Promoting Renewable Energy Use Through Community-Based Education

Powering and Empowering Rural Thailand

Recommendations and conclusions submitted to
The Population and Community Development Association
for the development of a learning center in Mae Mo, Thailand

Submitted by

Julia Darcy
Kiatikul Dilokrugtheeraphop
Ashley Marcinkowski
Giovanna Olson
Chanica Pitaksakorn
Chanis Sukreepirom
Madeline Willer

Date: 1 March 2013
## Table of Contents

Table of Contents ........................................................................................................................................... i
Figures and Tables ........................................................................................................................................... ii
1 Introduction .................................................................................................................................................. 1
2 Learning center site ..................................................................................................................................... 3
  2.1 Proposed layout of the learning center ............................................................................................... 3
3 Renewable energy technologies .............................................................................................................. 5
  3.1 Solar photovoltaic energy and technology ......................................................................................... 5
    3.1.1 Benefits and applications ............................................................................................................. 7
    3.1.2 Feasibility justification ............................................................................................................... 8
    3.1.3 Specifications ........................................................................................................................... 8
  3.2 Biomass energy and technologies ...................................................................................................... 9
    3.2.1 Benefits and applications ........................................................................................................... 9
    3.2.2 Feasibility justification ............................................................................................................. 11
    3.2.3 Specifications .......................................................................................................................... 12
  3.3 Micro-hydro energy and technology ................................................................................................. 13
    3.3.1 Benefits and applications ......................................................................................................... 13
    3.3.2 Feasibility Justification ............................................................................................................. 13
    3.3.3 Specifications ........................................................................................................................... 13
4 Educational opportunities and methods ................................................................................................. 15
  Proposed schedule ..................................................................................................................................... 21
5 Development of the learning center ....................................................................................................... 22
  5.1 Evaluations ........................................................................................................................................... 22
  5.2 Contact list ........................................................................................................................................... 22
  5.3 Increase accessibility .......................................................................................................................... 22
  5.4 Community outreach ........................................................................................................................ 23
  5.5 Topics to expand the scope of the learning center ............................................................................ 23
Appendix A: How the list of criteria was determined ................................................................................. 24
Appendix B: Evaluating the possible learning center locations ................................................................. 29
Appendix C: PDA Mae Mo Learning Center Visitor Evaluation ................................................................. 32
Appendix D: Contact List .......................................................................................................................... 33
Appendix E: Cost-benefit analysis of renewable energy technologies ..................................................... 35
Appendix F: Additional information ....................................................................................................... 37
Works Cited .................................................................................................................................................... 43
Figures and Tables

Figure 1: Recommended site layout and descriptions of features ........................................ 4
Figure 2: Solar cell, module, array.......................................................................................... 6
Figure 3: Diagram of alternating current (AC) water pump system ....................................... 9
Figure 4: Diagram detailing production of biofuels from different feedstocks
(http://www.camelclimatechange.org/articles/view/165171/) ........................................ 11
Figure 5: Drawing of floating drum biomass digester (Laird) .............................................. 12
Figure 6: Results of interviews with villagers about electricity production from conventional
methods ............................................................................................................................ 15
Figure 7: Results of interviews with community members about social and environmental costs
of conventional energy use ............................................................................................... 16
Figure 8: Knowledge of villagers about the existence of renewable energy technology ....... 17
Figure 9: Educational material preferences of the community members ............................... 18
Figure 10: Solar panel display at Sunny Bangchak ................................................................. 19
Figure 11: Renewable energy video at Sunny Bancghak ....................................................... 19
Figure 12: Biomass diagram at Baan Dong .......................................................................... 19
Figure 13: Responses to interview question about visiting Cabbages and Condoms.............. 30

Table 1: Results of evaluating possible learning center locations ....................................... 3
Table 2: Energy use of countries (in 1,000 TWh) .................................................................. 6
Table 3: List of criteria ........................................................................................................... 24
1 Introduction

The goal of our project was to provide recommendations to PDA Mae Mo to develop a learning center about renewable energy technology. Through interviews with PDA representatives, small business, and villagers, we developed important information about the following topics:

1. Learning center site
2. Renewable energy technologies
3. Educational opportunities and methods
4. Learning center developments

Our recommendations about the development of the learning center 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. This includes feasible renewable energy options and methods to successfully implement renewable energy. For the future development of the learning center, we have provided a list of recommendations.

Our recommendations are limited by the amount of time we were able to spend on this project as well as by the number of interviews that we were able to gather. Throughout this report, we will recommend that PDA continue to investigate and validate these findings and recommendations to ensure the development of a successful learning center.

We recommend that PDA follow the general timeline presented below to develop the learning center. Completing these goals in roughly this chronological order will work to ensure that the learning center develops to accurately meet the needs of community members.

**Proposed timeline** (a long-term timeline can be found in the additional information files)

1. Educate PDA representatives on renewable energy technologies (RETs) (*chapter 3*)
2. Prepare Cabbages and Condoms to be used as a learning center site (*chapter 2*)
3. Acquire prototypes of biomass digesters (floating drum and polyethylene tube) and solar photovoltaic panels (*chapter 3*)
4. Contact other experts in renewable energy for advice, information, and collaboration in developing the learning center (*chapter 5 and appendix D*)
5. Develop educational materials (posters, brochures, presentations) (*chapter 4 and additional information*)
6. Develop training sessions that incorporate lectures and hands-on demonstrations (*chapter 4*)
7. Create an informational website (*chapter 5*)
8. Develop calendar of training sessions
9. Set up transportation to and from learning center (*chapter 5*)
10. Open learning center to the public
While developing the learning center, PDA can continually work to take the following actions:

1. **Outreach to the community** and make it clear that the learning center is being developed for and catered to them. Their opinions should be incorporated into the development of the learning center.

2. **Host events** with other organizations and experts in RETs. Holding public events such as discussions and lectures will increase how much community members know before the opening of the learning center.

3. **Raise awareness** about the negative effects of conventional energy and benefits of renewable energy. This will serve to increase the communities’ understanding of the usefulness of a learning center about RET
2 Learning center site

Through site visits to existing learning centers, interviews with community members in Mae Mo, and PDA representatives we were able to choose a suitable location for the learning center in Mae Mo.

