Drought (February/March – April)
    - Ground water is too alkaline
        - Limestone from the mines
    - Ground/soil composition is volcano rock which can't hold water due to the porosity, for certain time when the water absorbed by pores, will stabilize and condense the soil.
    - Electricity is not the main concern anymore as many are connected to the grid
        - We can propose and show that solar cell or solar energy is really good and able to improve their life by reduce the cost of living of energy use
        - Electricity shortages during the rainy season
            - Villagers don't know when the electricity will go out; therefore needs a supplement source source that won't go out with the grid.
            - Some communities aren't connected to the grid.
        - R.E. : A lot of people can/are living without RE and we have to convince them the benefits they can receive from RE.
    - Suggestions: Needs a cost/ benefit model, long term/ short term cost, statistics (maybe focus on electrical appliances rather than light bulbs). Must be careful about budget. Spreading knowledge about RE is vital.

2. What benefit do you think your community can receive from electricity or renewable energy?
    - It would be great if technology was cheap and easy to understand
        - Would be useful if it could be applied to household and agricultural uses
    - Learning center has to convince villagers that RE is useful and beneficial to them
    - Show that renewable energy can save money in the long-term

- Not sure what benefits are right now because they're unsure about the technology available

3. What is your opinion of renewable energy? And have you ever experienced it before?
    - Since PDA has been implemented the solar panel for water pumping system in many places in Northeastern of Thailand, they do know the benefit from using renewable energy.
    - Eventually, fossil fuel will be completely consumed. So replace and change to renewable energy will be a good start.
    - However, if we (IQP) want to implement or create a learning center, the most important thing that must be keep in mind is to deliver and show the benefit with easy comprehension, otherwise if the cost of implement is higher and not last and not come with an easy instruction.
    - Would be great if technology could be provided with maintenance information: cost, times of service
    - Technology should be durable and easy to maintain

4. What are the characteristic of good learning center? In term of location, accessibility, materials, and demonstration?
    - All of leaders agree to set up a learning center at the Cabbages and Condoms, since it seems to be the center of PDA and Amphoe Mae Mo.
    - Above all, by installing the learning center there will be supervised by PDA staff (leader) themselves, and they can easily set up a training session, and easy for them for maintenance.
    - A good learning center should be/include:
        - A learning center must show technologies that can be implemented in real life.
        - Demonstration prototypes should be easy to maintain and not too complicated for locals.
        - Materials provided to the committees can be technical but materials for villagers/ communities should be easy to understand using simple diagrams and words.

5. Would you visit learning center behind Cabbages and Condoms to learn about renewable energy technology? Why or why not?
    - Would prefer the learning center to be at C&C
        - Staff can maintain the center rather than villagers, problems will be addressed more quickly
        - Can keep up with new technologies
        - Good location – neutral (not favoring another district)
    - They willing to have a center and be a teacher themselves

- Would transfer the knowledge to other learning centers
- Choosing another site with community leaders but not PDA representatives might lead to problems educating other communities
- If the project fails, PDA would have a bad reputation

6. What materials about renewable energy would you prefer to see?

Ranked from most preferred to least preferred:

- Prototypes
- Training Programs
- Diagrams/Pictures
- Technical manuals (for committee)
- Posters
- Videos
- Brochures

Summary

The learning center would be most useful to PDA at C&C.

Prove that the benefits outweigh the costs and that the system will be effective. Use simple and reliable technology so that community members understand once they have the technology.

Make sure that our purpose is made clear in interviews – we are not promising large scale systems.

The implementation of the project should not be a scientific experiment, as it will directly impact the improvement of society. We need to present clear ideas with detailed descriptions in our future proposals.

The technology itself must last and sustain, contain the advantage that obviously see that the use of technology will benefit in cost and energy consumption, can lead to further application.

Showing the output and potential uses of renewable energy technology will be beneficial in proving the results of our recommendations.

Normally, PDA has conversation energy campaign that encourage people, and if the learning center about renewable energy would be create, it will benefit in helping PDA deliver the concept of living under self-sufficient economy.

