A STUDY OF COMMUNITY RENEWABLE ENERGY PROJECTS MOVING TOWARDS BEST MANAGEMENT PRACTICES BASE ON SUSTAINABLE COMMUNITY RENEWABLE ENERGY IN SATHYA SAI SCHOOL THAILAND

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การศึกษาโครงการพลังงานทดแทน เพื่อมุ่งสู่วิธีปฏิบัติการจัดการที่เป็นเลิศ ภายใต้ชุมชนพลังงานทดแทนอย่างยั่งยืน โรงเรียนสัตยาไส ประเทศไทย

นางสาวปาณิชาติ กิติสิทธิชัย

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาศิลปศาสตรมหาบัณฑิต
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ปาณิชาติ กิติสิทธิชัย : การศึกษาโครงการพลังงานทดแทน เพื่อมุ่งสู่วิธีปฏิบัติการจัดการที่เป็นเลิศภายใต้ชุมชนพลังงานทดแทนอย่างยั่งยืน โรงเรียนสัตยาไส ประเทศไทย. (A STUDY OF COMMUNITY RENEWABLE ENERGY PROJECTS MOVING TOWARDS BEST MANAGEMENT PRACTICES BASE ON SUSTAINABLE COMMUNITY RENEWABLE ENERGY IN SATHYA SAI SCHOOL THAILAND) อ.ที่ปรึกษาวิทยานิพนธ์หลัก: รศ. ดร. อริยา อรุณินท์ , 110 หน้า.

พลังงานทดแทนเป็นทางออกหนึ่งของหลายปัญหาด้านพลังงานและสิ่งแวดล้อม ทั้งเรื่องการบรรเทาปัญหาการเปลี่ยนแปลงสภาพภูมิอากาศจากการลดการปล่อยก๊าซเรือนกระจก และการลดค่าใช้จ่ายจากพลังงานหลัก อย่างไรก็ตามพลังงานทดแทนยังไม่มีความเสถียรภาพแปรเปลี่ยนตามฤดูกาลและสภาพภูมิอากาศ จึงไม่สามารถตอบสนองความต้องการใช้พลังงานที่เพิ่มสูงขึ้นตามการเพิ่มของประชากรโลก จำเป็นต้องใช้พลังงานทดแทนแบบผสมผสานกับพลังงานหลัก อีกทั้งต้นทุนเทคโนโลยีในการผลิตพลังงานทดแทนบางประเภทยังมีราคาแพงและต้องนำเข้าจากต่างประเทศ จากข้อดี ข้อเสียดังกล่าวข้างต้น ยังคงสร้างความไม่แน่ใจสำหรับสังคมหรือชุมชนที่สนใจริเริ่มใช้พลังงานทดแทนแบบพึ่งพาตนเอง องค์การระหว่างประเทศว่าด้วยการมาตรฐานได้จัดทำมาตรฐานระบบการจัดการพลังงาน (Energy Management System) หรือ ISO 50001 : 2011 โดยต้องปฏิบัติอย่างต่อเนื่องตามหลักการ P-D-C-A คือ วางแผน (Plan) ปฏิบัติ (Do) ตรวจสอบ (Check) และแก้ไขและปรับปรุง (Act) อย่างไรก็ตามมาตรฐานสากลเหล่านี้เป็นเพียงข้อกำหนดที่เหมาะสมกับบางโครงการ บางบริบท แต่ไม่ได้ครอบคลุมกับทุกโครงการ โดยเฉพาะโครงการขนาดเล็ก วิทยานิพนธ์ฉบับนี้ ต้องการนำเสนอมุมมองที่แตกต่างของการจัดการโครงการพลังงานทดแทนในชุมชน ซึ่งเป็นการจัดการที่เน้นการปฏิบัติจริง มีความเรียบง่าย ไม่ยึดติดกฎเกณฑ์ มีความยืดหยุ่นในการปรับตัวให้เข้ากับสถานการณ์แวดล้อม และนำไปสู่ความยั่งยืนให้กับชุมชนได้ในที่สุด โดยศึกษาจากกรณีศึกษาโรงเรียนสัตยาไส ประเทศไทย ที่มีการจัดการองค์กรแบบชุมชนและมีการศึกษาเป็นรากฐาน ประชากรภายในชุมชนเชื่อมั่นในศักยภาพของพลังงานทดแทน และเชื่อในแนวคิดการพึ่งพาตนเองที่เริ่มต้นปฏิบัติจากระดับเล็กภายในชุมชน อันส่งผลต่อการลดวิกฤตการณ์ภาวะโลกร้อนซึ่งเป็นปัญหาระดับโลกต่อไป การศึกษานี้ ใช้กระบวนการวิจัยแบบผสมผสานทั้งวิธีวิจัยเชิงคุณภาพและวิธีวิจัยเชิงปริมาณ วิธีวิจัยเชิงคุณภาพได้ใช้วิธีเก็บข้อมูลภาคสนามโดยการสังเกตการณ์ เพื่อค้นหาลักษณะรูปแบบของโครงการพลังงานทดแทนในชุมชนและคุณลักษณะของพื้นที่ตั้งโครงการ และวิธีสัมภาษณ์ผู้มีส่วนเกี่ยวข้องกับโครงการ เพื่อค้นหาการมีส่วนร่วมและประโยชน์ที่ได้รับจากโครงการ และที่สำคัญคือค้นหาอัตลักษณ์ของคนและวัฒนธรรมภายในชุมชน สำหรับวิธีวิจัยเชิงปริมาณ ได้ใช้แบบสอบถามความพึงพอใจ 2 ประเด็น ได้แก่ ประเด็นการจัดการโครงการ และประเด็นผลประโยชน์ของโครงการ เพื่อค้นหาทัศนคติ ความพึงพอใจ และเน้นการมีส่วนร่วมในการแสดงความคิดเห็นของคนภายในชุมชนต่อโครงการพลังงานทดแทนในชุมชนตนเองอย่างแท้จริง จากการศึกษาพบว่า ผลการค้นหาทิศทางสู่การจัดการอย่างเป็นเลิศสำหรับโครงการพลังงานทดแทนในชุมชนที่แท้จริงนั้น เกิดจากการทำความเข้าใจองค์ประกอบภายในชุมชน วิถีชีวิตคน ลักษณะภูมิประเทศ ภูมิอากาศ และทรัพยากรธรรมชาติตามความเป็นจริง และเลือกใช้วิธีการจัดการให้เหมาะสมกับแต่ละบริบท โดยมีแก่นของการจัดการอยู่ที่การลงมือปฏิบัติจริงอย่างยั่งยืน โดยการมีส่วนร่วมของคนในชุมชนอย่างตระหนักในความสำคัญของพลังงานทดแทน และต่อยอดการเสริมสร้างประสบการณ์ด้วยการแลกเปลี่ยนองค์ความรู้เกี่ยวกับพลังงานทดแทนระหว่างกลุ่มเครือข่าย เพื่อการพัฒนาพลังงานทดแทนทั้งในด้านวิชาการและด้านวิชาชีพให้เหมาะสมกับสภาพแวดล้อมที่เปลี่ยนแปลงอย่างเป็นพลวัตร

สาขาวิชา สิ่งแวดล้อม การพัฒนา และความยั่งยืน ลายมือชื่อนิสิต ....

ปีการศึกษา 2556 ลายมือชื่อ อ.ที่ปรึกษาวิทยานิพนธ์หลัก ....

5487552220 : MAJOR ENVIRONMENT DEVELOPMENT AND SUSTAINABILITY
KEYWORDS: BEST MANAGEMENT PRACTICES (BMPS) / RENEWABLE ENERGY / COMMUNITY RENEWABLE ENERGY (CRE) / SELF-SUSTAINABILITY / SUSTAINABLE COMMUNITY RENEWABLE ENERGY / CLIMATE CHANGE MITIGATION / SUSTAINABLE DEVELOPMENT / SATHYA SAI SCHOOL THAILAND

PANICHAT KITISITTICHAI: A STUDY OF COMMUNITY RENEWABLE ENERGY PROJECTS MOVING TOWARDS BEST MANAGEMENT PRACTICES BASE ON SUSTAINABLE COMMUNITY RENEWABLE ENERGY IN SATHYA SAI SCHOOL THAILAND. ADVISOR: ASSOC. PROF. ARIYA ARUNINTA, Ph.D., 110 pp.

Renewable Energy (RE) is a solution to address various environmental and energy problems such as climate change from GHGs emission and high cost of conventional energy. However, RE system itself is intermittent and its technology as well as production cost is very expensive and need to be imported. Although production quantity (supply) is increased, it still doesn’t meet with people’s demand. Therefore, to meet with people’s demand, RE and conventional energy needs to be used concurrently. The mentioned disadvantages of RE make people and communities feel hesitated to initiate self-reliant RE because they worry about the efficiency and quality of RE. Regarding this, organization working on standard control, then, defined a universal standard for energy management such as ISO 50001:2011, this international standard is based on the Plan - Do - Check - Act (PDCA) continual improvement framework and incorporates energy management into everyday organizational practices. Nonetheless, these universal standards are only suitable with some projects and contexts but cannot cover every project, especially small projects. This research aims to present different aspects of Community Renewable Energy (CRE) projects management, emphasizing on practice which is unrestricted, simple, and flexible to surrounding environment and eventually will lead to sustainability in the community. The case studied is RE projects of Sathya Sai School Thailand, an education-based community which has community-like organizational management. The community residents believe in potentiality of RE and in self-sustainability, beginning with micro scale in the community which will impact to reduction of the global warming crisis at global level. This research uses both qualitative and quantitative method. For qualitative method, field observation was used to find RE specific site characteristics and interview was used to find participation of community members and benefit they gained from RE projects as well as, importantly, identity of people and culture in the community. For quantitative method, preference questionnaire was used to find out community residents’ attitudes and preferences on the issues of CRE projects management and theirs benefit and to explore genuine involvement of community residents. The results of exploring direction to Best Management Practices (BMPs) for CRE are from actual understanding of elements in the community, way of life, characteristics of geography, climate and natural resources, and from the use of method that is appropriate to the context, with sustained practice by community residents as a core of management. Furthermore, experiences can be sprung further by exchanging of knowledge between networks in order to improve RE to be suitable with dynamic environment both in academic and professional fields.

Field of Study: Environment Development and Sustainability

Student's Signature ....

Advisor's Signature ....

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ABBREVIATION

BMPs	-	Best Management Practices
CRE	-	Community Renewable Energy
PV	-	Photovoltaic
RE	-	Renewable Energy

CHAPTER 1
INTRODUCTION

1.1 Background and statement of the problem

Energy is directly associated with the most important economic, social and environmental issues which have an effect on sustainable development for instance mobility, production of food, quality of environment , local and universal security issues (Bassam. et al, 2013). Nowadays, approximately 1.2 billion people in the world (20% of world population) currently have no access to electricity, which impacts on the fulfillment of their basic human needs, and is likely to increase future energy demand. Meanwhile, energy itself is accounted for 66% of total greenhouse gas (GHG) emissions (UNCCC, 2011). For the purpose of limiting the rise of global temperature to 2 degrees Celsius above pre-industrial levels, global GHG emissions need to be cut at least by half of 1990s levels by the middle of the century (IPCC, 2007).

To reduce future GHG emissions from fossil fuels and to mitigate climate change risk, adopting clean and renewable energy (RE) has quickly, effectively and extensively become an important solution to the climate change issue (Hoffer, Caldeira et al, 1998). According to recent estimations renewable energy (RE) accounted for 12.9% of the total primary energy supply in 2008 (IPCC, 2011) and provided 16% of the world final energy use in 2010 (REN21, 2011) with a potential to increase to 50% of the worldwide demand for energy by 2050 (Bilen K, et al, 2008).

Thailand has considered RE as its crucial and urgent issues. The Eleventh Thailand's National Economic and Social Plan (2012-2016) indicate that RE for sustainability is one of the issues that must be focused in the framework of the present National Research Policy and Strategy.

By this mean, RE projects in Thailand have been supported by various agencies that have visions in creating energy security to reduce energy shortage, to reduce pollution from the use of energy that affect climate change, to reduce the cost of energy imported. However, it is also essential that RE projects management is improved by or with individuals' close participation, and that local communities gain experiences and benefits from RE bottom up approaches from communities and top down initiatives from government must be included in the RE project managements various actors including, local authorities, NGOs, charities and other organizations that are interested in RE and community development, have also sought to promote and enable energy solutions at the local level – what describe as ‘Community Renewable Energy’, or CRE (Hoggett, 2010).

Nonetheless, as involvement of these actors comes with different managements, interests and approaches, therefore Best Management Practices (BMPs) need to be determined. BMPs are the most practical and effective techniques or way used in accomplishing a goal while the optimum use of the resources of community is made. BMPs can help CRE projects avoid creating unintentional negative impacts and develop effective RE. It can also help improve quality of life of people in the community and enable sustainable self-reliance community. If CRE projects could be managed with BMPs, the community would therefore comply with sustainable development and become sustainable community renewable energy.

1.2 Research question

How can Community Renewable Energy projects achieve Best Management Practices of sustainable community renewable energy?

1.3 Objectives of the study

1. To study community participation methods and community benefits in Community Renewable Energy (CRE) projects in Sathya Sai School Thailand.
2. To identify strengths and weaknesses as well as keys to success of Community Renewable Energy (CRE) projects management in Sathya Sai School Thailand.
3. To provide recommendation for Community Renewable Energy (CRE) projects to achieve Best Management Practices (BMPs) of sustainable community renewable energy from the case study of Sathya Sai School Thailand.

1.4 Scope of study

The study focused on Community Renewable Energy (CRE) projects in community-like organizational management namely ‘Sathya Sai School Thailand’, an education-based community located in Lam Narai Subdistrict, Chai Badan District, Lopburi Province in Thailand. The importance of this community is it is self-sustained with awareness on warming issue so that they implement CRE projects to serve their energy needs. This community initiated CRE projects generated in three categories of energy-used for community:

- electricity generate from solar PV; generating capacity 5.25Kilowatt (kW)
- electricity generate from wind turbine; generating capacity 20 Watt
- cooking gas from biogas; production capacity 0.3 – 0.5 m^3 gas/m^3 digester volume per day (Sustainable sanitation and water management, 2007)
- transport fuel from biodiesel; production capacity 4,950 litres/year

If these CRE projects could be managed with BMPs, the community will therefore comply with sustainable development and become sustainable community renewable energy.