Our site visits to other learning centers allowed us to develop a list of criteria that makes a learning center successful. Interviews with community members allowed us to cater the criteria of the learning center to meet the needs and preferences of the Mae Mo community. The evidence that shows how this list was determined can be found in Appendix A.

Below is a table showing the results of our finding which show how the possible locations for the learning center compared. As seen in Table 1, Cabbages and Condoms restaurant and resort meets the most criteria.

Table 1: Results of evaluating possible learning center locations

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

The evaluations of each of the sites that helped in creating this list can be found in Appendix B.

2.1 Proposed layout of the learning center

To show how the learning center should be set up to maximize its potential, we have created a site plan in the form of a diorama. Figure 1 shows our recommendations for the layout. This includes recommendations for renewable energy technology demonstrations and potential uses for features already available on-site.
The site plan displays different interactive learning stations and where they will be. The different stations will be used for educational purposes at the learning center. Cabbages and Condoms restaurant has conference rooms that can be used for lecturing, meetings, conferences, and presentations (PowerPoint, video etc.) and is suitable for 20 people or less (number 7). There is also an open-air teaching area that is suitable for larger groups (number 3).

As a result of our findings through interviews and site visits in Mae Mo, we recommend that various renewable energy prototypes be available at the learning center. At the far end, solar PV technology (number 1) is demonstrated by pumping water from the pond to the water tanks (number 5) which is then transported to the farm for crop irrigation (number 6). Biomass technology will be demonstrated at the biomass station (in the center of the learning center) where visitors will learn about how local biomass can be easily turned into cooking gas. In turn, the cooking gas from this station can be used for cooking at the Cabbages and Condoms restaurant (number 2). Since a stream runs through the property, micro-hydropower technology can be demonstrated in the future (number 4).
3 Renewable energy technologies

Renewable energies and renewable energy technologies (RETs) are versatile systems that can benefit society in many ways. Renewable energy technologies use inexhaustible and natural resources to generate electricity which can reduce conventional energy consumption, thereby limiting the emission of GHGs and mitigating climate change (Adapting to the Impacts of Climate Change, 2010).

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 can do not emit harmful pollutants such as carbon dioxide and heavy metals (Pflüger, 2010).

RETs can provide many benefits to particular economic and societal sectors, including agriculture such as used to pump and purify water, provide electricity, and reduce reliance on conventional energy sources. 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).

There are many different renewable energy technologies that can be utilized for various applications and benefit different sectors of society and the economy. In this section, we will only focus on solar photovoltaic, biomass, and micro-hydropower.

3.1 Solar photovoltaic energy and technology

Active solar energy is energy from the sun’s radiation, collected and transferred, then distributed as electricity and stored as needed. Active solar technologies are used to convert solar energy into another more useful form of energy usually heat or electricity. There are two types of technologies that are used to convert solar energy for useful purposes: solar photovoltaic and solar thermal energy. This section will focus on solar photovoltaic technology.

Solar photovoltaic (PV) is a method of generating electricity by converting solar radiation to direct current (DC) electricity. It uses semiconductors that exhibit the photovoltaic effect: the creation of voltage or electric current in a material upon exposure to light (Seale, 2003). Solar panels are used to generate power and are composed of solar cells containing photovoltaic materials. Examples of these materials include: monocrystalline silicon, polycrystalline silicon, amorphous silicon, cadmium telluride, and copper indium gallium selenide/sulfide. Copper solar cables connect the module cables, array cables, and subfields. Solar PV cells require protection from the environment and are packed behind a glass sheet. When more power is required, the cells can be connected to form a solar PV module (panel). A module is enough to power an emergency telephone but, in order to power a house, the modules must be arranged as arrays (Figure 2).
The operating mode of a PV cell is a photodiode, which means the current generated in the device is produced exclusively by transduced light energy. Solar cells produce electricity in the form of direct current (DC). It can be used in a smaller market (off-grid) to recharge a battery, power for remote homes, boats, electric cars, roadside emergency telephones, cathodic protection of pipelines etc. In order to connect to the grid an inverter is required to convert DC to alternating current (AC).

In order to maximize performance, terrestrial PV systems should aim to face the sun as much as possible. Solar trackers have achieved this by moving solar PV panel to follow the sun. Doing this can increase solar radiation input by as much as 20% in the winter and 50% in the summer. Mounted solar PV systems can maximize solar radiation input by analyzing the sun path and arranging panels to a latitude tilt and adjusting the angle for the summer and winter. Temperatures above room temperature will hinder the performance of the device.

Photovoltaic materials have advanced in recent years because of an increase in demand for renewable energy. Solar photovoltaic is a sustainable energy source (Pearce, 2002) and is now the third most important renewable energy source in terms of installed global capacity. By 2011 a total of 67.4 GW has been installed and is determined to generate 85TWh/year, which is enough to power 59.73% of global energy use in 2008 (IEA/OECD, 2010).

Table 2: Energy use of countries (in 1,000 TWh)

<table>
<thead>
<tr>
<th>Country</th>
<th>2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>26.6</td>
</tr>
<tr>
<td>EU-27</td>
<td>20.4</td>
</tr>
<tr>
<td>Middle East</td>
<td>6.9</td>
</tr>
<tr>
<td>China</td>
<td>24.8</td>
</tr>
<tr>
<td>Latin America</td>
<td>6.7</td>
</tr>
<tr>
<td>Region</td>
<td>Value</td>
</tr>
<tr>
<td>------------</td>
<td>-------</td>
</tr>
<tr>
<td>Africa</td>
<td>7.7</td>
</tr>
<tr>
<td>India</td>
<td>7.2</td>
</tr>
<tr>
<td>Others*</td>
<td>42.2</td>
</tr>
<tr>
<td>The World</td>
<td>142.3</td>
</tr>
</tbody>
</table>

Source: IEA/OECD, Population OECD/World Bank

*Others: Mathematically calculated, includes e.g. Australia and countries in Asia. The use of energy varies between the “other countries”: E.g. in Australia, Japan or Canada energy is used more per capita than in Bangladesh or Burma.

### 3.1.1 Benefits and applications

Solar PV installation can be mounted to the ground or built onto the roofs or walls of a building (building-integrated photovoltaic). Advances in technology and increases in the scale of manufacturing have contributed to the decline in the cost of PVs (Swanson, 2009). The levelized cost of electricity from solar PV is becoming almost the same as conventional sources of energy (i.e. Coal, oil, fossil fuels) and is a rising global trend. This is because financial incentives such as feed-in tariffs for renewable energy have supported solar PV installation (Sawin, 2012).