Interviews with small business owners

Interview with Baan Baibua (House of Lotus Leaf)
21 January 2013
Interviewers: Chanis
Note-taker: Julia
Interviewee: Piak

- 5 households work to make products out of lotus leaves (boxes, picture frames, etc.)
- Mostly hand-made – machinery is used to cut leaves
- "by nature"
    - 2 sources of leaves: in the city and in a pond in Lampang
- Takes half the day to air dry leaves (on wire rack)
- Receive and process orders every month (about 2,000 units)
- 20,000 B income for 5 households working in this business
- See 50% decrease in rainy season
- Would like to have a drying machine
- Wet leaves can cause mold, bacteria and lead to defects
- They have heard of the biodiesel campaign launched by the king
- They think it would be good to save the cost of electricity and their products
- Use 3 tanks of gas per month (110 B per tank)
    - Dying the leaves
    - Household use
    - Assistant/partners also use gas
- 400 B/month for electricity for the house
    - Could foresee supplementing with RE
- Woman would go to a learning center at Cabbages and Condoms
    - Has food, close to the main road
    - Would like to learn by looking at a prototype
    - Would learn from a community leader
    - Doesn't think that reading a brochure is as effective

Interview with textile industry

21 January 2013

Interviewer: Chanis

Note-taker: Julia

- Formed by the government in 2006 licensed since 2007
- Funded by PDA (materials provided)
- Electricity increase from 1000 Baat to 2000 Baat per month due to more machinery for clothing creation
- 80 km round trip to get to place that makes badges to be put on clothing (decrease in productivity due to lack of workers- specialization → every worker is important)
- Making badges requires a machine that costs about 100,000-110,000 Baat not including the computer that is needed to design the badges. This requires too much electricity
- Cotton used in clothes comes from local farmers
    - Improvements in agriculture = improvements in products = more profit and lower cost of products

Ban Clip (Fried fish pastries)

11 January 2013

Interviewers: Kenny, Chanis, Chanica

Occupation: 4-5 months has been making this fried fish pastry, home makers

How did PDA help you start this business?

- PDA provided funding for this business by providing the bowl, pan and roller

Do you have electricity? How much does it cost?

- Yes, site is connected to the grid but it will go in and out during the rainy season
- 200, 700, 400, 1000 baht/month (for each separate worker)
- The actual cost per unit is low but there is a fee called (FT) that increases their price
- Don't really know how electricity is made or where it comes from
    - All of their husbands work for EGAT

Is this a large cost compared to your income per month?

- Yes (x5)

Have you had any experience with renewable energies in the past?

- Yes they knew what it was and how it helps with pollution
- Not sure if the technology actually works or if they can afford it
- Haven't used it before

Do you think RE can support your energy needs?

- Yes biomass would help produce gas for cooking and converted to electricity

Do you understand how electricity is made through conventional sources?

- No, it comes from EGAT, but didn't know through which process

Are you aware of any costs/benefits of conventional energy? Of RE?

Do you want to learn more about RE? Why or why not?

- They would go just to learn and gain more knowledge

- They are concerned about pollution

Have you been to a learning center/educational facility?

- No, they know of a program that PDA has where they will provide vegetables to plant and grow for consumption or to sell but isn't given guidance as to how to accomplish this successfully.
- They were aware that PDA hadn't helped them as much because they are newer to the area (they were relocated)

Why were you relocated to this area?

- With the expansion of the power plant, their residence was too close (under 2 km) and were forced to move

What makes a good learning center?

Would you go to Cabbages and Condoms?

- Yes, but they think the learning center should be inside Mae Mo (C&C is just outside of Mae Mo)
- Yes, Mae Mo should have a learning center about job creation, how to use the resources of the area to have an income.

How would you prefer to learn about RE? I.e. friend, community leader, PDA representative?

What materials would you find helpful to learn from?

- Videos, brochures/pamphlets, training session

Mushroom Farm

11 January 2013

Interviewers: Chanis, Kenny, Chanica

Name: Jun Som Kantar

Do you have a reliable water supply? How much does it cost?

- 200 baht/ month

Do you have electricity? How much does it cost?