1.5 Expected outcomes

1. Methods of community participation and community benefits received by Community Renewable Energy (CRE) projects in Sathya Sai School Thailand.
2. Strengths and weaknesses as well as keys to success of Community Renewable Energy (CRE) projects management in Sathya Sai School Thailand.
3. Recommendation for Community Renewable Energy (CRE) projects to achieve Best Management Practices (BMPs) of sustainable community renewable energy from the case study of Sathya Sai School Thailand.

1.6 Implication of the research

1. To provide information for influential stakeholders of renewable energy sector and other communities.
2. To advance the research in sustainable energy generation within the global sustainability challenge.

1.7 Research plan

Duration of the study was started from February 2013 to July 2014.

ACTIVITIES	2013											2014						
	FEB	MAR	APR	MAY	JUNE	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY
RESEARCH TOPIC	FEB																	
LITERATURE REVIEW AND METHODOLOGY		MAR	APR															
PROPOSAL DEFENSE				MAY, 10														
COLLECT DATA					JUNE													
RESULT AND DISCUSSION					JUNE		AUG	SEP	OCT	NOV	DEC	JAN						
CONCLUSION AND RECOMMENDATION													FEB	MAR				
THESIS PUBLICATION WRITING																MAY		
THESIS PUBLICATION SUBMISSION AND REVISION																	JUNE	
THESIS WRITING														MAR	APRIL	MAY		
DRAFT THESIS CHAPTERS SUBMISSION AND REVISION																MAY	JUNE	
THESIS FINAL ORAL DEFENSE																		JULY
THESIS SUBMISSION																		JULY

Figure 1.1: Research plan

CHAPTER 2
LITERATURE REVIEW

2.1 Community Renewable Energy

2.1.1 Definition of Community Renewable Energy

In the literature, there is a lack of consensus on the meaning of CRE. *In Energy Policy* journal, topic *Public perceptions of opportunities for community-based renewable energy projects*, a community energy scheme defined by Rogers and others is

> *"Installation of one or more renewable energy technologies in or close to a community, with input from members of that community. The scheme must benefit the community - either directly through supply of energy to multiple properties or a community facility, or indirectly, for example through sale of energy generated to the grid. Community members' input may be in various forms, for example project initiation, administration, construction, financial support, or decision-making." (Roger, et al, 2012).*

A research of Walker and Devine-Wright's (2008) emphasizes that 'community energy' is not solely related to local generation, or to community participation, but relates to the social process of energy technology establishment, with economic and social advantages accruing to that community (Walker, et al, 2008). In this way, CRE is regarding the arrangements of society around how renewable energy that leads to sustainability solution is executed and provides benefit for people (Walker, et al, 2007).

Since there is no consensus in the literature on the definition of CRE, the study has chosen to define CRE with three main features that have appeared in the literature:

- Renewable energy generated within the community;
- Community participation is required;
- Renewable energy generated must benefit the community.

Ideally, CRE refers to a community producing enough energy to fully response to electricity and heating needs of the community's residents. In reality, communities are working towards full CRE on a project-by-project basis or have only single CRE project that can partially meet with electricity and heating demand of the community. Similarly, many communities with renewable energy generation are in the process of building awareness on community participation and increasing benefits from the CRE project in the own community.

2.1.2 Community Renewable Energy generation

Compared to production of considerable amounts of power in a small number of sites and usage of inefficient long-distance transmission cables for energy delivery, the production of smaller amounts of energy in a large number of sites from suitable renewable sources is more feasible.

The study focuses on the use of renewable energy sources at Sathya Sai School in Thailand. The renewable energy sources include: Solar PV, Wind turbine, Biogas, and Biodiesel.

Although there are environmental and social benefits associated with consuming the energy produced in a community locally (Walker 2008; St Denis and Parker 2009; High-Pippert 2012 and Hoffman 2012), it is not always legally possible for communities to distribute energy locally, or it may not be economically feasible to do so. This research therefore covers CRE where energy is both produced and consumed, and where energy is produced locally, but fed back into the community;

- electricity generate from solar PV; generating capacity 5.25Kilowatt (kW)
- electricity generate from wind turbine; generating capacity 20 Watt
- cooking gas from biogas; production capacity 0.3 – 0.5 m^3 gas/m^3 digester volume per day (Sustainable sanitation and water management, 2007)
- transport fuel from biodiesel; production capacity 4,950 litres/year

Details of each RE technology described as follow:

2.1.2.1 Electricity

- **Solar Photovoltaic (PV)**

Solar energy is making usage of the sun's rays to generate other forms of energy. In addition, this energy has been powering life on Earth for millions of years. Solar energy is a large and important RE source. It can be used as either for heating and electricity generation. Electricity generation from solar energy can be classified into two main technologies. The first is to convert sun's radiation directly to electricity via Photovoltaic (PV) device. The other is to concentrate solar thermal to produce steam for electricity generates. However, this study focused only on Solar Photovoltaic (PV), a form of solar power, which is a way to generate electricity by converting sunlight into electricity. PV cell is normally produced from semiconducting materials such as cadmium, copper, and silicon (EERE, 2012).

- ***Description of Solar PV technology***

PV cell can be produced in various shapes from various silicon forms such as amorphous, single crystal, multi-crystal, and ribbon. With different shape and different materials, higher efficiencies for different applications can be created (Trieb, 2005). Electrons are given off once a PV cell is hit by light. For formation of solar module, the PV cells are put on a panel together with wires which run through the cells. Electron is capable of flowing between different cells and producing electricity after a large number of cells give off electrons. The wires in the panel are capable of gathering this electricity and carrying it out of the panel. Modules are connected in an electrical series, and a group of linked solar modules is known as a solar array (Southface, 2010). PV cells generate electricity in the form of direct current (DC). The inversion of electricity to alternating current (AC) is required in order for being use in most electrical machines or putting back into the grid. In the absence of sunlight during the day, adding batteries can be performed to store energy.

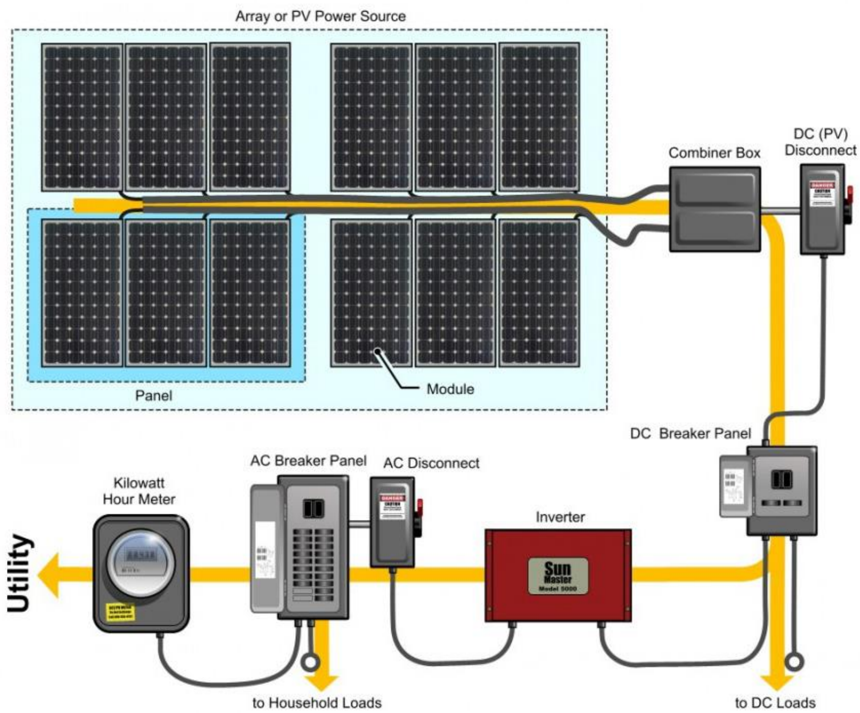

Figure 2.1: Solar PV system diagram

Source: http://www.claffisica.org/genius-solar-power-systems-for-homes-money-saving/detail-plan-of-solar-power-system-for-homes-installation-from-the-sources-to-the-consumer-of-solar-cell/

- ***Efficiency of Solar PV***

Geographically, Thailand has high potential for solar energy. Thailand is located slightly above equator, rendering constant daylight hour throughout the year. The potential solar energy of a certain area does not only depend on hours exposing to sunlight, but also relies on amount of solar radiation in the area (Piyasil, 2012). Lopburi Province, located at the central part of the country, has the average annual solar radiation in the range of 5 - 5.3 kWh/m^2. In Lopburi Province receives around 5 hours of sunlight per day, around 1,825 hours per year (Shrestha, et al, 2006).

- ***Downsides/Environmental Impacts of Solar PV***

There are a few disadvantages for PV systems. In terms of small scale uses, a small number of modules and a tiny amount of space are required for PV system. As per residential applications, PV modules are usually mounted onto the existing house's roof, using areas which were unusable before. Turning to large scale PV, there are a few drawbacks. The most suitable locations for large scale PV are usually dry areas which are known as desert like areas. The impact on the land is dependent on site specifics. Nevertheless, in the presence of appropriate design and planning, they can be minimized. These places normally are not inhabited areas by humans and show a little visual value. The worst noise and visual effects appear during decommission and construction of a site. To minimize these negative effects, a plant should be located away from densely populated neighborhoods and natural places (Tsoutsos, et al, 2005).

PV systems have very few negative environment impacts. PV emits no gas, liquid or radioactive pollutants. Hazardous materials are used during the manufacturing of PV. However, they can be controlled and limited through following safe manufacturing policies. Small amounts greenhouse gases are emitted during manufacturing of PV, in the range of 25-35 g/kWh. (Alsema, et al, 2006)

- Wind energy

Wind energy can be classified into two main categories, onshore and offshore wind energy. The main difference between the onshore and offshore systems is the foundations. The foundation size and shape varies between land and ocean applications. The most common foundations are gravity base, rock anchored, and deep foundation. The same turbines are used for both; however larger models are often used in the ocean. CRE projects in this research mainly focused on offshore wind energy system.

- *__Description of Technology of Wind energy__*

Wind turbines all work in a similar manner. Wind energy is generated by turbines that are powered by blades. The blades are connected to a rotor with a shaft that travels back into the nacelle, which contains the gear box. The gear box then increases the RPMs to a level at which the generator operates. The blade and generator assembly are placed on top of a tower and are generally 164 feet to 262 feet (50 m to 80 m) above ground. This height varies depending on manufacture and the optimization of available wind (NYS, 2005). Wind turbines have a range of wind speeds that they can operate at. They are known as the cut-in and cut-out speed. They vary by manufacture, but cut-in speeds average around eight mph and cut out speeds around 55 mph (88.5 kilometer per hour) (Global wind energy council, 2010). The cut in speed is the lowest speed at which the generator is able to operate. The cut-out speed is the speed at which the stresses on the structure become too high. When this happens a brake will stop the blades from spinning. Some models also rotate 90° to lessen the forces on the structure.

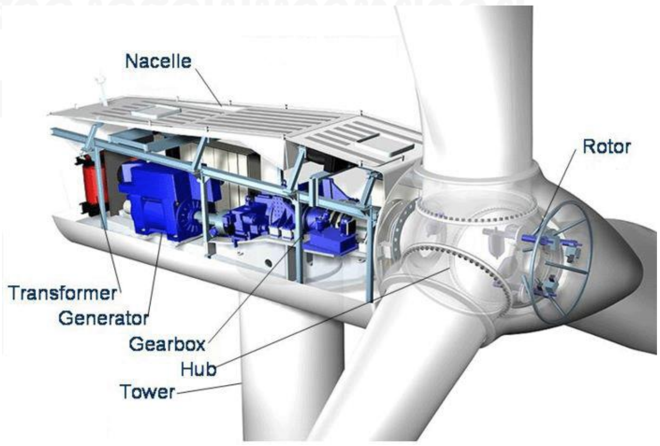

Figure 2.2: Diagram of Wind turbine

Source: http://www.rowan.edu/colleges/engineering/clinics/cleanenergy/case_study_summaries/wind_power.htm

- ***<u>Efficiency of Wind energy</u>***

Power available from wind greatly increases with the increase of wind speed. Wind turbine efficiency is ultimately measured by its capacity factor. The capacity factor is used for all power generation and is the amount of power produced over a period of time divided by the power that would have been produced if the turbine operated at a maximum output of 100% during the same period. Because the wind does not constantly blow, a capacity factor of 25 to 40% is normal (American wind associate, 2009).

- ***<u>Downsides/Environmental Impacts of Wind energy</u>***

Wind power has very few environmental impacts. Bird deaths have been an area of concern for wind turbines. Noise pollution is also a negative aspect of wind turbines; however, decibel level produced by wind turbines is the same level as the background noise in a residential house, 50-60 dB (Bred, 2008). In recent years the maximum sustained wind speed in Lopburi province is equivalent of around 23 mph. AWEA also provides a model zoning ordinance for residential turbines which states, in part:

> *"For wind speeds in the range of 0-25 mph, small wind turbines shall not cause a sound pressure level in excess of 60 dB, or in excess of 5dB above the background noise, whichever is greater, as measured at the nearest neighboring inhabited dwelling" (AWEA, 2013)*

2.1.2.2 Biogas

Biogas is a gas mixture, but mainly methane, that is created from microbial digestion of organic substances under anaerobic conditions. At least since 1958, it has been exploited as an alternative source of energy both in suburb and industrial areas (Stuckey, 1984).