Solar PV panels based on crystalline silicon modules are encountering competition from panels that use thin-film solar cells. Thin-film solar cells uses amorphous silicon or microcrystalline silicon, and have been experiencing market growth and are expected to account for 31% of the global installed power by 2013 (Cheyney, 2011). Other developments in the field is casting wafers (semiconductor materials) instead of sawing, concentrator modules (CSP systems), Silver cells (uses just one tenth of the costly silicon used in conventional solar panels while matching power, performance, and efficiency) and continuous printing (printing to create electrical devices on various substrates) process.

#### Benefits for agricultural use:
Both methods of transporting water can utilize renewable energy. At the Royal Project Site, a solar panel can be used to pump the water to the gardens. Na Sak, having a large amount of animal waste, can utilize a biomass system to convert the waste into a useable fuel for the water pump. Na Sak can also implement a solar panel to power the pump.

#### Benefits community members will see from using it:
Solar powered water pump reduced the cost from 5 baht per unit to 2 baht per unit. Through an interview with Khun Chainarong, we found that in Mae Mo, the current cost is 8 baht per unit, and a renewable energy source will reduce it to 4 baht per unit. In both cases, renewable energy led to a fifty percent reduction in the cost of electricity. This cost per unit does not include the initial cost of implementing the technology. This provides community members with economic incentive to switch to renewable energy. The money community members will save by switching to renewable energy will allow them to use that money for other needs and desires.

#### Other benefits:
There are other benefits to using renewable energy that the farmers may not see. Since renewable energy resources are inexhaustible, these resources will serve the communities of Mae Mo for the long-term. The will increase energy security and energy independence for communities of Mae Mo. Aside from increased energy security, renewable energy technologies
have little to no impact on the environment. Renewable energy technologies can be used to reduce conventional energy consumption, thereby reducing greenhouse gas emissions and mitigating climate change (Adapting to the Impacts of Climate Change, 2010).

3.1.2 Feasibility justification

We believe that familiarity is an important aspect of feasibility. Community members throughout Mae Mo were familiar with solar PV technology and we believe that this can serve to increase the success of the technology. If the panels are donated, the high initial cost of the technology will be eliminated and economic benefits will be reaped immediately.

Solar PV cells have an average conversion rate of 12-18% but Solar Junction recently produced a multi-junction concentrator solar cell in 2011 with the efficiency of 43.5% and is considered to be the most efficient solar cell to date. The highest efficiencies achieved without concentration is 35.8% achieved by Sharp Corporation in 2009. In 2010, an experimental demonstration led by Harry Alwater of the Caltech group measured an absorption efficiency of 85% in sunlight and 95% at certain wavelengths (Oliwenstein, 2010). Although the absorption efficiency seems to be near perfect, it should not be confused with sunlight to electricity conversion efficiency (Ars.usda.gov, 2012).

3.1.3 Specifications

The solar PV water pump system works by utilizing a solar array to power an electric generator controlled by a controller (that adjusts the speed and output according to the input from the solar array). The generator powers the mechanical pump that transports the fluid. The fluid will then be stored in a water tank and used when necessary. There are two types of solar water pumps: DC (direct current) and AC (alternating current) system. DC solar pumps can power up to 3kW and is suitable for smaller pumps. AC solar pumps (Figure 3) can power from 55-150 kW but an inverter is needed to convert the direct current of the solar array. AC systems are more suitable for larger scale projects.
3.2 Biomass energy and technologies

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 from livestock, is high in carbon composition and can be converted into carbon dioxide and methane ("What is biomass?," 2011). The chemical composition of organic molecules will be broken down by microorganisms which converts complex chains of carbon into methane (natural gas) and carbon dioxide (waste emission) ("What is biomass?," 2011).

The main source for biomass consists of complex chain of hydrocarbon such as sugar ("Sources of Biomass,"), starch (polysaccharide), lignocellulose, and oils/fats which are essential for the metabolism of organic waste and provide methane and carbon dioxide as byproducts under anaerobic conditions (Whiticar, Faber, & Schoell, 1986). Moreover, sugar cane, corn, wheat, beet, and high content sugar crops can produce biodiesel and bioethanol through fermentation. Fermented biodiesel and bioethanol can be mixed with petrol to reduce greenhouse gas emissions ("Biodiesel and Bioethanol," 2006).

3.2.1 Benefits and applications

Electricity generation follows biogas generation. Biogas is generated from microorganism degradation of biomass under closed system condition. The fermented waste is gradually converted into biogas. The gas itself can be directly used as cooking gas, but a further application is to connect the system to a steam turbine, gasifier, or direct combustion (gas engine) to generate electricity. The amount of electricity generated depends on quantity of input biomass.
for biogas conversion. Therefore, the scale of biomass renewable energy implemented can vary, from the scale of a household to an industrial landfill to a biomass power plant that can produce up to 11,000 MW ("Power Scorecard," 2000). Research in United Kingdom showed that there is more than 30 percent of landfill gas from total renewable energy use in 2006 ("UK Energy in Brief," 2007). Apart from utilizing the biogas for electricity generation and cooking, the biogas can also be used in combined heat and power (CHP) systems as process heat.

In order to produce biogas, which is basically methane, you’ll need a contraption called a biogas generator/ biomass digester. Such device will digest biomass to create biogas in the form of methane. Most biogas generators consist of two major parts, the biogas digester, and the storage container. The biogas digester is the component where the animal, human, and other organic wastes are put into, usually with water in a form of slurry, to break down anaerobically. The storage container is the component used to hold the gas that is produced from the biogas digester, which can then be piped out for consumption.

There are two major types of biogas digesters, the continuous and the batch. The different between the two is that the continuous system requires a continuous input of material and the batch system is a system, where it will produce methane per batch, and will require cleaning after each batch.

A domestic version of the biomass digester can be easily made for domestic use. The simplest one can be made out of any form of container, such as a plastic tank or a plastic drum. you would then put your biomass in that container and cover it with a gas release outlet at the top, and after a certain period, methane will be produce, and will be send to a storage container for later domestic consumption.