- 12 baht/unit; They have x units = 300 baht/ month

Have you had any experience with renewable energies in the past?

- Initially doesn't recognizes the term until examples are given
- Aware that solar panels work

Do you think RE can support your energy needs?

- She is looking into making her own feeding bags for the mushrooms, and increase and vary her product
- She can do this through renewable energy use – will allow her to dry mushrooms

Do you understand how electricity is made through conventional sources?

Are you aware of any costs/benefits of conventional energy? Of RE?

- CE: Doesn't know what negative effects are or what they do to you
- RE: Reduce the cost of electricity and it could put more value in our product. Right now she uses wood as fuel when she attempts to make the bag for mushroom food.
- Would be able to increase the value of her product through increased electricity access (i.e. dry mushrooms)

Do you want to learn more about RE? Why or why not?

- She would love to try using renewable energy; she has seen solar panels successful in agriculture use. Wants to learn more about solar power

Have you been to a learning center/educational facility?

- PDA introduced her/ brought her to a learning center to learn about how to cultivate mushrooms
- PDA also gives them funding

How did you learn about farming?

- Learned through brochures, posters and trainings at learning center

What makes a good learning center?

- Information on renewable energies would be nice (it wasn't available at the learning center she visited)

Would you go to Cabbages and Condoms?

- Yes it's not too far.

How would you prefer to learn about RE? I.e. friend, community leader, PDA representative?

What materials would you find helpful to learn from?

- Step by step training process for making the mushrooms
- She didn't like the livestock information because it was irrelevant to her
- Model (prototype), pamphlet, training

Rainbow Rice Chips
11 January 2013
Interviewers: Kenny, Chanica, Chanis

What do you do for work?

> They are home makers who make these rice chips. It includes sun drying them three times then deep frying them later on. They use vegetable and fruits for color.

How has PDA helped you?

> They learned out to complete this process from a friend from another district, not from PDA

Do you have electricity? How much does it cost?

- Grid electricity
- For 2 buildings, 1,000 baht per month

Have you had any experience with renewable energies in the past?

- Yes they named solar, hydro, and wind.

Do you think RE can support your energy needs?

- Concern about the limitations of RE, they don't have farm animals to generate biomass and no decent supply of running water for hydro
- Interest in solar cells

Do you understand how electricity is made through conventional sources?

- They understand the lignite mining and power plants

Are you aware of any costs/benefits of conventional energy? Of RE?

- CE:
- They have experience from these harms from the coal mine and power plant including asthma developed in their children
- Effected by the dust particles and they smell can smell the lignite
- RE:
- Cost saving (of electricity) and help with pollution control

Do you want to learn more about RE? Why or why not?

Have you been to a learning center/educational facility?

- Yes, they have in Chaing Mai about how to raise frogs to sell them
- The community leaders told them about the learning center and took them there
- They received a training session and there are consultants available if there are any questions about the process.
- EGAT paid for the transportation and stay at the learning center.

How did you learn about farming?

What makes a good learning center?

Would you go to Cabbages and Condoms?

- Yes it is ok, and they are interested in a learning center for renewable energy.

How would you prefer to learn about RE? I.e. friend, community leader, PDA representative?

What materials would you find helpful to learn from?

- Training session, video, pamphlet/workshop

What were some benefits you have seen from the learning center?

This is an opportunity for them to generate income while their husbands are working.

Interviews with community members

Interview with Villagers
21 January 2013
Royal Project Site - Mae Mo
Interviewers: Chanis (Ashley and Julia)

Interviewee: Boontiam Pongtiya

What do you do for work?

- She farms, makes 2000 baht per month which is enough for food.
- Her husband works for EGAT making 50K a year.

What problems do you face?

- She doesn't face any problems in the home.

Are you familiar with renewable energy?

- Not familiar with the term

Do you have electricity? How much does it cost?

- Has electricity at home.
    - She owns a TV and computer
- Pays 400 baht per month

What benefits do you think you will receive from renewable energy?

- If renewable energy were to take away some of the cost of her electric bill, she thinks renewable energy would be great. She is already spending quite a bit now, so cutting the cost of her bill would be a benefit.