According to Briefing Anaerobic Digestion paper, weekly separation of collections in order to be treated by anaerobic digestion is considered as the most sustainable method to treat food wastes from household. Description of Anaerobic Digestion technology under Briefing Anaerobic Digestion paper reported that shredding the material to be processed is capable of increasing the surface area that microbes can digest. As a result, the digestion speed becomes faster. The process of digestion under anaerobic conditions occurs in a digester which is an airtight container" (Friend of the earth, 2008). Food wastes serve as a great candidate for anaerobic digestion because they possess high moisture content as well as organic compositions. The way that organic matter is naturally and biologically degraded without oxygen is known as anaerobic digestion resulting in biogas. The compositions of biogas are 60–70% methane, 30–40% carbon dioxide, and other trace gases. Biogas can be utilized for most devices proposed for natural gas (EPA, 2009).

Hydrolysis is a chemical reaction reported to be the first step of anaerobic digestion. In this step, the breakage of complex organic molecules into simple sugars, amino acids, and fatty acids happens, along with the addition of hydroxyl groups. Throughout anaerobic digestion, manure is broken down by bacteria in environment where oxygen is absent. Anaerobic digestion provides many natural products including biogas.

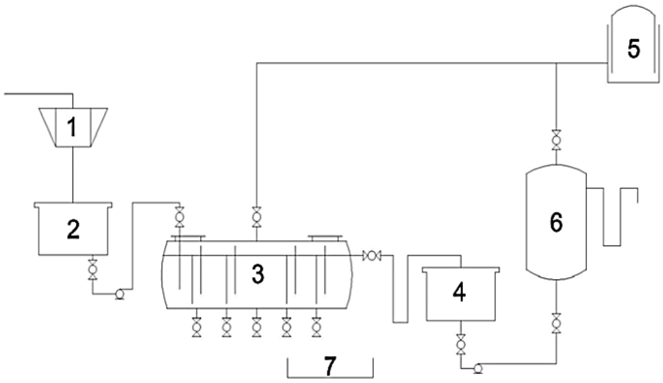

Figure 2.3: Anaerobic digester pilot plant flow chart

Source: http://sustainable.kmutt.ac.th/wp-content/uploads/2012/10/BIOGAS-PILOT-PLANT-FROM-FOOD-WASTE.pdf

Figure 2.3 showed detail of component in anaerobic digester pilot plant consists of no.1 Grinder, no.2 Mixing Tank, no.3 Anaerobic Plug Flow Reactor, no.4 Waste water Storage tank, no.5 Biogas Storage tank, no.6 Anaerobic Hybrid Reactor and no.7 Sand bed.

Figure 2.4: Anaerobic digester pilot plant in Sathya Sai School Thailand

- ***Downsides/Environmental Impacts of biogas***

Potentially negative environmental impacts of anaerobic digesters that combust biogas include the generation of nitrogen oxides and potentially increased ammonia emissions during digestive spreading (BC farm, 2012)

2.1.2.3 Biodiesel

- ***Description of Biodiesel technology***

Derived from animal fats, vegetable oils, waste cooking oil, or tall oil which is a by-product obtained from pulp and paper processing, biodiesel is fuel considered safe as well as biodegradable.

Transesterification is a process where biodiesel is manufactured from these feedstocks. During this process, reaction among oil, an alcohol which is typically methanol, in spite of that ethanol can be employed as well, and a catalyst, for example, sodium hydroxide. This chemical reaction generates glycerin and biodiesel which is an ester. Figure 2.4 displays this process.

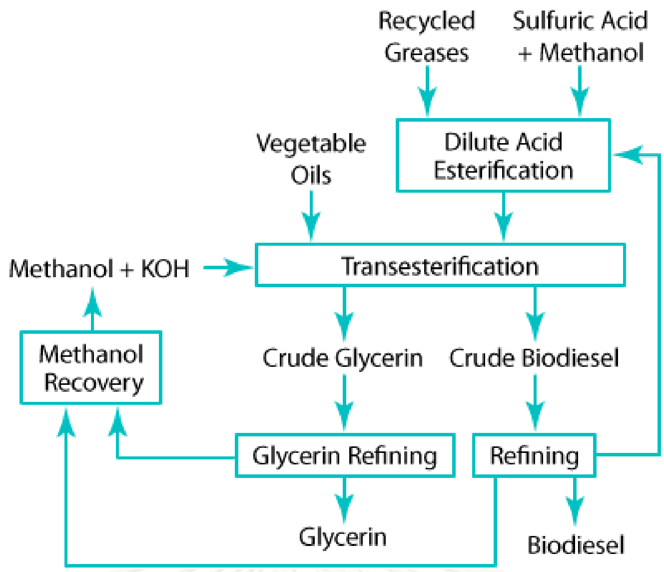

Figure 2.5: Biodiesel production diagram

Source: http://www.afdc.energy.gov/afdc/fuels/images/flowchart_biodiesel_prod.gif

Mixed with conventional diesel at many different levels such as 2%, 5% and 20%, biodiesel can be called B2, B5, and B20, respectively. The highest one is B100 without addition of petroleum base diesel. Additionally, wearing on an engine can be decreased by biodiesel through an increase in its total lubrication. 1% blend of biodiesel is capable of increasing lubrication by 65% (Clean cities, 2005)....

- ***Downsides/Environmental Impacts of Biodiesel***

In comparison to normal diesel, biodiesel creates smoke with less strength of the smell due to the fact that it burns remarkably greater and cleaner. Unlike traditional diesel, no sulfur is found in biodiesel. Therefore, this fuel is burned without releasing of sulfur. Although biodiesel generates fewer pollutants including hydrocarbons, airborne toxins, carbon monoxide, and particular matter as compared to conventional diesel, a slight rise in the emission of nitrogen oxide is observed. When 20% blend is used, occurrence of nitrogen oxides (NOx) increases by 2- 4%.

Pure biodiesel is a non-toxic and renewable fuel. Long-term direct exposure to this fuel very little irritates skin. As compared to table salt, its toxicity is one tenth. In environment, it is degraded four times more rapid in comparison to conventional diesel (National biodiesel, 2013).

2.1.3 Community participation

Hoffman and High-Pippert (2012) emphasized that by creating a system with participation of community residents, Community Renewable Energy (CRE) becomes an energy system that reflects local needs, values and resources. Community participation can support CRE to be more than just a policy or plan, and encourage energy development with knowledge of local details, and support from a network of local conditions found in businesses, community groups, educational institutes and government institutions. (St Denis and Parker, 2009; Walker, 2008; Rogers and others, 2012; Walker and Devine- Wright, 2008; Hoffman and High-Pippert, 2012).

The term community is normally employed for referring to people categorized based on either geography or common interest, identity or interaction. A definition given by Smithies, J. & Webster, G. is

> *"A group of people who share an interest, a neighborhood, or a common set of circumstances. They may, or may not, acknowledge membership of a particular community."*

The term *participate* clearly implies several different things. One is defined by Smithies, J. and Webster, G, 1998; Smithies, J and Adams, 1990; Bracht, N. and Tsouros, 1990 that it is

> *"A process by which people are enabled to become actively and genuinely involved in defining the issue of concern to them, in making decisions about factors that affect their lives, in formulating and implementing policies, in planning, developing and delivering services and in taking action to achieve change."*

However, expert who work in local authorities as well as other organizations probably have different arguments as follow;

> *"Participation in community is capable of helping us target resources in a more effective and efficient way."*

> *"Within community, skills can be developed as well as competencies and capacities can be built with assist of approaches used for community participation."*

> *"Community involvement in making decision will result in better decisions being made, which are not only more appropriate but also*

more sustainable due to the fact that people own these decision themselves."

"New opportunities for creative thinking as well as innovative planning and development can be provided by community involvement."

The following community participation options for CRE found in literature are drawn from Walker, 2008; Rogers and others, 2012; Hoffman and High-Pippert, 2012; Michalena and Angeon, 2003; Middlemiss and Parrish, 2009; Madlener, 2007; Jobert and others, 2007; and Hvelplund, 2006.

Options of community participation from these sources include:

- **Initiation**. Project initiated by community members, or community members invited to be involved in a decision-making platform;
- **Ownership**. Full or partial ownership by members of the community:
  - 100% community owned through self-funding, often with Government or inter-Governmental funding grants;
  - Co-ownership with a private sector organization;
  - Cooperative ownership: people in the community are members of a cooperative that finances a renewable energy project;
  - Community charities: an association with charitable status runs a community facility such as a village hall with renewable energy;
  - Shares owned by a local community organization; and
  - Individual investment: community members buy shares in a localized renewable energy project, advertised or offered to them directly.
- **Project design, decision-making, management and administration within the community.** This is done by administrative board of Sathya Sai School Thailand on behalf of community members.
- **Engagement of community members**. Understanding of CRE project is increased and occasional input from the wider community is sought through:
  - Working groups: to establish active input obtained by interested members of the community, particularly those having either professional experience or related skills;
  - Community meetings: to update community members, seek input to guide the project, and vote on major decisions for CRE;

- Education events: to ensure a high level of community understanding, such as training events, or education programs;
- Information: media coverage, and outreach through social institutions such as RE learning center help increase the knowledge of a local renewable energy projects amongst community members and others.

Significantly, different methods of participation have different implications for community members; however, it is problematic to specify how people should be involved in all cases given the unique contexts of community needs, histories and CRE vision.

Community benefits of CRE presented in social, economic, and environmental categories. Based on this understanding the study is investigated these possible benefits and looked for others in the actual experience of communities undertaking CRE. These benefits demonstrate many reasons why CRE can be important for a community across a wide range of areas. Although benefits will be different for each community, the study expected that such reported benefits would act as incentives that create motivation for community to initiate or continue sustainable community renewable energy.

2.2 Best Management Practices

2.2.1 Definition of Best Management Practices (BMPs)

Best Management Practices or (BMPs) can be defined as the most efficient and practical methods or techniques in obtaining an objective while making the optimum use of available resources.

The particular requirements or objectives and the specific site properties to be addressed are relating to "Best" because specific needs of management and site properties are addressed by most BMPs, it is useful in case that BMPs is identified and classified in accordance to where they are most efficient.

Renewable Energy Action Team in California Energy Commission explained the definition of BMPs that

> "*BMPs are recommended practices (or combined practices) determined to provide the most effective, environmentally sound, and economically possible mean of managing a project or facility and addressing the impacts. BMPs are recommended in the spirit of informing project developers of the typical practices that community expects and requires in permits or other regulatory approval documents. The BMPs address the post-application permitting/ pre-construction, construction, operation, repowering/ retrofitting, and decommissioning development phases. BMPs are too general to be project specific mitigation measures. The specific measures will be developed during individual project regulatory processes. Additionally, the BMPs list should not be considered final because additional BMPs may be identified to avoid and/or minimize impacts based on a proposed project design, technology and site specific characteristics." (California energy commission, 2013)*

2.2.2 Energy Management

2.2.2.1 Energy Management Systems

Energy management allows organizations to decrease their energy consumption while productivity is maintained or improved. Approximately 60% of energy around the world is used both by industrial and commercial sectors (DOE, 2013). Energy management system can lower energy consumptions by organizations in these sectors between 10% and 40% if implemented efficiently.

The concept of energy management systems is based on the Plan-Do-Check-Act (PDCA) cycle of management which is created by Dr. W. Edward Deming and globally utilized as a foundation for many management systems and standards throughout the world. Figure 2.6 shows how continuous improvement can be achieved when the PDCA process is constantly used.

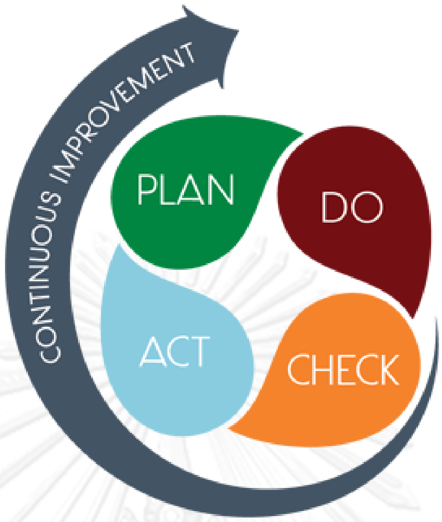

Figure 2.6: Plan-Do-Check-Act cycle for continuous improvement

Source: http://www.dpsgsustainability.com/page/environmental-sustainability

As a combination of processes, procedures, and tools which is designed to involve staff working within an organization at every level in managing energy consumption on a continuous basis, energy management system offers systematic tracking, analyses and planning of their usage of energy, better control of energy performance as well as ongoing improvement in energy efficiency to organizations.

2.2.2.2 Area of knowledge and skill for implementing energy management system

To become successful, it is necessary that any corporate energy management system has to receive the responsibility of the greatest management to offer the resources required for a sustainable attempt. Typically, it is the responsibility of an energy team to implement the energy management system and it is also a role of this team to improve energy performance securely. Nonetheless, the team's size and composition will be varied by organization. In order to achieve the best management assistance, presentation of a business case on the positive effects to a community in long term on main business objectives, for example, environmental performance, financial efficacy as well as social responsibility.

Representatives from 11 countries'; namely Denmark, India, Japan, Australia, Canada, Mexico, Sweden, South Africa, European Commission, Republic of Korea and the United States; participated in the Energy Management Working Group (Partnership, 2013) to support more extensive utilization for wider adoption of energy management systems. The working group mapped knowledge and skill areas needed to the implementation steps of an energy management system as follows;

1. **Initiating an Energy Management Program**: Understanding fundamental ideas and requirements; obtaining leadership in organization responsibility; creating an energy team; improving an energy policy.
2. **Conducting an Energy Review**: Gathering energy information; analyzing energy consumption and costs; identifying main uses of energy; conducting energy assessments; identifying potential chances.
3. **Energy Management Planning**: Establishing a baseline; defining performance metrics; assessing opportunities and choosing projects; improving action plans.
4. **Implementing Energy Management**: Getting resource commitments; providing training and raising awareness; communicating to all stakeholders; executing action plans.
5. **Measurement and Verification**: Comprised of knowledge and skills needed for monitoring, measurement, verification, tracking, and documentation of energy use and conservation.
6. **Management Review**: Executing a progress review; Modifying targets and action plans required to maintain ongoing improvement; recognizing achievement and major contributors.