A continuous system can also be easily made for domestic use. This system will consist of the main biogas digester, which can be made out of an airtight drum or some sort of an airtight container, this container will need to have an inlet for the biomass to go in, and outlet for the use biomass to come out, to be used as fertile, and piping system to pipe methane into a container. Then from the holder, the methane can be used as cooking gas, power, or even create electricity.
3.2.2 Feasibility justification

We have seen that biomass in the form of agricultural waste is feasible for agricultural communities through Mae Mo. Biomass systems are easy to comprehend and easy to maintain. According to interview session, we recognized that the previous implemented biomass system was considered as user-friendly and affordable. Moreover, the availability of resource for input is widely available since majority of local villagers are farmers and they have useable amounts of animal manure and agricultural waste.

Biomass systems can generate gas for cooking and replace unreliable energy sources such as charcoal and wood. However, the generated biogas was not utilized at its optimal. We believe that by connecting a biogas generation sector with electric generator is able to enhance and provide an improved sufficient energy use for household. Therefore, we recommend implementing a biomass system for learning material at the learning center.

**Short Term**

We propose installing gasifiers to produce biogas to use at the learning center. The purpose of this implementation is to demonstrate the gasification and its application as cooking gas for the learning center use. Waste disposed from Cabbages and Condoms restaurant and garden in the back would be an essential source for biomass.

**Long Term**
The electricity generator sector can be further connect to the gasifiers and demonstrate the cost benefit of producing electricity from waste. To help promote the benefit of using renewable energy and exhibit the simplicity of the system

### 3.2.3 Specifications

The simplest form of biomass digester can easily be built, understood, and maintained. **We recommend a floating drum biomass digester for use at the learning center and in applicable areas throughout Mae Mo.** The biogas digester will use agricultural waste and water to produce natural gas that can be used directly for cooking, or hooked up to a generator to produce electricity.

The materials for such biomass digester are two plastic containers/drums that have an airtight lid. A slightly larger metal drum that will hold water, some PVC piping, valve, and rubber hoses. For the digester tank, firstly you’ll need to drill two hole of different size on the lid of the drum, to accommodate the rubber hose for gas outlet, and larger hole for the PVC piping for the inlet for biomass. On that same drum, 1 foot from the ground, on its side drill a hole to accommodate the PVC piping for outlet of used biomass. Both the PVC piping on the digester tank, will also need a valve to control the inlet and outlet, and will also require plastic glue, in order to make the tank airtight (Laird).

For the storage tank, two holes will need to be drilled on the bottom of the plastic drum to accommodate the rubber hoses from the digester tank, and the outlet for gas to be used in houses. Plastic glue should also be applied to the connection point. The plastic drum will be flipped upside down and place inside of the metal drum, which is half filled with water (Laird).

To operate this kind of biomass digester, water mixed with biomass should be poured half way into the digester tank, and every day it must be filled with a gallon of biomass/water mixture. After a week the gas should be ready to use. In order to maintain this system, after the initial week, a gallon of biomass/water mixture must be put in but also taken out through the outlet. The holding and digester tank, and the all the connection must also be checked for leaks (Laird).

![Figure 5: Drawing of floating drum biomass digester (Laird)](image-url)
Another type of biomass digester can be made at very low cost from polyethylene sheeting. The details of this design can be found here. We would recommend investigation into this system as a feasible, reliable, simple, and low-cost technology for use in Mae Mo.

3.3 Micro-hydro energy and technology

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).

3.3.1 Benefits and applications

The use of micro-hydroelectric is specific to the Cabbages and Condoms restaurant and resort in Mae Mo. There is a strong stream accessible on site during the rainy season, therefore there is a potential to use micro-hydro technology to generate electricity. To implement this technology at other sites in the surrounding districts of Mae Mo, the access to a strong flow of water must first be assessed including measuring the flow of water at its slowest. There has been concern in the community about an unreliable grid connection, especially during the rainy months. Micro-hydro could provide the opportunity to stabilize the electricity generation of the community and support community members’ energy needs in areas where flowing water is easily accessible.

3.3.2 Feasibility Justification

We recommend that PDA install a micro-hydro system at the learning center in the future. Based on our preliminary findings, we believe that this technology 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 when heavy water flow is available. 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.

The Border Green Energy Team (BGET) has successfully implemented micro-hydroelectric systems in rural Thailand. Their technology contains materials that can be found locally in the communities, easy to maintain and operate and affordable for the communities. The following are specifications of the technology and we have you with a contact at BGET, who we have consulted on this project, and can therefore provide you with extended knowledge about the technical specifications.

3.3.3 Specifications
We recommend that PDA implement a micro-hydro system that BGET has used in the past. BGET uses an off-the-shelf centrifugal pump, but instead of using it to pump water using electricity, it is run backwards as a turbine. The induction motor also runs backwards to create a generator. Together is converts the mechanical energy of the falling water to turn a turbine and generate electricity. The pumped used is called a centrifugal pump, which are a widely available technology with high efficiency and both simple and affordable. The use of this pump as a micro-hydro system is a new technology called PAT or “pump as turbine”. It was pioneered Arthur Williams and Nigel Smith at the Intermediate Technology Development Group.

To complete the project, the water flow must first be diverted from the stream to a power house. A simple mixture of concrete can be poured to provide a dam, and direct the water to the pathway from the stream to the power house. The pathway, or penstock, is made of PVC piping. A settling tank may be utilized depending on the quality of water. If the water contains significant sediment, a settling basin must be used to slow the water entering the system and to allow sediment to settle.

The specific pump used was the Ebara pump ME 50-125/4, 2230V, 3-phase. The specifications were based on the flow rate of the steam, the length of the penstock, and the elevation difference between the settling basin and the pump. The power output when the pump is working at full capacity is 2.2 kilowatts. The material costs will vary depending on the scale of the project, but for this BGET project, the costs were as follow (in baht):

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dam</td>
<td>19,195</td>
</tr>
<tr>
<td>Piping</td>
<td>16,425</td>
</tr>
<tr>
<td>Powerhouse</td>
<td>16,425</td>
</tr>
<tr>
<td>Electric componets</td>
<td>101,340</td>
</tr>
</tbody>
</table>

The flow of the stream must be measured during the dry season when flows are lowest. For the cabbages and condom’s site, measure the flow at the lowest part of the rainy season. This system does divert water for the power system; it must utilize no more than 50% of the lowest flow rate.