Have you visited a learning center? What did you go there to learn?

- She used to visit a learning center in Laos
- Went there to lean about agriculture and livestock
    - Learned how to ferment manure for natural gas to be used for cooking.

How were you taught? What methods did the center use to teach?

- Walk around
- Listen to the instructors (lecture)
- Interactive part where she actually planted

What was good/bad about their methods?

- This was an introduction (first step) to agriculture and livestock
    - Had little criticism or positive feedback from her visit

How did you learn to farm, since that learning center was your introduction to agriculture?

- Came back to the Royal Project Site, where PDA set up this farming community
- Local government taught her in more detail about farming
    - Learned how to make antibacterial water for the soil
    - Taught her through a presentation on how to make the water
        - She showed us how she makes it.--She adds in organic waste and ferments it for about a month, and then she uses it by adding the water to the soil, which nourishes it prior to planting, then uses the solid waste for fertilizer

Would you visit/like a learning center about renewable energy?

- Yes, she would like one, but if she has to travel far to visit, she wouldn't go
- She would prefer to have her community leader teach her about what he learned in the learning center

Why did she visit the learning center is Laos? What made her want to learn about agriculture?

- Trip was free and she was interesting in farming.

Interviewee: Sun Chaisompong

What do you do for work, grow for food, and sell?

- Retired from EGAT 2 years ago
    - Lives on savings
    - No income
    - Used to make 50,000 B/month
- Uses the space at the gardens to grow his food
    - Sells when there is excess
    - Village owns the land, PDA invested in the water towers for the space

Are you familiar with renewable energy?

- Not familiar with the term "renewable"
- Knows that energy can be generated from the sun
- EGAT had programs for energy conservation and renewable energy

What benefits do you think you will receive from renewable energy?

- Unknown
- Pays 200-300 B/month for electricity at home
    - Fan, TV, fridge
- Doesn't feel the need for more electricity

Have you visited a learning center? What did you got there to learn? How were you taught? What methods did the center use to teach? What was good/bad about their methods?

- Wife has been to a learning center
- He thinks he would like to learn if someone instructed him, in-depth, in a group session

Interviewee: [middle-aged female]

How do you like to learn?

- Hands-on
- Something to refer to while back at home would be great. Posters and pamphlets

Have you been to a learning center before?

- She has been to a learning center and would go again
- She once learned how to make preserved pork at a learning center. She is still selling it today for profit

What is the problem you and your community face?

- Water is the main problem here

What do you know about renewable energy technology?

- Doesn't know about renewable energy but is definitely willing to learn

Interviewees: [middle-aged male and female]

What is the problem you and your community faces?

- Pests are a large problem when trying to grow plants.

What is your opinion about renewable technology?

- Maintenance is an issue

Have you gone to a learning center before?

- Will happily go to a learning center→ want an easy way to understand technology
- A shuttle bus takes villagers to other provinces' learning centers

Interviewee: [woman]

What is the problem you and your community faces?

- Water is the main problem here. They only turn the water on to water our plants in the evening.

Do you think electricity could help in your daily life?

- Yes. We don't have electricity in the farm and it would be very useful

Would you like to go to a learning center to learn about renewable energy technology?

- I live and learn here. There is no reason for me to go elsewhere

Interviewee [older woman]
Interviewer: Kenny and Maddie

She works in the Royal project site from 6am to 6pm
Grows food for herself as well as to sell (either in the market or right at the site)

What are the problems your community faces?

- Water shortage is the biggest problem
- During the draught season the pond will be empty and they rely on the rain

What do you pay for the water supply?

- 25 Baht/month

What is your opinion on PDA?

- She likes them very much, they have helped the community for a very long time

Have you visited any learning centers?

- Learned to farm right here at the royal project site
- She has been here ever since, hasn't visited any others

What benefits would renewable technology bring to you or the community?

- Didn't understand renewable technology until it was explained
- Knew that their water pump system was connected to the grid
- Interested in renewables if it were introduced here or at a learning center

Would you travel to a learning center located behind C&C?