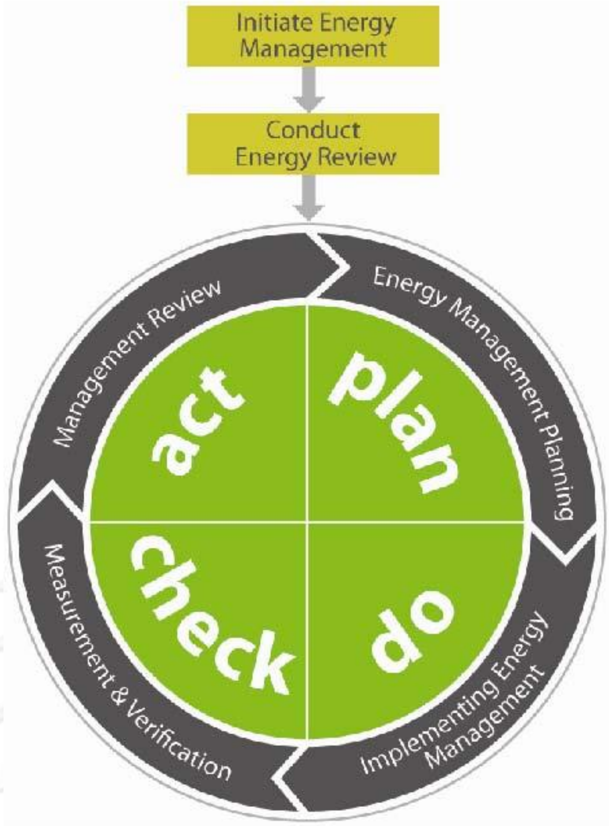

Figure 2.7: Steps in Energy Management Systems

Source:http://www.cleanenergyministerial.org/Portals/2/pdfs/GSEP_knowledge_skills_EnMS_implementation.pdf

These steps are engaged in the cycle of Plan-Do-Check-Act, according to Figure 2.7. Apart from these ordinary areas of knowledge, ancillary skills and knowledge which will promote understanding of major topics in energy management are identified by the EMWG.

After the commitment of Best Management Practices is received, a plan should be developed by the energy team to implement the program of energy management and establish a structure facilitating documentation as well as recordkeeping. Some basis tasks engaged in the initiation of an energy management program are listed below:

1. Business case development;
2. Determination of internal and external audiences as well as their responsibilities in advocating energy management;
3. Stakeholders engagement;
4. Multidisciplinary team development

2.2.3 The Scale and Sustainability Score Sheet

The Scale and Sustainability Score Sheet is a tool to examine planning and implementation separately for each category. Therefore, the community is capable of seeing the complete picture of scale and sustainability efforts to date, identifying gaps and determining how to go forward. The purpose of the tool creation is to be applied for practices and programs which have high quality evidence or showed potential.

The leader and team can use the Scale and Sustainability Score Sheet to establish requirements for ensuring the eventual scale and sustainability of the change strategy. It is also vital to engage a team.

Scale: It relates to both "breadth" (such as widespread adaptation of a practice or program) and "depth". In other words, it is evidence of penetration and high quality in all programs resulting from the alteration. The highly successful scale should provide a clear understanding of the main concept of original model. As the spreads of practice or program, there is the presence of the right balance of preserving the essential properties of the original, and allowing for and promoting local adaptations.

Sustainability: It relates to both the long-term staying power of the resulting program and alterations in human behavior. Although supportive law and policies and satisfactory funding play an important role in sustainability, they seem to be insufficient. As per sustainability, it probably starts with laws, policies and funding. In the end, nevertheless, the alteration has to be embedded into the culture, attitudes, values and behaviors of those most impacted by it.

The ratings and evidence by completing the tool which are supposed to provide the community leader a great idea of the specifics needed for implementation and planning have a tendency to cause scale and sustainability.

The purpose of the tool creation is to be applied for practices and programs which have high quality evidence. In addition, the tool is showed potential. The five stages are as follow:

- **Stage one**

  Explain the practice or program that you are realizing scaling and sustaining; What it is, Why it is essential, How you know it is of high quality of valued?, and What results anticipated are

- **Stage two**
  Make a list of the core or non-negotiable elements of the practice or program
  Stage three
  Rate the present status of the main group of Scale and Sustainability in the case of planning as well as implementation
- **Stage four**
  Think about your ratings for planning as well as implementation in group each and evaluate what is required for promoting Scale and Sustainability. Complete the Score Sheet including the right-hand column. This will contribute to strategy development for furthering progress and filling gaps.
- **Stage five**
  Based on the requirements you have evaluated strategies should be developed for implementation as well as planning. The group of scale and Sustainability throughout implementation should be continuously monitored and mid-course corrections are made if necessary.

Combination between Planning score and Implementation score of each category will present a total rating. The highest score is 10”. For a total of the average sub-totals for each ‘Sustainability’ category and each ‘Scale’ category the highest score is “100”. The scores are supposed to help the leader evaluating where the scale of sustainability the CRE projects management are and where the gaps are both in individual category and between implementation and planning (Spiro, 2011).

The rating of Scale and Sustainability will be analyzed on Chapter 4 and synthesized on Chapter 5 whether or not CRE projects have Best Management Practices. Details of the Scale and Sustainability Score Sheet shows in Table 2.1 and Table 2.2 as follow:

SCALE & SUSTAINABILITY SCORE SHEET

STEP 1

DESCRIBE THE PROGRAM OR PRACTICE THAT YOU ARE CONSIDERING SCALING AND SUSTAINING

What is it? Why is it important? How do you know it is of high quality and valued? What results are anticipated?

STEP 2

LIST THE CORE OR NON-NEGOTIABLE ELEMENTS OF THE PROGRAM OR PRACTICE

STEP 3

RATE THE CURRENT STATUS OF THE KEY CATEGORIES OF SCALE & SUSTAINABILITY IN TERMS OF *BOTH* PLANNING AND IMPLEMENTATION [12]

	For Planning - There is:		**For Implementation:**
5 =	A comprehensive plan in place that all stakeholders "own"	5 =	All aspects have been fully implemented
4 =	A comprehensive plan in place that most stakeholders support	4 =	Most aspects have been fully implemented
3 =	A partial plan in place with some support	3 =	Some aspects have been implemented
2 =	A partial plan with modest support	2 =	Few aspects have been implemented
1 =	No plan	1 =	No aspects have been implemented

STEP 4

CONSIDER YOUR RATINGS FOR BOTH PLANNING AND IMPLEMENTATION IN EACH CATEGORY AND IDENTIFY WHAT IS NEEDED TO PROMOTE SCALE AND SUSTAINABITY

Fill in the right-hand column of the *Score Sheet*. This will lead you into development of strategies to further progress and fill gaps.

STEP 5

DEVELOP STRATEGIES FOR BOTH PLANNING AND IMPLEMENTATION BASED ON THE NEEDS YOU HAVE IDENTIFIED

Continue to monitor the categories of scale and sustainability throughout implementation and make mid-course corrections as necessary.

SCALE & SUSTAINABILITY SCORE SHEET – Part I: Scale

To what extent have the following elements been incorporated into your program or practice?

For Planning (P) - There is:		For Implementation (I)	
5 =	A comprehensive plan in place that all stakeholders "own"	5 =	All aspects have been fully implemented
4 =	A comprehensive plan in place that most stakeholders support	4 =	Most aspects have been fully implemented
3 =	A plan in place with some support	3 =	Some aspects have been implemented
2 =	A partial plan with modest support	2 =	Few aspects have been implemented
1 =	No plan	1 =	No aspects have been implemented

	SCALE CATEGORY	RATINGS (P)	(I)	Total P + I	Evidence for the Rating		What Is Needed For Scale
I.	A model with demonstrated effectiveness or promise			0	(P) (I)		
II.	A program or practice not only in more places, but with high quality and depth of implementation in all those places			0	(P) (I)		
III.	A "logic model" or theory of action that identifies the steps leading to the model's desired outcomes			0	(P) (I)		
IV.	A justified hypothesis and/or research that supports the rationale behind the model			0	(P) (I)		
V.	Replication of identified core elements of the original model with contextual modifications. Ownership by local adapters			0	(P) (I)		
VI.	High demand for program or practice; fills an acknowledged need			0	(P) (I)		
VII.	A large number of supporters beyond "early adopters"			0	(P) (I)		
VIII.	Structural mechanisms by which the model can be spread			0	(P) (I)		
IX.	Personnel who are skilled in the model who can train others			0	(P) (I)		
X.	A strong implementation plan with monitoring and continuous improvement built in			0	(P) (I)		
	SCALE Total (P & I) →	**0**	**0**	**0**	**<--Combined Total (P+I)** *(out of 100)*		
	Total	(P)	(I)	(P+I)			

Table 2.1: Scale and Sustainability Score Sheet (Part I: Scale)

Source: http://www.wallacefoundation.org/knowledge-center/school-leadership/district-policy-and-practice/Documents/leading-change-handbook.pdf

SCALE & SUSTAINABILITY SCORE SHEET – Part II: Sustainability

To what extent have the following elements been incorporated into your program or practice?

	SUSTAINABILITY ELEMENT	(P)	(I)	Total P + I	Evidence for the Rating	What is Needed for Sustainability?
I. LAWS, REGULATIONS, POLICIES						
a.	Supportive laws or regulations in place			**0**	(P) (I)	
b.	Institutionalized outcomes of the change (i.e., procedures, position descriptions, curriculum requirements)			**0**	(P) (I)	
	I. AVERAGE SCORES FOR CATEGORY	**0**	**0**	**0**		
II. STAKEHOLDERS (Key individuals)						
a.	Key stakeholders engaged			**0**	(P) (I)	
b.	Little active opposition			**0**	(P) (I)	
	II. AVERAGE SCORES FOR CATEGORY	**0**	**0**	**0**		
III. EXTERNAL PARTNERSHIPS (Key groups or organizations)						
a.	Key organizations engaged			**0**	(P) (I)	
b.	Key organizations perceive the program or practice as furthering their own goals			**0**	(P) (I)	
c.	Union contracts support the program or practice			**0**	(P) (I)	
	III. AVERAGE SCORES FOR CATEGORY	**0**	**0**	**0**		
IV. INTERNAL ORGANIZATIONAL CAPACITY						
a.	Organizational goals furthered by the change			**0**	(P) (I)	
b.	Well-defined procedures and systems for implementation			**0**	(P) (I)	
	IV. AVERAGE SCORES FOR CATEGORY	**0**	**0**	**0**		

Table 2.2: Scale and Sustainability Score Sheet (Part II: Sustainability)

Source: http://www.wallacefoundation.org/knowledge-center/school-leadership/district-policy-and-practice/Documents/leading-change-handbook.pdf

SCALE & SUSTAINABILITY SCORE SHEET - PART II: Sustainability

	SUSTAINABILITY ELEMENT	(P)	(I)	Total P + I	Evidence for the Rating	What is Needed for Sustainability?
V. HUMAN CAPITAL						
a.	A clear and legitimate procedure of succession for those leading the effort			0	(P) (I)	
b.	Staff with the skills and knowledge to implement the new program or practice			0	(P) (I)	
c.	An institutionalized system for training personnel in the skills needed by the program or practice			0	(P) (I)	
	V. AVERAGE SCORES FOR CATEGORY	0	0	0		
VI. FUNDING						
a.	On-going funding from diversified sources			0	(P) (I)	
b.	Coordination of several funding sources to support the new program or building in the new program or practice within existing programs			0	(P) (I)	
c.	Cost neutral strategies (reallocation of resources to the new program or practice including cutting funding to programs that are not working well)			0	(P) (I)	
	VI. AVERAGE SCORES FOR CATEGORY	0	0	0		
VII. CULTURE						
a.	Program or practice furthers existing values and norms			0	(P) (I)	
b.	Favorable attitudes toward the new program or practice			0	(P) (I)	
	VII. AVERAGE SCORES FOR CATEGORY	0	0	0		
VIII. CONTINUOUS IMPROVEMENT (Formative Evaluation)						
a.	Continuous gathering of data to support the achievement of the change goal			0	(P) (I)	
b.	Provisions for monitoring, learning lessons and consequently making mid-course corrections			0	(P) (I)	
	VIII. AVERAGE SCORES FOR CATEGORY	0	0	0		

Table 2.3 (cont.): Scale and Sustainability Score Sheet (Part II: Sustainability)

Source:: http://www.wallacefoundation.org/knowledge-center/school-leadership/district-policy-and-practice/Documents/leading-change-handbook.pdf

SCALE & SUSTAINABILITY SCORE SHEET - PART II: Sustainability

	SUSTAINABILITY ELEMENT	(P)	(I)	Total P + I	Evidence for the Rating	What is Needed for Sustainability?
IX. COMMUNICATIONS						
a.	On-going communications mechanisms including use of media and public relations			0	(P) (I)	
b.	Transparency of progress to all constituencies			0	(P) (I)	
	IX. AVERAGE SCORES FOR CATEGORY	0	0	0		
X. EVALUATION (Summative)						
a.	Assessment of the program or practice's accomplishments versus planned outcomes after a specified time period			0	(P) (I)	
b.	Identified lessons learned			0	(P) (I)	
	X. AVERAGE SCORES FOR CATEGORY	0	0	0		
	SUSTAINABILITY Total (P & I)	**0**	**0**	**0**	*(out of 100)*	
	Total	(P)	(I)	(P+I)		

Table 2.4 (cont.): Scale and Sustainability Score Sheet (Part II: Sustainability)

Source:: http://www.wallacefoundation.org/knowledge-center/school-leadership/district-policy-and-practice/Documents/leading-change-handbook.pdf

CHAPTER 3
RESEARCH METHODOLOGY

The structure of methodology was formulated by the three sections as follows:

3.1 Research methodology

3.2 Conceptual framework

3.3 Data analysis

3.1 Research Methodology

According to documentary research in community renewable energy, the key factors to consider are Best Management Practices (BMPs). So, this study focuses mainly on the community residents and Community Renewable Energy (CRE) projects management in Sathya Sai School Thailand. The methodology relating to documentary was searched into two main parts as follows;

3.1.1 Primary data collection

This method applied in the study to compare the information analyzed from the document with the information gathered from the actual site. The processes uses are as follows:

- **Field research**

Field research applied in the study to search for, survey and compare the validity of the document. It also revealed in-depth data from the community and RE specific site characteristics. Information gained from field research relating to two processes as follows:

- *Field observation*

The purpose of carrying the field observation was to gain information related to three main focus areas as follow:

a) Renewable energy technologies generated in form of electricity (solar PV and wind turbine), biogas and biofuel;

b) Identity of people and culture in the community;

c) Site characteristics; climatologic, topologic, and geologic conditions.