For a further study of this micro-hydroelectric system please contact the BGET, we have provided a name in the contact list and the website with their project reports can be found here. This system has been successfully implemented in rural communities of Thailand and is a system that meets the criteria we have developed for feasible renewable energy technologies. Although this technology may not be appropriate for many sites in Mae Mo, especially without a strong flow of water throughout the year, but it we recommend it for the learning center. It will allow community members to extend their knowledge about renewable energy options, and have a physical demonstration of the technology at Cabbages & Condoms.
4 Educational opportunities and methods

Our research identified several gaps in knowledge about the harms of the conventional energy produced in Mae Mo. Many community members also had little to no knowledge about renewable energies and their applications and benefits. Through interviews, we were able to determine the most desirable methods for teaching community members about renewable energy technologies.

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?”

Community member's knowledge about how electricity is produced

As displayed in Figure 6, the majority of villagers that were interviewed were either misinformed or unaware of how conventional energy methods produce 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.

Further, as displayed in Figure 7, the majority of villagers interviewed by our team were unaware of the negative effects of conventional energy production. These findings display a gap in knowledge about the risks that community members face.
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 understood 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 harms of conventional energy, it can be difficult understand the benefits of renewable energy technologies.

To determine the present state of knowledge about renewable energy technology, 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 and benefits. As displayed in Figure 8 below, the majority of community members interviewed knew little to nothing about renewable energy technology or could only identify solar power 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.

**Community members's knowledge about the existance of RET**

![Pie chart showing knowledge levels of community members about renewable energy technology](image)

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.

Other community members, however, have been relocated as a result of the power plants. Additional community members connected incidences of asthma to the emissions from the power plants. Some had a clear understanding of what renewable energies and resources were available. To reach more comprehensive audience, PDA can continue to investigate the state of knowledge of community members and educate accordingly.

**Educational Materials**

By discovering this gap in knowledge, we identified how crucial it will be to have successful learning materials in the learning center at Cabbages and Condoms. The following is how we determined which learning materials would be helpful to have in the learning center at Cabbages and Condoms.

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 9 shows the results of our interviews with community members on their learning preferences.
Many villagers preferred to learn through visual aids such as posters, videos, and brochures (Figure 9). 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. 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 educate themselves in renewable energy technologies and will then seek to educate other community members.

**Educational Media**

Through interviews with the staff of learning centers, we determined options of educational media for the learning center in Mae Mo.

The Royal Thai project site utilized hands-on trainings where the farmers were taught how to plant. We interviewed 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 10 and Figure 11. 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 10: Solar panel display at Sunny Bangchak](image1)

![Figure 11: Renewable energy video at Sunny Bangchak](image2)

At the Baan Dong learning center in Mae Mo, a biomass system is used for demonstrations and trainings. As seen in Figure 12, 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 12: Biomass diagram at Baan Dong](image3)

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 the center will spend a full day at the 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.
Final Recommendations

We recommend that the Cabbages and Condoms utilize the following methods to successfully educate community members and PDA representatives about RETs in the learning center:

1. 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 due to their varying roles in renewable energy implementation in Mae Mo.

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. PDA can also take steps to educate customers of the restaurant and other miscellaneous visitors of Cabbages and Condoms.

We recommend that PDA create materials such as brochures, posters, and flyers about the different benefits of renewable energy and the harm of conventional energy production. These materials can be displayed around the restaurant and resort for public viewing and distribution. You can view samples in the additional information file provided to you.

2. Methods and demonstrations for interactive trainings

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. 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.
## Proposed schedule

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>9:00 am</td>
<td>pick up students in central location</td>
</tr>
<tr>
<td>10:00 am</td>
<td>morning session &lt;br&gt; This morning session could include a combination of lecture strategies such as a presentation with supporting materials including posters and pamphlets.</td>
</tr>
<tr>
<td>12:00 pm</td>
<td>break for lunch, provided by Cabbages and Condoms</td>
</tr>
<tr>
<td>1:00 pm</td>
<td>afternoon session &lt;br&gt; 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.</td>
</tr>
<tr>
<td>3:30 pm</td>
<td>conclusions and take-away points, evaluations &lt;br&gt; Have students complete the evaluation form (see appendix) 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. &lt;br&gt; 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.</td>
</tr>
<tr>
<td>4:00 pm</td>
<td>bring students back to village</td>
</tr>
</tbody>
</table>
5 Development of the learning center

We have developed recommendations for helping the learning to expand in the future.

5.1 Evaluations

As seen through interviews with existing learning centers, we found that evaluations can help a learning center to measure their success and to help improve. We believe evaluation forms are an effective method of receiving and processing feedback from visitors of the learning center. Utilizing an evaluation form can help in the development of the learning center through:

1. Adapting educational material and sessions to the target audience
2. Evaluating the effectiveness of communicating information
3. Adjusting the content of the learning center to the needs of the visitors

A sample evaluation form for use in the learning center at Cabbages and Condoms can be found in Appendix B.

5.2 Contact list

In completing this project, we contacted renewable energy experts in order to determine the feasibility of renewable energy technologies in Mae Mo. Renewable energy experts such as the Border Green Energy Team (BGET), Palang Thai, and Professor Naebboon Hooncharoen provided us with useful information on renewable energy technologies. Renewable energy experts can help in the implementation of renewable energy technologies. They can also serve as guest lecturers for the learning center to educate community members about renewable energy.

Through site visits to existing learning centers about renewable energy technologies, we received the contact information on companies that could help with providing the technology and implementation. Companies like SolarFlower, Panasonic and Ida-Tech have donated solar panels to learning centers before. We also provided the learning centers we visited as contacts. We recommend that PDA use these contacts to aid with the development of the learning center. Contact information can be found in Appendix D.

5.3 Increase accessibility

Through interviews with our target groups, we found that some community members were concerned with the distance of Cabbages and Condoms. Some community members said they wouldn’t go to the learning center because of the distance. We found that in some of the community members’ past experiences with learning centers, transportation and food was provided. We recommend that transportation be provided to the learning center for the target groups. This will help eliminate distance as a factor in whether they visit the learning center or not. As seen through interviews with community members, complimentary meals may help draw the target audience to the center.
5.4 Community outreach

Through interviews with community members we found that many members never attended a learning center because they were unaware that trainings were taking place. We recommend that events and trainings at Cabbages and Condoms be advertised throughout Mae Mo to inform the community of the educational opportunities available to them.