- Yes it is a great location and many people pass by there

Interviewee [older woman (2)]
Interviewer: Kenny and Maddie

What benefits might you and your community gain from renewable energy technology?

- Interested in renewable energy technology, not sure what it does

Would you visit a learning center at cabbages and condoms?

- No, it is not a good location, too far away

Second site visit interviews
11 February 2013
Interviewee: leaders of the SML garden
Interviewer: Kenny and Ton
Note-taker: Ashley and Julia

What is the purpose of this site?

- Newest agricultural area based on the ideals of the royal sufficiency economy
- SML company – gave funds to create underground piping system
- Installed water tanks – PDA is installing more across the street
- Wants to make site into mini learning center about agriculture

Do you have electricity? How much does it cost?

- Farm is connected to the grid
- 700 B/month for water
- 2 B/kWh
- Wells are metered and villagers pay based on the meter
    - Max 100 B/month, min 5 B/month
    - Average cost: 25-30 B/plot/month

What energy problems do you face?

Do you take any steps to decrease your energy use? If not, are you aware of ways that you could?

Have you had any experience with renewable energies in the past?

- Man would like RE
- Has been part of groups that have gone to learn about renewable energy
- Thinks that RE is "better"
- Likes solar

Were the RET easy to understand/maintain? Why or why not?

- Believes that solar panels are clean and easy to use

Do you think RE can support your energy needs?

- Yes, like that it's cheaper and better

Are you aware of any costs/benefits of conventional energy? Of RE?

- Distinctly aware of the process of producing electricity
- Hydropower, steam from lignite is used to power generator
- Sulfur catchers have improved air quality

Do you want to learn more about RE? Why or why not?

- Yes

Have you been to a learning center/educational facility?

- Group has been to learning center about fertilizer and soil (generally agriculture)
- Trip was sponsored by local government

What did you like or dislike?

- Learning center helped create market for their products
    - Taught them skills and found them business
- Famers gave their products to the learning center for sale

What was the best part of the learning center?

- Liked a lot of the materials
- Think that villagers need different learning materials
    - Hands-on materials would be better; might not understand pamphlets or brochures

What makes a good learning center?

Would you go to Cabbages and Condoms?

- It's a little far

How would you prefer to learn about RE? I.e. friend, community leader, PDA representative?

Unknown

What materials would you find helpful to learn from?

- Like tangible things
- Poster is good and visible but might be too technical for villagers
- Hands-on activities as well as videos and pamphlets

Interviewee: Snowaluck Techanun
Interviewer: Ton
Note-taker: Julia

What are difficulties that you face in daily activities?

- None

Do you have electricity? How much does it cost?

- Connected to the grid
- 1000 B/month in normal season
- 2000B/month in hottest season

What energy problems do you face?

- None

Do you take any steps to decrease your energy use? If not, are you aware of ways that you could?

Have you had any experience with renewable energies in the past?

- Has not heard of renewable energy

Were the RET easy to understand/maintain? Why or why not?
NA

Do you think RE can support your energy needs?
NA

Are you aware of any costs/benefits of conventional energy? Of RE?

- Thinks that electricity just comes from the city
- Doesn't know about the connections between lignite and pollution
- Is aware of NGOs and other protests that have happened in Mae Mo but still doesn't understand why

Do you want to learn more about RE? Why or why not?

Have you been to a learning center/educational facility?

- Yes, in Chiang Mai
- Only toured the facility, didn't participate in educational program

What did you like or dislike?

- Liked everything – it was beautiful

What was the best part of the learning center?
NA

What makes a good learning center?

NA

Would you go to Cabbages and Condoms?

- Doesn't like it, thinks it's too close to the center of Lampang and not close enough to Mae Mo

How would you prefer to learn about RE? I.e. friend, community leader, PDA representative?
NA

What materials would you find helpful to learn from?
NA

Interviewee: Siriphan Jinamoy
Interviewer: Ton
Note-taker: Julia

What are difficulties that you face in daily activities?

- Not many
- Live comfortably but not extravagantly (i.e. no travel)
- Husband works for EGAT and earns 50,000 B/month

Do you have electricity? How much does it cost?