- ***Interview***

The purpose of carrying interview was to gain in-depth information. Interviewees are key-persons of the community which are community director, staffs involved in RE, and representative of community resident. A list of questions is under the three main focus areas as follow:

a) Community participation methods in CRE projects;

b) Community benefits received by CRE projects; and

c) Strengths and weaknesses as well as keys to success experienced by community undertaking CRE projects management.

Overall qualitative data gained from field research method were gathered regarding research objective number one; *To study community participation methods and community benefits in Community Renewable Energy (CRE) projects in Sathya Sai School Thailand;* and research objective number two; *To identify strengths and weaknesses as well as keys to success of Community Renewable Energy (CRE) projects management*.

- **Preference Questionnaire**

Preference questionnaire was used to gather information about community residents' attitudes and preferences on mobilizing the CRE projects towards sustainability. The preference questionnaire results were identified on sustainability scale in the CRE projects management and were implied whether or not CRE project management is a best management practice.

Questions for preference questionnaire was developed in order to ensure consistency in using different methods for information gathering, to recheck the issues of CRE project management and its benefits and to explore genuine involvement of community residents. To identify questionnaire participants, the study distributed requests for contribution through community residents in age range between 13 – 60 years old.

3.1.2 Secondary data

The study also gathered secondary data relating to theories on Community Renewable Energy (CRE); *Community Renewable Energy generation, Community participation, Community benefits*, Energy Management; *Energy Management Systems, Knowledge and skill areas for energy management system implementation* and Best Management Practices (BMPs); *Definition of Best Management Practices (BMPs).*

Using existing literature, the study developed a CRE review because there was a vast array of views. The study only chose to define CRE generation within Sathya Sai School Thailand that incorporated some degree of participation in community and its benefits. Also, there are different views of the BMPs at industrial scale, the study decided to inquire about the appropriate method that would contribute to accomplishment of BMPs for overall local renewable energy

3.2 Conceptual Framework

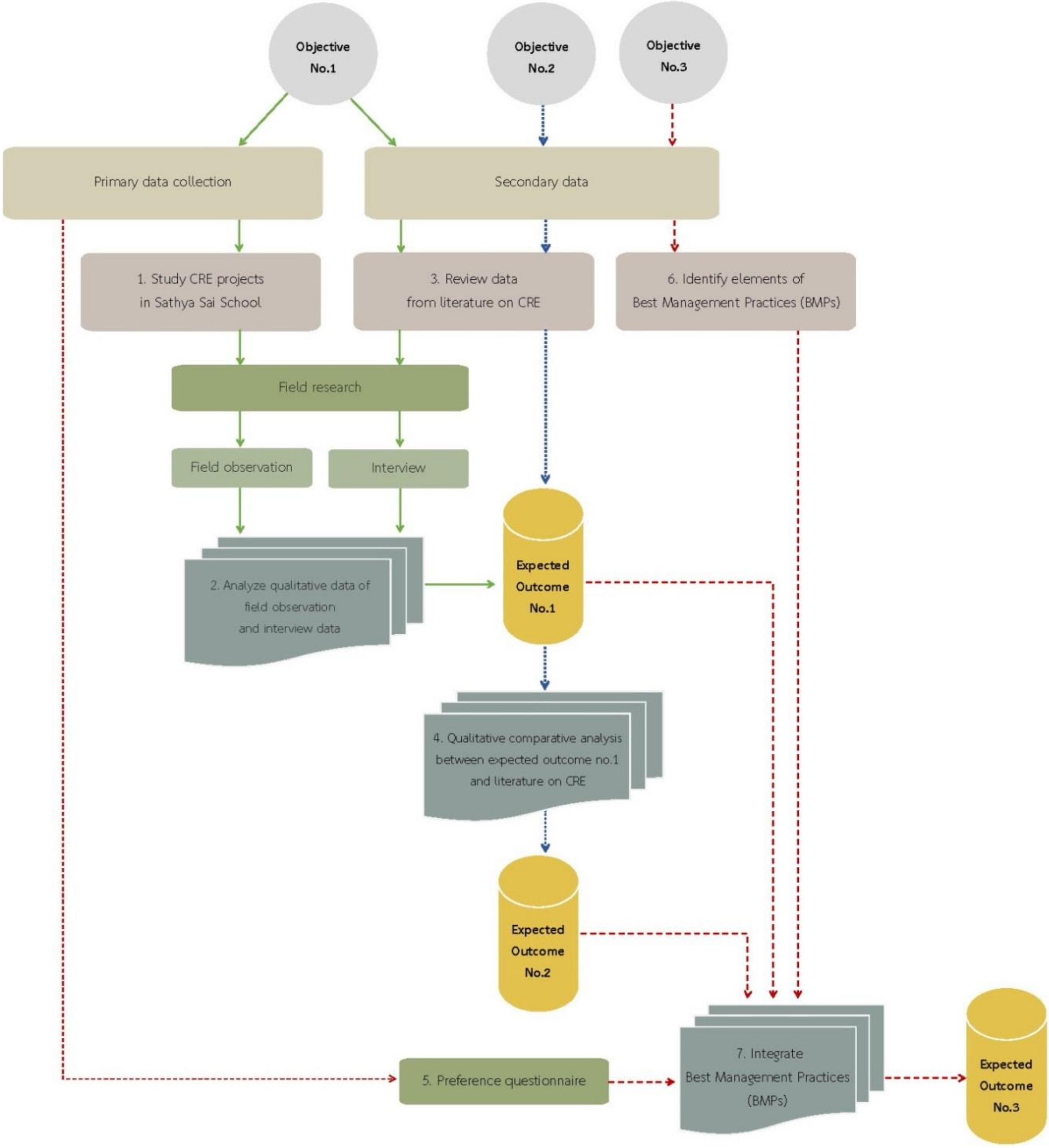

Figure 3.1: Conceptual Framework

Using the conceptual framework outlined above, the study develops and refines three research objectives then, identify seven methods of research that will appropriately assist the study in gathering data to answer the research question and reach research expected outcomes. These seven methods are as follows:

1. Studying CRE projects; field research applied to field observation to search for and survey on site characteristics, RE technologies community participation methods, and benefits experienced by community undertaking CRE projects by field observation. It also reveals in-depth data about participation methods of community members and benefits they gained from RE projects as well as, importantly, identity of people and culture in the community by interviewing key-persons of the community.

2. Analyzing qualitative data of field observation and interview data; results of this analysis render research expected outcome number one; Methods of community participation and community benefits received by CRE projects in the community.

3. Reviewing data from literature on CRE; **the study gathers secondary data relating to theories on CRE;** CRE generation, Community participation, Community benefits and Energy Management; Energy Management Systems, Area of knowledge and skill for implementing energy management system.

4. Qualitative comparative analysis between expected outcome number one and Literature on CRE; the results of this analysis result render research expected outcome number two; Strengths and weaknesses as well as keys to success of CRE projects management.

5. Preference questionnaire to community residents; preference questionnaire is used to assist community in gathering quantitative data about community residents' attitudes, preferences, and opinions on moving the CRE projects towards sustainability.

6. Identifying elements of Best Management Practices (BMPs); the study gathers secondary data relating to theory on BMPs.

7. Integrating the BMPs for CRE projects to preference questionnaire result, research expected outcome number one and research expected outcome number two; this integrated result render research expected outcome number three; Recommendation for CRE projects to achieve BMPs of sustainable community renewable energy.

3.3 Data Analysis

Variables observed in the data set of field research (field observation and interview results) and some part of literature review on CRE are analyzed. The results of this analysis render research expected outcome number one; *Methods of community participation and community benefits received by Community Renewable Energy (CRE) projects in Sathya Sai School Thailand.*

Then, qualitative comparison analysis method was used for analyzing research expected outcome number two and then applying the rules of CRE and Energy Management to determine descriptive inferences. The results of this analysis render research expected outcome number two; *Strengths and weaknesses as well as keys to success of Community Renewable Energy (CRE) projects management in Sathya Sai School Thailand.*

Integration BMPs theory with research expected outcome number one, research expected outcome number two and preference questionnaire interpretative results under analysis with three pillars of sustainability (economics, social, and environment) was used for rendering research expected outcome number three; *Recommendation for Community Renewable Energy (CRE) projects to achieve Best Management Practices (BMPs) of sustainable community renewable energy from the case study of Sathya Sai School Thailand.* The recommendation was in the format of checklist and flowchart diagram for BMPs of sustainable CRE project.

CHAPTER 4
RESULTS

This section presents research findings from field observation, interviews and preference questionnaire interpretation gathered from CRE projects in Sathya Sai School Thailand, Lam Narai District, Lopburi Province, Thailand during June 10 – 15, 2013. The structure of findings was formulated into three sections in accordance with the research objectives as follows:

Section 4.1: Finding on participation methods of community members and community benefits from CRE projects in Sathya Sai School Thailand.

Section 4.2: Finding on strengths, weaknesses and keys to success of CRE projects management in Sathya Sai School Thailand.

Section 4.3: Finding on preference questionnaire interpretation.

4.1 Participation methods of community members and community benefits from CRE projects

4.1.1 Participation methods of community members

The following section presents findings of community participation in CRE projects. The findings were gathered from key-person interviews. The interview results were summarized in Table 4.1 below.

Table 4.1: Interview results of participation methods of community members

Participation method	Detail	Interviewee
Education-based community	- RE curriculum for community residents; RE course for community residents aged 13 and Science course for community residents aged 14	- Community Director - Representative of community residents
Education activities	- Community residents had a study trip to biogas project at Chitralada Villa, Dusit Palace in Bangkok. - Community residents practiced as RE projects tour guides.	- Community director - Staff
Working group	- Staff contributed organic waste to produce biogas.	- Staff
Community meetings	- Discussions and comments on CRE projects	- Staff

The interview with key-persons of the community can be concluded that community participation methods in CRE Projects are with 'awareness' on the importance of RE. Community members agreed that RE is a must and should be managed in the pattern of education-based community, with integration of RE knowledge into community activities, such as

- Education-based community; RE curriculum for community residents; RE course for community residents aged 13 and Science course for community residents aged 14.
- Education activity; community residents joined a study trip to biogas project at Chitralada Villa, Dusit Palace in Bangkok.
- Working group; staff contributed organic waste to produce biogas.
- Community meetings; discussions and comments on CRE projects.

The integration of RE knowledge into community activities, as mentioned above, enabled strong RE knowledge base among community members that they were able to share such knowledge to the society. It initially started from the very determined community director who had put great effort in making community members aware of global warming crisis and encouraging them to participate in global warming solution by using RE as the main tool.

Summary of the proportion of community participation in CRE projects is shown in figure 4.1 below.

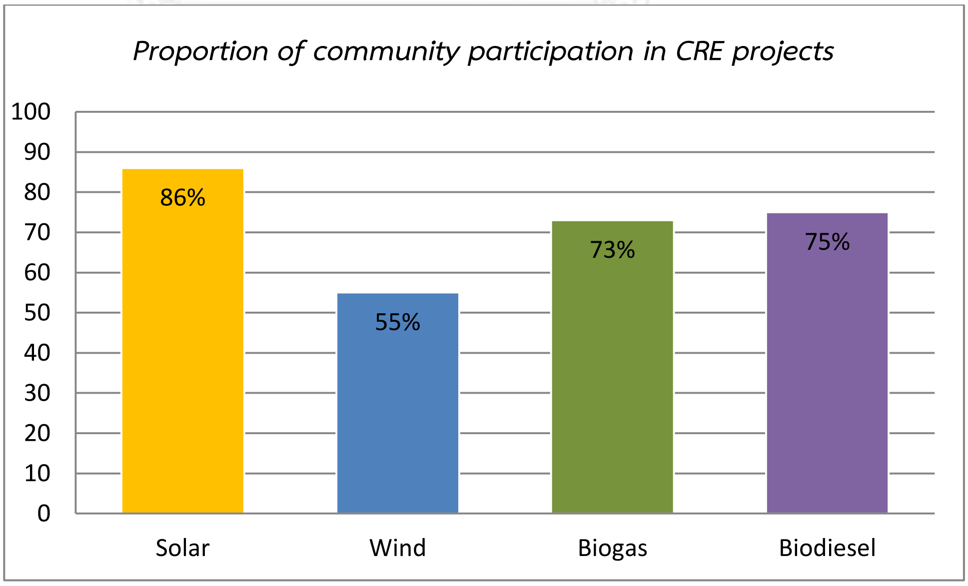

Figure 4.1: Proportion of community participation in CRE projects

Figure 4.1 the bar chart shows that community participation in each RE project is above 50% and participation rate of every project is about the same proportion:

- Solar energy project: participation ratio of community residents was 86%
- Wind energy project: participation ratio of community residents was 55%
- Biogas project: participation ratio of community residents was 73%
- Biodiesel project: participation ratio of community residents was 75%

Not only contribution from community residents, but CRE projects also received supports from stakeholders such as government agencies; Department of Alternative Energy Development and Efficiency (DEDE) Ministry of Energy, Faculty of Engineering Silpakorn University; and private sectors who supported on technical knowledge and equipment and tools to produce energies. The relationship between stakeholders and the community towards CRE projects is summarized as Figure 4.2.