One way to advertise is through a website. Since the target audience of the learning center isn’t limited to communities of Mae Mo, we suggest creating a website about the learning center. The website can provide updates to people interested in attending about the trainings, upcoming events, and information on renewable energy.

5.5 Topics to expand the scope of the learning center

Climate Change

Through interviews with community members we identified some gaps in knowledge that could help support the efforts to promote renewable energy. We found in the interviews that many community members were unaware of the harm of conventional energy. This led to the conclusion that community members could be unaware of climate change. Unfortunately due to our short visits, we were not able to confirm this. We would like to recommend that community member’s understanding of climate change be evaluated. If there is a gap in knowledge about climate change, we recommend that the learning center address these gaps in the learning center. This can help in promoting renewable energy as a solution to climate change.

Water Conservation

Our recommendations for a renewable energy powered water pump will 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, we saw water purification systems that were used to provide water to the gardens.

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.
Appendix A: How the list of criteria was determined

Through sites visits to existing learning centers and interviews with community members, we were able to determine a list of criteria. The list was separated into two types of criteria. One list of criteria, shown in Table 3, was developed through interviews with existing learning centers. Interviews with staff led us to a general list of criteria based on what was typically seen in learning centers and have made them successful.

Table 3: List of criteria

<table>
<thead>
<tr>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address an educational need</td>
</tr>
<tr>
<td>The location should be accessible</td>
</tr>
<tr>
<td>Located in neutral territory</td>
</tr>
<tr>
<td>There needs to be appropriate facilities</td>
</tr>
<tr>
<td>A variety of educational media</td>
</tr>
<tr>
<td>Evaluate the effectiveness</td>
</tr>
</tbody>
</table>

We visited the following learning centers, where we examined the criteria that made these successful through a tour of the site and interviews with the staff.

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

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 addressed in the learning centers we visited. When visiting surrounding communities, we understood why the issue was being addressed. 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.

**There needs to be appropriate facilitates**

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. 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.

At the Baan Dong learning center in Mae Mo, a biomass system is used for demonstrations and trainings. 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.

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 9 shows the results of our interviews with community members on their learning preferences.
As seen in Figure 13, 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 13, 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 Figure 13. 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 the 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.
Appendix B: Evaluating the possible learning center locations

In order to evaluate the options for the location of the learning center, we performed site assessments. The four main options for the location were:

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

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.

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 have the same target group. However, we have found through interviews with PDA that they hope to reach more than just farmers. Some of the features such as a water tank and pond already exist on site which would be useful in adding a renewable energy powered water pump. While this site is accessible for the current target group, it may not be for all the communities in Mae Mo. This land is not in neutral territory.

Na Sak is currently a learning center about mixed use agriculture to show a working example of a self-sustaining farm. Na Sak learning center already targets farmers which would be useful when a renewable energy technology is promoted for sustainable agriculture. However PDA would like to reach other community members as well.

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. 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. There are appropriate facilitates already on-site such as a biogas digester and a lecture hall for presentations. However this location is far from other villages and not easy accessed.

It is important to note, that the possible locations for the learning center on renewable energy are already 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 not currently a learning center, however it contains some 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. 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.

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.

Interviews with PDA representatives confirmed that Cabbages and Condoms was an ideal location for the learning center of Mae Mo. Cabbages and Condoms is located just outside of Mae Mo in neutral territory and not affiliated with any particular district. 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 can be accessed by the communities of Mae Mo

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.

Would you visit a learning center at Cabbages and Condoms?

- Yes 14%
- No 29%
- Not sure where it is 57%

Figure 14: Responses to interview question about visiting Cabbages and Condoms

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.

**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 m²), 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 is 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 for future renewable systems, this could be an ideal site to demonstrate a water purification system. 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.
Appendix C: 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.

<table>
<thead>
<tr>
<th></th>
<th>No response</th>
<th>Dissatisfied</th>
<th>Somewhat dissatisfied</th>
<th>Somewhat satisfied</th>
<th>Satisfied</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cleanliness</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organization</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Layout</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Services provided</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th></th>
<th>No response</th>
<th>Dissatisfied</th>
<th>Somewhat dissatisfied</th>
<th>Somewhat satisfied</th>
<th>Satisfied</th>
</tr>
</thead>
<tbody>
<tr>
<td>Understandability</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clarity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knowledge of instructor</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Course organization</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Course materials</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(i.e. training session, brochure, etc.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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:
Appendix D: Contact List

**Chris Greacen**  
Co-Founder and Advisor for the Border Green Energy Team (BGET) and Palang Thai  
Website: http://www.palangthai.org/  
Email: chris@palangthai.org

**Salinee Tavaranan**  
Director of Border Green Energy Team (BGET)  
Website: http://www.bget.org/  
Email: salinee@bget.org

We contacted Palang Thai and BGET, renewable energy experts in Thailand, to get information for the feasibility of systems in rural communities. BGET has completed many renewable energy projects throughout Thailand using micro-hydro, biogas, and solar. Palang Thai is partnered with BGET and together they work to ensure that renewable energy technologies are economically feasible in a community. They analyze the social and environmental implications of the technology to ensure that a technology helps a community socially and environmentally.

**Daniel Connell**  
Founder of Solarflower  
Website: http://www.solarflower.org/  
Email: solarflower.org@googlemail.com

We contacted Daniel to get more information on Solarflower, a solar energy collector. Our interviews led us to believe that this thermal collector is not ready for implementation into rural communities right now because of the complexity of converting to electricity. However, he is working on it.

**Ida-Tech**  
Website: http://www.ida-tech.com/index.html  
Telephone: 044-637-179

We heard about Ida Tech through a site visit to the PDA learning center in Chakkarat. Ida-Tech donated a solar panel to one of the villager and trained the villagers on how to maintain the panel. We believe Ida-tech might be a good contact for acquiring a solar panel since they have worked with PDA in the past.

**Panasonic Eco Solutions Sales (Thailand) Co., Ltd**  
Website: http://panasonic.net/energy/solar/index.html  
Telephone: +66-(0)2-231-3683

Panasonic donated some of the solar cells to Sunny Bangchak to be used in the learning center. The staff at Sunny Bangchak recommended we contact them.