- Yes, connected to the grid
- Pays 800-900 B/month
- Higher price, but makes life more convenient

What energy problems do you face?

- None

Do you take any steps to decrease your energy use? If not, are you aware of ways that you could?

- Doesn't sound like she does

Have you had any experience with renewable energies in the past?

- Has heard of RE
- Thinks that it is better but cannot explain why
- Aware that coal might need to be replaced with something more sustainable

Were the RET easy to understand/maintain? Why or why not?
NA

Do you think RE can support your energy needs?
NA

Are you aware of any costs/benefits of conventional energy? Of RE?

- Knows that electricity comes from lignite and that scrubbers clean sulfur
- Believes that coal is transported out of Lampang and electricity is generated somewhere else before being brought back in
- Has seen NGOs coming to protest but doesn't know why
- Hasn't experienced any personal problems

Do you want to learn more about RE? Why or why not?

- Would go to a learning center about RE if the majority of other farmers wanted to go

Have you been to a learning center/educational facility?
No

What did you like or dislike?
NA

What was the best part of the learning center?
NA

What makes a good learning center?
NA

Would you go to Cabbages and Condoms?

- Would go if the majority of farmers wanted to go

How would you prefer to learn about RE? I.e. friend, community leader, PDA representative?

What materials would you find helpful to learn from?

- Likes training sessions, brochures, videos

Interviewee: Rean Tong
Interviewer: Chanica
Note-taker: Maddie

Do you have electricity? How much does it cost?
It varies significantly, she had air-con therefore it cost 1,000 baht per month.

How much does water cost?
30/40 baht per month

Have you had any experience with renewable energies in the past?
Yes she had seen and heard about it, and thinks it will lower the cost of her water/electricity.

Do you think RE can support your energy needs?
At home she has no farm so it isn't convenient to have RE

Do you understand how electricity is made through conventional sources?
Yes

Are you aware of any costs/benefits of conventional energy? Of RE?
Yes, she has experienced the harms from the power plant, her crops died and turned yellow. She still understands the bad side effects but has seen improvements in her crops and from EGAT regarding pollution control.

Do you want to learn more about RE? Why or why not?

Have you been to a learning center/educational facility?
Yes the hydroponic vegetable (royal project center), there was a professor who came in a taught them hands on, and they received a manual. The hydroponic system was taught but she couldn't afford it so it was useless information for her.

How did you learn about farming?
(royal project center as stated above)

What makes a good learning center?

Would you go to Cabbages and Condoms?
No, it's too far. If transportation was provided she would with friends

How would you prefer to learn about RE? I.e. friend, community leader, PDA representative?

What materials would you find helpful to learn from?
Brochures and flyers caught her attention about the learning center, and then the hands on teaching materials were best.

Interviewee: Sumet
Interviewer: Chanica
Note-taker: Maddie

Do you have electricity? How much does it cost?

How much does your water cost?
50/60 baht per month

Have you had any experience with renewable energies in the past?
Did not know anything about RET.

Do you think RE can support your energy needs?
If it will reduce the cost of her water it would be good, but only on the community scale because she doesn't believe she could afford it on her own for her home.

Do you understand how electricity is made through conventional soruces?

Are you aware of any costs/benefits of conventional energy? Of RE?
She has never had a problem with pollution and doesn't see the coal mine/power plants as an issue.

Do you want to learn more about RE? Why or why not?

Have you been to a learning center/educational facility?
Yes, PDA's learning center on the production of fertilizers. They also give samples of the fertilizer after the session, and the session only includes a tour like lecture not hands on. She loved everything about it.

How did you learn about farming?

What makes a good learning center?

Would you go to Cabbages and Condoms?

How would you prefer to learn about RE? I.e. friend, community leader, PDA representative?

What materials would you find helpful to learn from?

Interviewee: Undom
Interviewer: Kenny
Note-taker: Ashley

Do you have electricity? How much does it cost?

- Yes, used for pumping water for farming
- It costs 28 Baht per month
- He grows garlic, said that the amount of water needed varies depending on the crops grown (garlic doesn't require as much water as others)

Have you had any experience with renewable energies in the past?