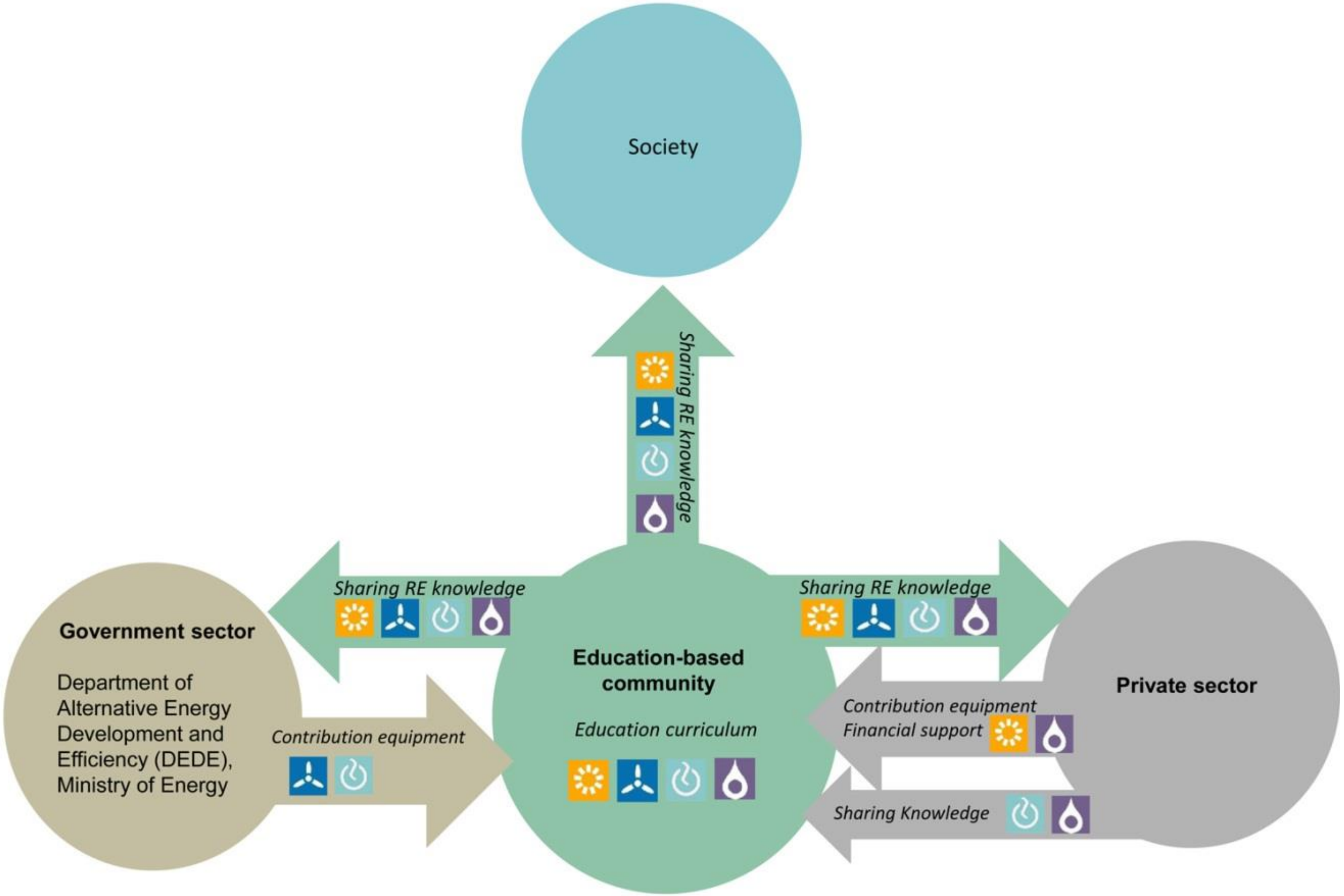

Figure 4.2: Relation between stakeholders and the community towards CRE projects

Figure 4.2 shows stakeholders participation as follow:

- Government sector: Department of Alternative Energy Development and Efficiency (DEDE), Ministry of Energy participated in CRE projects by contributing Anaerobic Digestion technology for biogas production and wind turbine for wind energy production.
- Private sector: private companies participated in CRE projects by contributing solar PV panels for solar energy production and used-cooking oil for biodiesel production as well as financial support of solar energy projects. Furthermore, RE specialist shared RE knowledge and techniques to community residents.
- Education-based community: As the community itself is education-based community which has education curriculum and activities related to RE education, the community served the society by sharing RE knowledge.

4.1.2 Community benefits from CRE projects

The following section presents findings of the benefits that the community received from CRE projects. The findings were gathered from observation of RE technologies generated in form of electricity (solar PV and wind turbine), biogas, and biofuel. However, full details of CRE projects are not presented in this section, but in Appendix A.

As the final expected outcome of this research focuses on BMPs of sustainable community renewable energy, the result of community benefits in CRE projects is classified according to the three pillars of sustainability; social, economic, and environment; as described in Table 4.2.

Table 4.2: Interview and field observation results of community benefits in CRE projects

Category	Community benefit of CRE projects	Type of Renewable Energy			
		Solar	Wind turbine	Biogas	Biodiesel
Social	- Created networks for information exchange	✔	✔	✔	✔
	- Strengthened relationship between community and energy supplier	✔	✔	✔	✔
	- Increased community cohesion	✔	✔	✔	✔
	- Increased RE education in the community	✔	✔	✔	✔
	- Increased understanding of climate change and renewable energy	✔	✔	✔	✔
	- Increased awareness of capability of community residents	✔	✔	✔	✔
Economic	- Community members experienced on energy cost saving	✔	✔	×	✔
	- Increased local job	×	×	×	✔
Environ-mental	- Reduced greenhouse gas emissions	✔	✔	✔	✔
	- Inspired other sustainable development projects	✔	✔	✔	✔

4.2 Strengths, weaknesses and key to success of CRE projects management

4.2.1 The relevant findings to identify strengths, weaknesses and key to success of CRE projects management

This subtopic presents significant findings gathered from field observation of CRE projects and key-persons interview which help identify strengths and weaknesses of CRE projects management in subtopic 4.2.2. The relevant findings are described as follow.

4.2.1.1 Identity of people and culture in the community

The studied community is education-based community which has community-like organizational management. Population of the community aged 13 - 60 year old is approximately 350 people, Interview results of chief executive officer of the community, who was involved in setting community visions, stressed that the community members would be trained to become a person of good character with truth, right conduct, peace, love, and non-violence (Jumsai, 2003). The goal of community management was to become self-sufficient and sustainable community.

In addition, interview results of community director, who was involved setting RE education program, stressed that the community residents have principles which influence their thoughts and consideration in life that is they should always ask two questions before acting on any activity; "What am I going to do, good for me?" and "What am I going to do, also good for everyone?" (Jumsai, 2003). Therefore, the participation of community residents in CRE projects is by realization of RE's values.

4.2.1.2 Site characteristic

Gathering site characteristic data is necessary for CRE projects management since understanding site information is needed for appropriate renewable energy screening for the community. Significantly, it will show resources that can be used to identify strengths and weaknesses as well as key to success on CRE projects management.

The studied area is approximately 100 acres (300 Rai – land area unit in Thai). The geographic coordinate of the community is 15°12′22″N 101°8′12″E; in Lam Narai Subdistrict, Chai Badan District, Lopburi Province in Thailand. Lopburi Province is located at the central part of the country.

The studied area receives around 5 hours of sunlight per day or around 1,825 hours per year. The average annual solar radiation is in the range of 5 - 5.3 kWh/m². The average daily wind speed is around 2 km/h, which is equivalent to about 1 mph, or 1 knot. In recent years, the maximum sustained wind speed has reached 37 km/h, which is equivalent to around 23 mph, or 20 knots (Weather2).

The location of each project shows in Figure 4.3 as follow:

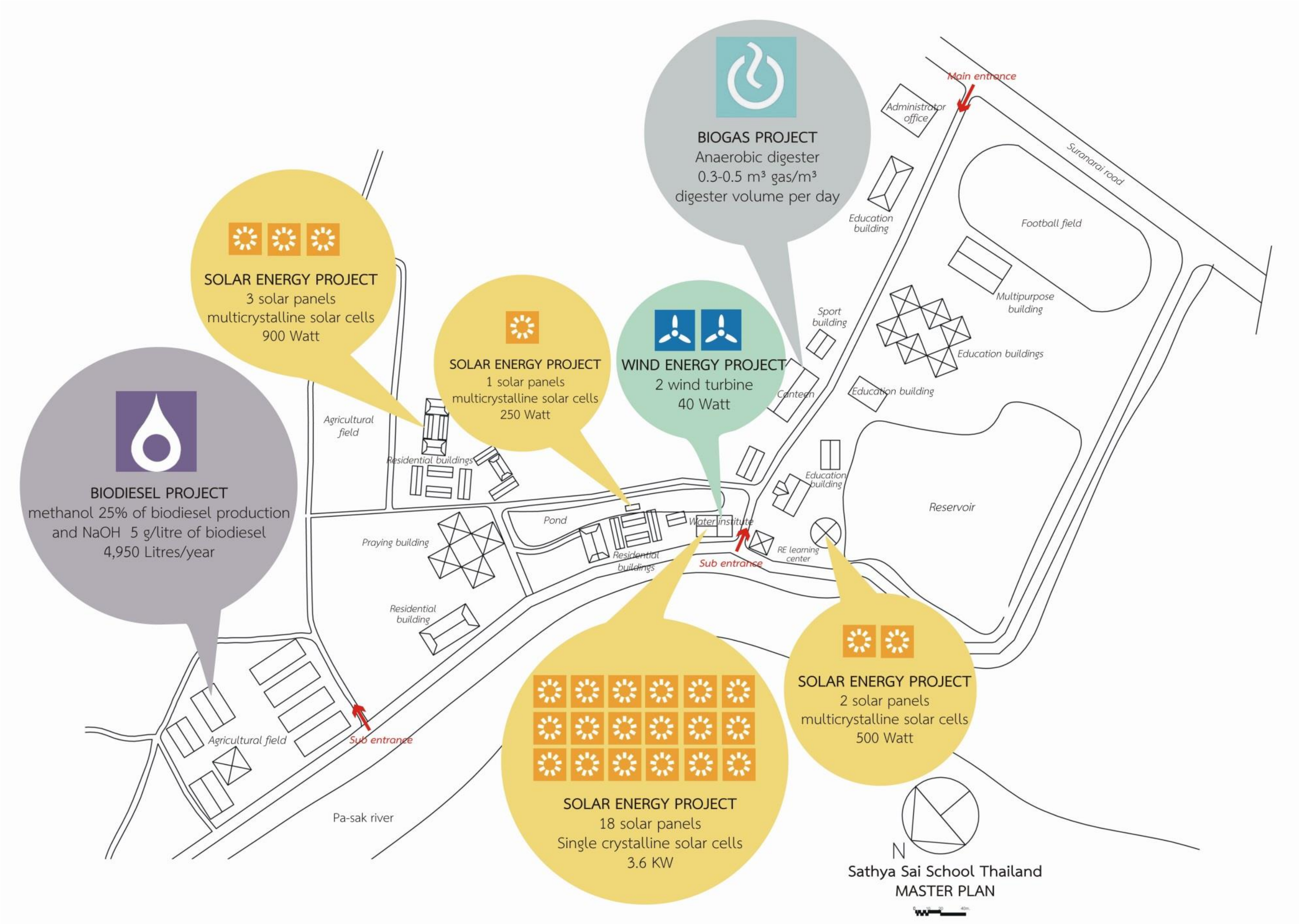

Figure 4.3: Master plan of CRE project in Sathya Sai School Thailand

4.2.1.3 CRE projects information

This section presents selected CRE projects information which helps identify strengths and weaknesses of CRE projects management in subtopic 4.2.2. Full detail of CRE project information, see Appendix A.

Table 4.3: CRE projects information

Category	Type of RE	CRE projects information
Technical	Solar energy	 24 Solar panels; 18 Single crystalline solar cells and 6 multicrystalline solar cells. Total generating capacity of 5.25 Kilowatt (kW)
	Wind energy	 2 Wind Turbines; specifications are as follow (The General Electric Company, 2007) - Designed to IEC 61400-1 - Class S winds: 7.5 m/s average wind speed; B turbulence intensity - Rotational direction: Clockwise viewed from an upwind location - Speed regulation: Electric drive pitch control with battery backup - Aerodynamic brake: Full feathering of blade pitch Total generating capacity of 20 Watt

Category	Type of RE	CRE projects information
	Biogas	 Anaerobic Digestion technology Total generating capacity is 0.3 – 0.5 m^3 gas/ m^3 digester volume per day
	Biodiesel	  Use methanol 25% of biodiesel production (used-cooking oil) and NaOH 5 g/litre of biodiesel. Total production capacity is 4,950 Litres/year
Social	Solar energy Wind energy Biogas Biodiesel	**Offer RE training** Renewable energy study for community residents **Technological understanding** Renewable energy guidance for student grade 8 **Creates long-term, high quality jobs and skills** Support undergraduate scholarship to community residents studying in RE program. **Consequences for other benefits** Renewable energy learning centers were established to build the skills and RE knowledge.
Economic	Solar energy	**Facing high maintenance cost;** Operation and maintenance cost of solar energy is higher than income gained. Operation and maintenance cost is 108,000 baht/year but income is only 37,800 baht/year.
	Wind energy	**No data**

Category	Type of RE	CRE projects information
	Biogas	**Reduce cooking fuel cost;** Cooking fuel (LPG) costs 103,850 baht/year. If biogas production is highly efficient, LPG cooking gas cost would be reduced around 1,971 baht/year. (More detail, see APPENDIX A Table 2: CRE projects information on economic aspect)
	Biodiesel	**Reduce fuel cost;** ▪ Operation and maintenance cost is 121,913.75 baht/year ▪ Reduce fuel cost 148,500 baht/year (30 baht/litre) and sell biodiesel 6,720 baht/year, Total economic benefit is 155,220 baht/year (More detail, see APPENDIX A Table 2: CRE projects information on economic aspect)
Environment	Solar energy	**Waste type:** No waste, deterioration 1%/year/panel **Waste management:** Change solar panel every 50 years **Reduce CO2 emission** Reduce CO_2 emission = 5,757.885 KgCO_2eq/year (Emission factor 0.6093 tCO2e/MWh) (UNFCCC, 2006)
	Wind energy	**No data**
	Biogas	**Waste type:** Liquid and solid organic fertilizer **Waste management:** No utilization **Reduce CO2 emission** 55.61 KgCO2eq/year (Emission factor 0.4232 KgCO_2eq/kg LPG) (TGO, 2013)
	Biodiesel	**Waste type** • KOH • NaOH • Water contaminated by biodiesel • Glycerin **Waste management:** Glycerin recycle **Reduce CO2 emission** 1,957.34 KgCO_2eq/year (Emission factor 0.3954 KgCO_2eq/litre diesel) (Recoil the power of used cooking oil, 2012)
Political	Solar energy Wind energy Biogas Biodiesel	Lacking the ability to select preferred RE technologies.