**Aj. Naebboon Hooncharoen**
We contacted Aj. Naebboon Hooncharooen, a renewable energy expert, to gain an understanding of the feasibility of some renewable energy options in Thailand. Based on his expertise, he was able to give us information on some of the options and what we should look in a technology.

**PDA Learning Center**
Chakkarat, Naknonrachisma

We visited this learning center to gain an understanding of how they teach communities about renewable energy. They have successfully used a solar panel to power a water pump for agriculture in the communities surrounding the learning center. They had the solar panels donated and installed by Ida-Tech.
### Appendix E: Cost-benefit analysis of renewable energy technologies

#### Levelized cost of energy ($/kWh)

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>2010 Upper Bound ($/kWh)</th>
<th>2010 Lower Bound ($/kWh)</th>
<th>2013 Upper Bound ($/kWh)</th>
<th>2013 Lower Bound ($/kWh)</th>
<th>2030 Upper Bound ($/kWh)</th>
<th>2030 Lower Bound ($/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>0.058</td>
<td>0.047</td>
<td>0.058</td>
<td>0.047</td>
<td>0.074</td>
<td>0.05</td>
</tr>
<tr>
<td>Solar PV</td>
<td>0.32</td>
<td>0.18</td>
<td>0.3</td>
<td>0.15</td>
<td>0.2</td>
<td>0.08</td>
</tr>
<tr>
<td>Solar TE</td>
<td>0.21</td>
<td>0.18</td>
<td>0.22</td>
<td>0.18</td>
<td>0.15</td>
<td>0.09</td>
</tr>
<tr>
<td>Biomass</td>
<td>0.21</td>
<td>0.17</td>
<td>0.18</td>
<td>0.15</td>
<td>0.15</td>
<td>0.08</td>
</tr>
<tr>
<td>Small Hydro</td>
<td>0.065</td>
<td>0.046</td>
<td>0.059</td>
<td>0.043</td>
<td>0.056</td>
<td>0.034</td>
</tr>
</tbody>
</table>

#### Overnight capital cost ($1,000/kW)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>2.4</td>
<td>1.7</td>
<td>2.4</td>
<td>1.7</td>
<td>3.8</td>
<td>1.8</td>
</tr>
<tr>
<td>Solar PV</td>
<td>1.99</td>
<td>1.5</td>
<td>1.7</td>
<td>1.5</td>
<td>1.8</td>
<td>1.45</td>
</tr>
<tr>
<td>Solar TE</td>
<td>3.2</td>
<td>2.1</td>
<td>4.1</td>
<td>3.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biomass</td>
<td>3.2</td>
<td>2.1</td>
<td>4.05</td>
<td>3.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small Hydro</td>
<td>1.9</td>
<td>1.5</td>
<td>1.7</td>
<td>1.5</td>
<td>1.8</td>
<td>1.4</td>
</tr>
<tr>
<td>Wind</td>
<td>1.9</td>
<td>1.5</td>
<td>1.7</td>
<td>1.5</td>
<td>1.8</td>
<td>1.4</td>
</tr>
</tbody>
</table>

#### Fixed operating cost ($/kW)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>32</td>
<td>25</td>
<td>28</td>
<td>26</td>
<td>26</td>
<td>25</td>
</tr>
<tr>
<td>Solar PV</td>
<td>46</td>
<td>18</td>
<td>10</td>
<td>8</td>
<td>30</td>
<td>6</td>
</tr>
<tr>
<td>Solar TE</td>
<td>70</td>
<td>50</td>
<td>55</td>
<td>47</td>
<td>50</td>
<td>45</td>
</tr>
<tr>
<td>Biomass</td>
<td>32</td>
<td>54</td>
<td>34</td>
<td>80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small Hydro</td>
<td>28</td>
<td>54</td>
<td>32</td>
<td>82</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wind</td>
<td>28</td>
<td>10</td>
<td>28</td>
<td>10</td>
<td>30</td>
<td>10</td>
</tr>
</tbody>
</table>
### Variable operating cost ($/MWh)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>4.5</td>
<td>2.3</td>
<td>4.5</td>
<td>2.1</td>
<td>4.3</td>
<td>2.3</td>
</tr>
<tr>
<td>Solar PV</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3.3</td>
<td>0</td>
</tr>
<tr>
<td>Solar TE</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Biomass</td>
<td>3</td>
<td>0</td>
<td>3.2</td>
<td>0</td>
<td>3.1</td>
<td>0</td>
</tr>
<tr>
<td>Small Hydro</td>
<td>3</td>
<td>0</td>
<td>3.2</td>
<td>0</td>
<td>3.1</td>
<td>0</td>
</tr>
<tr>
<td>Wind</td>
<td>6</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>4.5</td>
<td>4.5</td>
</tr>
</tbody>
</table>

### Capacity Factor (%)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>85</td>
<td>80</td>
<td>85</td>
<td>80</td>
<td>85</td>
<td>79</td>
</tr>
<tr>
<td>Solar PV</td>
<td>26</td>
<td>18</td>
<td>25</td>
<td>20</td>
<td>28</td>
<td>18</td>
</tr>
<tr>
<td>Solar TE</td>
<td>41</td>
<td>30</td>
<td>30</td>
<td>22</td>
<td>50</td>
<td>30</td>
</tr>
<tr>
<td>Biomass</td>
<td>85</td>
<td>81</td>
<td>80</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small Hydro</td>
<td>84</td>
<td>81</td>
<td>80</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wind</td>
<td>44</td>
<td>38</td>
<td>47</td>
<td>36</td>
<td>48</td>
<td>40</td>
</tr>
</tbody>
</table>
Appendix F: Additional information

This appendix contains sample posters that PDA can use in a learning center to explain renewable energy and renewable energy technologies to visitors.
PROMOTING ENERGY USE THROUGH COMMUNITY BASED EDUCATION: Powering and empowering rural Thailand

CABBAGES AND CONDOMS LEARNING CENTER, MAE MO

This learning center will focus on educating local communities about renewable energy and its applications. To help educate locals about the potential applications of renewable energy technologies, the center will provide different kinds of learning materials.

There will be different stations throughout the site that showcase the different renewable energy technologies and their potential benefits for agricultural use. A solar PV system is used to demonstrate how solar PV system will be used to demonstrate pumping water into storage tanks for use in the farm. A biomass house will demonstrate the process of making biogas with local resources from the learning site. Furthermore, the biogas generated from this station can be used for cooking at the C&C restaurant. Future plans for micro-hydro power demonstration at the site is feasible because there is a stream that runs through the learning center.