- He was not familiar with the technical term, but understood what solar cells were
- Did not have actual experience with the technology

Do you think RE can support your energy needs?

- Reluctant on using renewable energy because of the high initial costs and he doesn't know if it would work all the time or is even worth it
- However if given the choice, he would use solar cell for pumping water

Do you understand how electricity is made through conventional soruces?

- Had a basic understanding of how it's made

Are you aware of any costs/benefits of conventional energy? Of RE?

- Understood that coal causes pollution and that renewable energy is better for reducing pollution

Do you want to learn more about RE? Why or why not?

- Yes, he is interested in seeing if solar cells actually work

Have you been to a learning center/educational facility?

- No, his understanding was that only leaders go, if it was open to villagers it wasn't advertised to them
- He likes it this way, thinks it is more efficient (PDA reaches out to leader, only they attend the learning center)

How did you learn about farming?

- He has farmed since he was a kid, his parents taught him.

What makes a good learning center?

- Hands-on training

Would you go to Cabbages and Condoms?

- It is too far for him to travel to

How would you prefer to learn about RE? I.e. friend, community leader, PDA representative?

- Community leader

What materials would you find helpful to learn from?

- Prefers to learn from visual aids such as pictures and videos along with a more hand-on training session

Second site visit interviews
11 February 2013
Interviewee: Sai Fan
Interviewer: Kenny
Note-taker: Ashley

Do you have electricity? How much does it cost?

- Yes, use it for pumping water for her farm
- 84 baht per month

Have you had any experience with renewable energies in the past?

- No, but she knows about solar cells

Do you think RE can support your energy needs?

- Not sure, she was afraid it won't work in the future

Do you understand how electricity is made through conventional sources?

- Yes

Are you aware of any costs/benefits of conventional energy? Of RE?

- She understood that burning coal causes pollution and solar energy doesn't

Do you want to learn more about RE? Why or why not?

- Yes, she is interested in seeing solar cell for pumping water

Have you been to a learning center/educational facility?

- No, she had no idea that there were learning centers in Lampang

How did you learn about farming?

- Parents taught her how to farm

What makes a good learning center?

- Hands-on training

Would you go to Cabbages and Condoms?

- No, it is too far

How would you prefer to learn about RE? I.e. friend, community leader, PDA representative?

- Community leaders

What materials would you find helpful to learn from?

- Visual aids such as pictures, videos combined with a hands-on training

Second site visit interviews
11 February 2013
Interviewee: Sureyun
Interviewer: Kenny
Note-taker: Ashley

Do you have electricity? How much does it cost?

- Has two lots that require electricity for pumping water
- It costs 134 baht per month

Have you had any experience with renewable energies in the past?

- No, wasn't familiar with any of the types or other names for it, recognized solar but not sure about the details

Do you think RE can support your energy needs?

- NA

Do you understand how electricity is made through conventional sources?

- Had no idea where his electricity came from or how it's made

Are you aware of any costs/benefits of conventional energy? Of RE?

- NA

Do you want to learn more about RE? Why or why not?

- He works two jobs, one is a driver for the mine, but doesn't have the time to attend a learning center
- If he had the time, he is interested in solar

Have you been to a learning center/educational facility?

- No, he doesn't have the time

What makes a good learning center?

- He was unsure since he has never been to one

Would you go to Cabbages and Condoms?

- It's okay for location, but still a little far for his preference

How would you prefer to learn about RE? I.e. friend, community leader, PDA representative?

- Community leader, would rather learn from them, because doesn't have the time to go there on his own

What materials would you find helpful to learn from?

- Hands-on training, picture, videos

Interviewee: Latatana
Interviewer: Kenny
Note-taker: Ashley

What do you do for work?

- She works in the textile mill

Do you have electricity? How much does it cost?

- Uses electricity for water pumping
- It costs 20-50 baht per month

Have you had any experience with renewable energies in the past?

- She has heard of it, but never used it and no idea what it's used for

Do you understand how electricity is made through conventional sources?

- No idea how it's made

Are you aware of any costs/benefits of conventional energy? Of RE?