4.2.2 Strengths and weaknesses of CRE projects management

Qualitative comparative analysis between Energy management theory and findings on subtopic 4.2.1 *(the relevance findings identified strengths, weaknesses and key to success on CRE projects management)* can be analyzed to present strengths and weaknesses of CRE projects management as shown in Table 4.4.

Table 4.4: Strengths and weaknesses of CRE projects management

Energy management system implementation	Strengths of CRE projects management	Weaknesses of CRE projects management
Initiating an Energy Management Program	**Social aspect:** 1. Can be a model of CRE for other communities. 2. Having RE Learning Center in the community as a center for exchanging and sharing knowledge on RE	-
Conducting an Energy Review	-	**Economic aspect:** There is no statistic record. The observation on financial data of CRE projects can show analysis that; 1. RE produced in the community was not adequate for selling. It could only reduce small expenses. <u>Biogas project:</u> During field research, anaerobic digestion equipment had been broken for 6 months, so there was not much information about it except the information that the donated anaerobic digestion equipment did not work efficiently so it was merely used for education benefit to introduce equipment to community residents. However, if biogas production is highly efficient, LPG cooking gas cost would reduce around 1,971 baht/year.

Energy management system implementation	Strengths of CRE projects management	Weaknesses of CRE projects management
		2. The cost of maintenance was higher than income gained, not worth for business investment. <u>Solar energy project:</u> Operation by filling distilled water to storage battery. Maintenance by changing storage battery every 2 years; battery marque *'DEEP CYCLE 3K EB65V'* price 4,500 baht/piece. 1 solar panel consumes 2 storage batteries; total storage batteries = 48 pieces = 48 x 4,500 baht = 216,000 baht. So, operation and maintenance cost is 108,000 baht/year
Energy Management Planning		No developing action plan as CRE projects received donated RE tools and equipment from government agencies that have never measured energy production capacity in each area, and have never surveyed the actual needs of the community and community residents.
Implementing Energy Management	**Social aspect:** Participation with 'awareness' on the importance of RE stimulated eagerness of community members and strengthen unity among community members through CRE project activities. **Economic aspects:** Encouraging reduction of conventional energy use which lead to reduction of imported energy of the country	**Economic aspects:** High operation and maintenance cost. **Technical aspect:** the community lacks personnel who have technical knowledge about RE.

Energy management system implementation	Strengths of CRE projects management	Weaknesses of CRE projects management
	Environmental aspect: Reinforcement on RE usage reduces the use of conventional energy, which causes pollution and global warming.	
Measurement and Verification	-	The skills and knowledge required for monitoring, measurement, verification, tracking, and recording energy use and savings are not measured and verified
Management Review	-	Progress is not reviewed. Additionally, goals and action plans required for ensuring continuous improvement are not adjusted. Furthermore, successes and key contributors are not recognized

4.2.3 Key to success of CRE projects management

As the study aims to find how CRE projects can achieve BMPs of sustainable community renewable energy, key to success of CRE projects management was analyzed base on the three pillars of sustainability. The findings on subtopic 4.2.1 and subtopic 4.2.2 show strengths on 'social aspect' that the community has been provided RE education to the society, and showed strengths on 'environmental aspect' that the CRE projects have reduced GHGs emission and have raised awareness of climate change crisis. However, the main weakness of CRE projects is 'economic aspect' since the community faced high operation and maintenance cost which consequently impacted other management aspects.

Hence, key to success of CRE projects management is the increasing efficiency of 'economic aspect' management as diagram shown in Figure 4.4

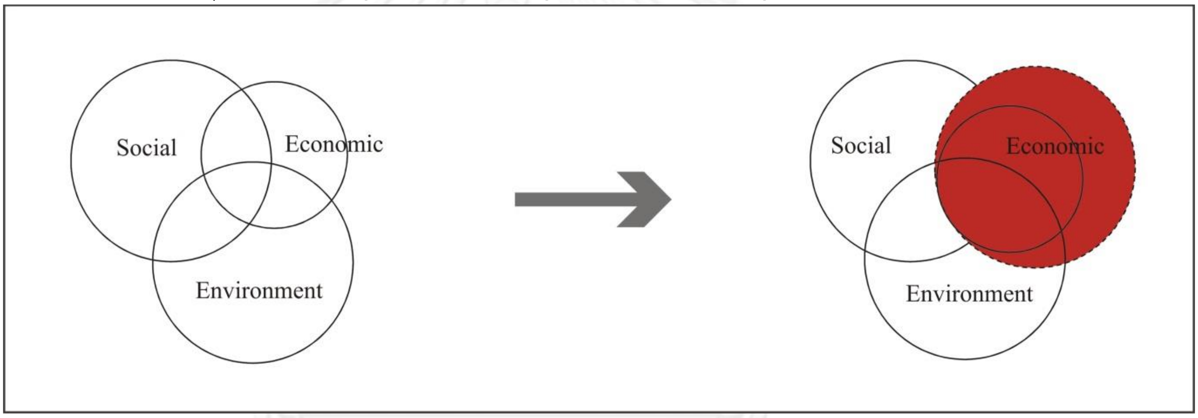

Figure 4.4: Diagram of key to success of CRE projects management

Aruninta described on WiMBY: A comparative interests analysis of the heterogeneity of redevelopment of publicly owned vacant land that ultimately, all three legs of the "land redevelopment tripod" – economic, social, and environmental – are necessary to keep land development balanced and sustainable (Aruninta, 2009). CRE projects in Sathya Sai School Thailand need to keep the economic aspect balanced and sustainable by increasing economic benefit since the special characteristic of the community is education-based community which has no financial benefits from sharing RE knowledge. Moreover, as shown in Table 4.3 of CRE projects information on economic aspect, it revealed that income from CRE projects were excessively less than operation and maintenance cost.

Hence, if CRE projects management could use appropriate RE technologies to reduce operation and maintenance cost, the CRE projects would plausibly achieved partial BMPs' sustainable community renewable energy.

4.3 Preference questionnaire results

This section aims to assess information about community residents' attitudes and preferences on moving the CRE projects towards sustainability. The preference questionnaires were developed to find out the directions of satisfaction in CRE projects management issue and its benefits issue. Moreover, the preference questionnaire interpretation results were to explore the satisfaction of community residents on participation in CRE projects. 170 Respondents were analyzed in this preference questionnaire. The preference questionnaire results shown as follow:

4.3.1 Attitude of community residents towards participation in each topic of CRE project management

The questions of preference questionnaire are about satisfaction concerning two issues as follows:

- **CRE project management issue**
  1. Location of CRE projects setting
  2. Safety of CRE projects production
  3. The readiness of equipment and personnel
  4. Contribution received from stakeholders
  5. Public relation of CRE projects
  6. Implementation of CRE projects

- **The benefits of CRE projects issue**
  1. Social benefit: Level of understanding of RE production processes
  2. Social benefit: Building a good relationship between residents of the community and their neighbors
  3. Economic benefit: Reducing conventional energy costs
  4. Economic benefit: Creating jobs
  5. Environmental benefit: CRE projects offer solution to help mitigate climate change crisis

Results of the preference questionnaire of the 2 issues can be formulated to radar charts as shown in Figure 4.5 and Figure 4.6;

4.3.1.1 CRE project management issue

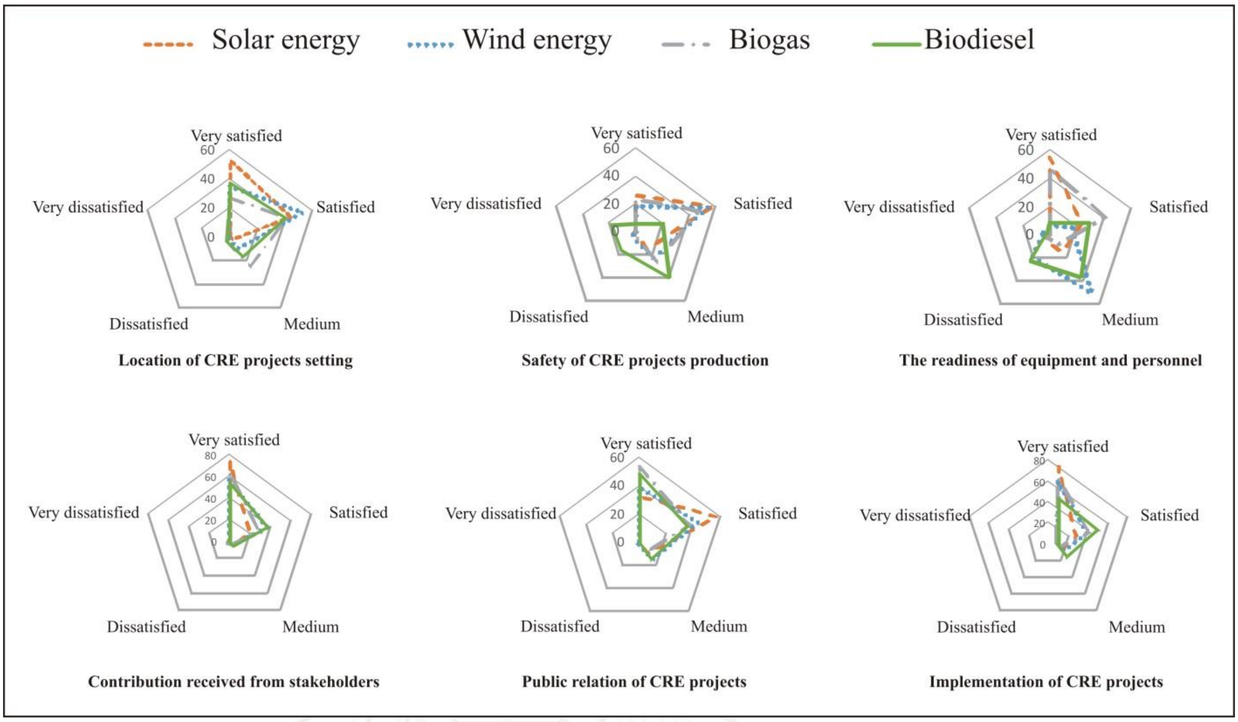

Figure 4.5: Satisfactions on CRE project management issue

Figure 4.5 radar charts shows that community residents' satisfactions on CRE projects management issues were mostly on very satisfied level and satisfied level except the satisfaction on *'Safety of CRE projects production'* which shows that Solar energy project (57%), Wind energy project (55%), and Biogas project (48%) bar were on satisfied level, while of Biodiesel project (41%) bar was on medium level. Furthermore, the satisfaction of *'Readiness of equipment and personnel'* result shows that Solar energy project (55%) and Biogas project (47%) bar were on very satisfied level, while of Wind energy project (52%) and Biodiesel project (37%) bar were on medium level.

The results could be interpreted that community residents' attitude towards CRE projects management issue was in high level. Although, community residents realized the limitation of each project; wind turbine can merely generate very small amount of electricity; equipment for biodiesel production is below standard, both in terms of safety and cleanness of biodiesel plant and the donated biogas generator is malfunction and broken very often; field observation and interview results chart shows that the satisfaction is on very satisfied level. This can be interpreted in two different ways that community residents either still feel confident with anaerobic digestion donated by Department of Alternative Energy Development and Efficiency

(DEDE), Minister of energy, or they do not conceive the problem occurred in biogas project.

4.3.1.2 The benefits of CRE projects issue

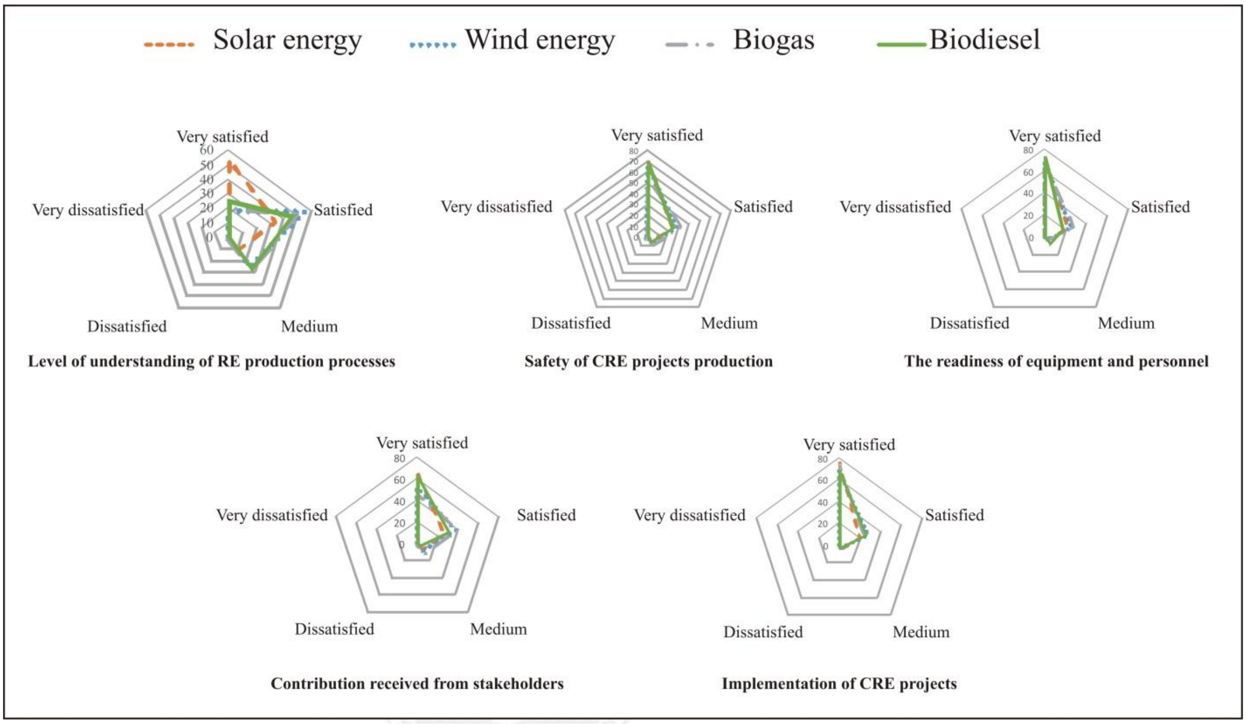

Figure 4.6: Satisfaction in the benefits of CRE projects issue

Figure 4.6 radar charts shown that community residents' satisfaction on the benefits of CRE projects issue were on very satisfied level except the satisfaction on '*Social benefit: Level of understanding of RE production processes'* which shows that Solar energy project (54%) bar was on very satisfied level, while of Wind energy project (50%), Biogas project (34%), and Biodiesel project (47%) bar was on satisfied level. The results could be interpreted that community residents had been promoted further knowledge of RE till they were confident with their knowledge on RE production. This means that the community had knowledge management scheme emphasizing human development, which is consonant with interview results of community leaders that community members had been sent to learn more about RE in many RE learning centers and sources. Moreover, RE experts were invited to the community to teach and share knowledge about RE. However, since there was no official responsible person for each project, knowledge management of RE production process still lacked consistency. This issue continues to occur nowadays.