Training programs are offered to ensure that locals are comfortable when learning about renewable energy technology and at the end of each program, participants will receive brochures after the sessions to ensure they don’t forget. Educational materials that are suitable to this learning center are prototypes of renewable energy technologies, diagrams, posters and videos about renewable energy technologies.

Learning Materials Provided at Learning Center

- Videos: 14%
- Posters: 36%
- Brochure: 24%
- Diagrams: 7%
- Prototype: 10%
- Training Program: 12%
PROMOTING ENERGY USE THROUGH COMMUNITY BASED EDUCATION: Powering and empowering rural Thailand

SOLAR PHOTOVOLTAIC

Solar panels are used to generate power and are composed of solar cells containing photovoltaic materials. Examples of these materials include: monocrystalline silicon, polycrystalline silicon, amorphous silicon, cadmium telluride, and copper indium gallium selenide/sulfide. Copper solar cables connect the module cables, array cables, and subfields. Solar PV cells require protection from the environment and are packed behind a glass sheet. When more power is required, the cells can be connected to form a solar PV module (panel). A module is enough to power an emergency telephone but in order to power a house the modules must be arranged as arrays (Figure 1).

Solar PV installation can be mounted to the ground or built into the roofs or walls of a building (building-integrated photovoltaics). In order to maximize performance, terrestrial PV systems should aim to face the sun as much as possible. Mounted solar PV systems can maximize solar radiation input by analyzing the sun path and arranging panels to a latitude tilt and adjusting the angle for the summer and winter.

Figure : Suitable degree of mounted solar PV in Lampang

Solar panels are used to power various household appliances. A solar panel can produce 100 watts to over 400 watts. It can power an air conditioner for 1.5 months, a computer (desktop) for 10 months, a refrigerator for 9 months, a television for 1 year, and a microwave for 1 year.

Figure : Solar cell, module, array
PROMOTING ENERGY USE THROUGH COMMUNITY BASED EDUCATION:
Powering and empowering rural Thailand

Solar thermal energy (STE) is used for harnessing solar energy in the form of heat. 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.

**LTC (Low Temperature Collector)**
- Air or water are used as the medium to transfer the heat to their destination.
- Solar heating, cooling, and ventilation technologies can be used to reduce energy consumption in that area.
- Thermal mass materials (i.e., water, concrete, air) store solar energy during the day and release it during cold nights. When properly integrated, thermal mass can passively maintain an ideal temperature while reducing energy consumption.

**MTC (Medium Temperature Collector)**
- Applications include solar drying: drying wood for construction and wood fuels for combustion.
- Solar drying can also be used to dry food products such as fruits, grains, crops, and fish. Another application is cooking. Solar cookers use sunlight for cooking, drying, and pasteurization. The benefits of solar cooking are that it not only reduces fuel costs but also demands for fuel and firewood. It also improves air quality for the source of smoke is removed.
- Medium-temperature collectors can also be used for distillation. Solar energy heats up the water in the still, the water evaporates and then condenses when it hits the covering glass to provide purified water.

**HTC (High Temperature Collector)**
- High-temperature collectors are mainly used in solar thermal energy plants. Solar radiation is concentrated by mirrors or lenses to obtain higher temperatures; this method is called Concentrated Solar Power (CSP). There are many designs of the system, for example, parabolic trough, power house, and dish design.
- The high-temperature collectors are used in power plants and can create electricity.
PROMOTING ENERGY USE THROUGH COMMUNITY BASED EDUCATION:
Powering and empowering rural Thailand

BIOMASS

Sources of Biomass

Biomass is a renewable resource which generates biogas for producing clean electricity. The material obtained from organic waste including agricultural waste and animal manure from livestock is high in carbon composition and able to convert into carbon dioxide and methane. The biogas generate from microorganism degradation of biomass under closed system condition. The fermented waste is gradually converted into biogas. The gas itself can be used as cooking gas, but the further application is to connect to the steam turbine, gasifier, or direct combustion (gas engine) to generate electricity.

Biomass

A low cost polyethylene tube digester (pictured above) can be used to produce gas through biomass digestion. The design consists of an isolated tank with one inlet pipe and two outlet pipes. The biomass slurry is put into the system through the slurry inlet, digested into natural gas, and the gas is released through the biogas outlet. The used slurry can be extracted through the slurry outlet. The gas generated through this system can be used directly for cooking or it can be connected to a steam turbine, gasifier, or gas engine to generate electricity.

Local Biomass Technology at Lampang

Another type of biogas collection system is a floating drum plant (pictured above). These systems have two components: an underground digester and gas-holder. The underground digester is dug into the ground and contains the biomass slurry. The gas-holder sits on top of the fermenting slurry and collects and stores the gas for use in cooking or electricity generation.
PROMOTING ENERGY USE THROUGH COMMUNITY BASED EDUCATION: Powering and empowering rural Thailand

TIMELINE

PHASE 1
Establish a Learning Center At Cabbages and Condoms, Lampang

To establish a successful learning center, PDA must seek to provide the local communities with a suitable learning center.

Solar PV and biomass technologies are the most feasible renewable energy technologies and should be showcased at the learning center in order to address the current problem about water for agricultural use.

Then, microhydropower and solar thermal energy demonstrations should be installed at a later time to showcase the readily available resources and its application at the site.

PHASE 2
Expansion of Learning Center at Cabbages and Condoms, Lampang

In this phase, PDA must try to reach out to audiences outside Amphoe Mae Mo.

Reaching a broader audience is what this Cabbages and Condoms learning center should focus on in the near future. Since the site is located near the main road, it provides easy access to visitors from other provinces.

In order for PDA to reach a wider audience advertisement of the learning center is key. Increasing public access to information will increase the accessibility of the knowledge about renewable energy technology at the learning center.

PHASE 3
Knowledge Expansion of Learning Center at Cabbages and Condoms, Lampang

In the 3rd phase, Cabbages and Condoms learning center Lampang should expand their teaching materials to include energy and water conservation, climate change issues, and so on.
Works Cited


Laird, D. A. Biochar Farms: Resources for sustainable use of biochar in agriculture.


Sources of Biomass. Wisconsin Grasslands Bioenergy Network.