- No

Do you want to learn more about RE? Why or why not?

- She wasn't sure what it was, so doesn't know if it's worth learning more about

Have you been to a learning center/educational facility?

- She had gone to three learning centers- one about income generation, one about agriculture, and one about textile

What did you like/dislike about it?

- She liked everything

What makes a good learning center?

- The learning centers she went to were hands-on, she preferred that

Would you go to Cabbages and Condoms?

- She has no clue where it is and no idea who PDA is

How would you prefer to learn about RE? I.e. friend, community leader, PDA representative?

- She liked going to the learning centers

What materials would you find helpful to learn from?

- She prefers the hand-on training along with educational materials such as posters and pictures

Interviewee: Prayut Pong
Interviewer: Kenny
Note-taker: Ashley

Do you have electricity? How much does it cost?

- Uses electricity for pumping water
- It costs 70 baht per month

Have you had any experience with renewable energies in the past?

- No, not familiar with any

Do you understand how electricity is made through conventional sources?

- No idea how electricity is created

Are you aware of any costs/benefits of conventional energy? Of RE?

- NA

Do you want to learn more about RE? Why or why not?

- She would go to a learning center on it, but just for curiosity, no particular reason

Have you been to a learning center/educational facility?

- Yes for agriculture and income generation run by the central government

What did you like/dislike about it?

- Liked that it was hand-on training for farming

What makes a good learning center?

- Combination of hands-on and visual aids

Would you go to Cabbages and Condoms?

- Not sure where it is

How would you prefer to learn about RE? I.e. friend, community leader, PDA representative?

- Learning center

What materials would you find helpful to learn from?

- hands-on, she prefers posters and pictures to go along with the hands-on

Appendix E: Open coding from interviews with target groups

Some interviewees have heard of renewable energy options, but don't recognize the term

Baan Baibua: heard of biodiesel campaign started by the king
Mushroom: aware that solar panels work
[older woman]: only knew after explanation
Jun Som: only recognizes after examples are given
Undom: not familiar with the technical term, but knows about solar cells
Sai Fan: only knows about solar
Sureyun: wasn't familiar with any of the types or other names for it, recognized solar

Some interviewees are unaware of renewable energy technologies.

Boontiam: unaware
Sun: unaware
[middle-aged female]: doesn't know about RE
[older women 2]: interested in RET but not sure what it does
Snowaluck: has not heard of renewable energy
Sumet: did not know anything about RET
Prayut Pong: not familiar with any

Some interviewees do not know how electricity is produce through conventional means

Fish pastries: comes from EGAT
Jun Som: doesn't know the negative effects of CE or consequences for people
Snowaluck: electricity comes from the city
Siriphan: thinks that coal is transported out of Lampang and electricity is produce elsewhere
Sumet: has never had a problem with pollution
Sureyun: Had no idea where his electricity came from or how it's made
Latatana: No idea how it's made
Prayut Pong: no idea how electricity is created

Target groups think that renewable energy is "better" but cannot explain why

Leaders of the SML garden: thinks RE is "better"
Siriphan: thinks that RE is "better"

Appendix F: Evaluation form for PDA learning center

This form can be given to visitors so that PDA may evaluate the effectiveness of the learning center and adjust their center according to the needs of the community

PDA Mae Mo Learning Center – Visitor Evaluation

Why were you here today?

What sessions did you come here for?

What prompted you to come to the learning center?

Please rank your satisfaction or dissatisfaction with the following aspects of the learning center.

	No response	Dissatisfied	Somewhat dissatisfied	Somewhat satisfied	Satisfied
Cleanliness					
Organization					
Layout					
Services provided					

Please rank your satisfaction or dissatisfaction with the following aspects of the session in which you participated.

	No response	Dissatisfied	Somewhat dissatisfied	Somewhat satisfied	Satisfied
Understandability					
Clarity					
Knowledge of instructor					
Course organization					
Course materials (i.e. training session, brochure, etc.)					

Do you feel that this course met your expectations? Why or why not?

Would you come back to this learning center? Why or why not?

Any other suggestions:

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