4.4 Summary of the analysis results

This section presents the brief summary from the analysis of significant findings on this chapter.

4.4.1 Summary of participation methods of community members and community benefits from CRE projects

- **Participation methods of community members**

  Community participation methods in CRE projects were with 'awareness' on the importance of RE. Due to the fact that the community is education-based community, participation methods revealed on education activities of CRE projects. Besides, CRE projects also received contribution of tools and equipment and technical knowledge support from stakeholders.

- **Community benefits from CRE projects**
  - **Social benefits**
    - Creating networks for information exchange
    - Strengthening relationship between community and energy supplier
    - Increasing community cohesion
    - Increasing RE education in the community
    - Increasing understanding of climate change and renewable energy
    - Increasing awareness of capability of community residents.
  - **Environmental benefits**
    - Reducing greenhouse gas emissions
    - Inspiring other sustainable development projects
  - **Economic benefits**
    - Community members experienced on energy cost saving only Biodiesel projects
    - Increased local job only Biodiesel projects

4.4.2 Summary of strengths, weaknesses and key to success of CRE projects management.

- **Energy Management Planning**

  <u>Weakness</u>

  No developing action plan as CRE projects received donated RE tools and equipment from government agencies that have never measured energy production capacity in each area, and have never surveyed the actual needs of the community and its residents.

- Implementing Energy Management

  Strengths

  - **Social benefit:** Participation with 'awareness' on the importance of RE stimulated eagerness of community members and strengthen unity among community members through CRE project activities.
  - **Economic aspects:** Encouraging reduction of conventional energy use which leads to reduction of imported energy of the country.
  - **Environmental aspect:** Reinforcement on RE usage reduces the use of conventional energy, which causes pollution and global warming.

  Weaknesses

  - **Economic aspects:** High operation and maintenance cost.
  - **Technical aspect:** The community lacks personnel who have technical knowledge about RE.

- Measurement and Verification

  Weakness

  The skills and knowledge required for monitoring, measurement, verification, tracking, and recording energy use and savings are not measured and verified

- Management Review

  Weakness

  Progress is not reviewed. Additionally, goals and action plans required for ensuring continuous improvement are not adjusted. Furthermore, successes and key contributors are not recognized.

4.4.3 Key to success of CRE projects management

The main weakness is economic aspect since the community has no financial benefits from sharing RE knowledge. Moreover, income from Solar energy project and Biogas project is excessively less than operation and maintenance;

- Solar energy project: Operation and maintenance cost is 108,000 baht/year but income is only 37,800 baht/year.

- Biogas project: Cooking fuel (LPG) costs 103,850 baht/year. If biogas production is highly efficient, LPG cooking gas cost would be reduced around 1,971 baht/year.

Hence, the key to success of CRE project management is increasing economic benefits or selecting appropriate RE technologies to reduce operation and maintenance cost.

The Analysis results of significant findings on this chapter will be synthesized on Chapter 5.

CHAPTER 5
DISCUSSIONS

This chapter presents the integration of BMPs method with research expected outcome number one, research expected outcome number two and preference questionnaire interpretative results.

Synthesis of rating result of *"scale of sustainability of CRE projects management; whether or not CRE projects have Best Management Practices"* and analysis under the three pillars of sustainability (economics, social, and environment) was used for rendering research expected outcome number three; *Recommendation for Community Renewable Energy (CRE) projects to achieve Best Management Practices (BMPs) of sustainable community renewable energy from the case study of Sathya Sai School Thailand*. The recommendation was in the format of checklist and flowchart diagram for BMPs of sustainable community renewable energy project.

The methodology is shown in Figure 5.1.

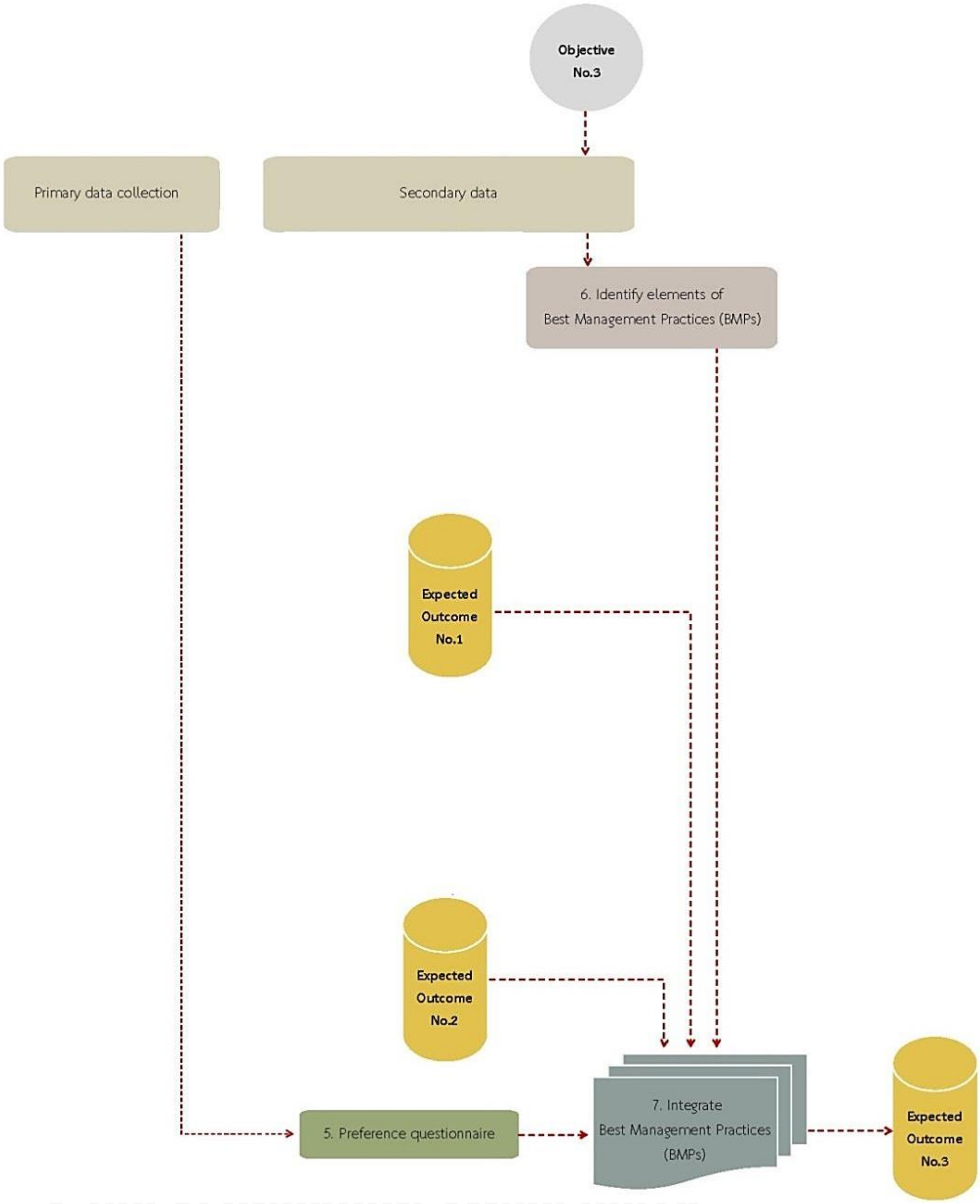

Figure 5.1: Research methodology of the final expected outcome

The structure of this chapter is as follow;

5.1 Scale of sustainability of CRE projects management; whether or not CRE projects have Best Management Practices

5.2 The recommendation for CRE projects to achieve Best Management Practices (BMPs) for sustainable community renewable energy in the case study of Sathya Sai School Thailand

5.3 Conclusion: Review of the research objectives and accomplishments

5.4 Limitations of the study

5.5 Recommendation for further research

5.1 Scale of sustainability of CRE projects management; Whether or not CRE projects have Best Management Practices

This section presents the evaluation of synthesis findings through *'The scale and sustainability score sheet'* tool (tool details was described in subtopic 2.2.3 in Chapter 2). The ratings and evidence which are provided by completing the tool should assist the community leader in determining where the scale of sustainability of the CRE projects management should be and where the gaps are, both in individual category and between planning and implementation (Spiro, 2011).

After completing step 5 of the "Scale and Sustainability Score Sheet", scores show as follow; (To see the full details of rating of Scale and Sustainability Score Sheet, see Appendix E).

- The overall "Scale" rating of the mentoring CRE project management is 74; Planning score is 38 and Implementation score is 36. Results reveal the high level of widespread adaptation of a practice; 74/100. As the practice spreads, there is the presence of the right balance of preserving the essential properties and allowing for and promoting local adaptations.
- The overall "Sustainability" rating of the mentoring CRE project management is 66; Planning score is 34 and Implementation score is 32. Results reveal that CRE projects management was on medium level of sustainability; 66/100. However, the narrow gaps in both individual category and between Implementation and Planning reveal that the community had the practical management since the community was able to implement project from planning to practice.

This is the possibility that CRE projects management could achieve BMPs if the community has the comprehensive plan in place in which all stakeholders own and all aspects have been completely applied, the CRE projects will achieve high level of sustainability and Best Management Practices.

5.2 Recommendation for Community Renewable Energy (CRE) projects to achieve Best Management Practices (BMPs) of sustainable community renewable energy from the case study of Sathya Sai School Thailand.

The Renewable Energy Action Team in California Energy Commission explained the definition of BMPs that

> *"BMPs are recommended practices (or combined practices) determined to provide the most effective, environmentally sound, and economically possible mean of managing a project or facility and addressing the impacts".*
>
> *(California energy commission, 2013)*

"Best" is associated with the specific objectives or needs and the particular area characteristics to be focused on, it is helpful to identify and classify BMPs according to where they are most effective. Hence, the recommendation for CRE projects in Sathya Sai School Thailand to achieve BMPs of sustainable community renewable energy focus on ***'actual problem-based solving approach'***.

The recommendations for the solution to the problems of CRE projects management in the case study of Sathya Sai School Thailand are; actual understanding of elements in the community; identity of people and culture in the community;, site characteristic; strengths, weaknesses as well as key to success of CRE projects management.

The recommendation is classified according to the three pillars of sustainability; social, economic, and environment. Besides, the recommendation is generalized as "Checklist and Flowchart diagram" in Figure 5.2 (Page 61).

The recommendation for CRE projects to achieve Best Management Practices (BMPs) of sustainable community renewable energy from the case study of Sathya Sai School Thailand is described as follows;

- **Social aspect**

1. Promote insight RE knowledge among community residents;
   - There should be continual development of knowledge related to RE as well as technical solutions 'RE Handbook', which is concordant with the context of the community, should be published and updated constantly.
   - Establishing renewable energy learning center that shows identity and culture of the community to motivate and to be a role model for other communities.

2. Promote concrete community participation
    - Acknowledgement on CRE projects.
    - Consideration and comments on CRE projects Participation in implementation and operation of CRE projects/ sharing ownership of CRE projects.
    - Participation in evaluation/ extending and expanding CRE projects.

3. Create long-term, high quality jobs and skills for undergraduate;
    - Support scholarship for community residents on RE related study and encourage them to work on CRE projects in the community after graduated.

- **Environmental aspect**

1. Analyze and study options or technologies that are compatible with CRE production and management:
    - **Solar energy;** solar panel Polycrystalline is the most suitable material for solar panel. The result of comparison between Monocrystalline panel and Polycrystalline panel reveals that MonoCrystalline is 3% more efficient but the cost is more expensive than PolyCrystalline around 10-15%. Therefore, Polycrystalline is the better option for solar panel investment.
    - **Biogas;** Polyethylene Biogas Digester (PBD) should be better. Option to save space and protect the plant from physical harm. Underground construction should be applied. The underground digester is protected from low temperatures during cold seasons and at night. Whereas it takes longer to heat up the digester in sunshine and warm seasons. The digester positively influences the bacteriological processes as there is no temperature variation between daytime and nighttime (Fixed-dome Biogas Plants, 2005). Furthermore, it requires short construction period and requires small construction area. Its maintenance is not complicated and it lasts for about 12-15 years.
2. Waste from RE production process must be managed efficiently, with guidance from specialists:
    - <u>**Biogas;**</u> a sanitized compost and nutrient-rich liquid fertilizer should be utilized for sustainable agriculture project in the community.

- **<u>Biodiesel;</u>** there should be wastewater treatment of contaminated water by Potassium hydroxide (KOH) and Sodium hydroxide (NaOH)

3. Utilize or apply the outputs of RE projects in other projects in the community:
    - <u>Electricity generated from solar energy and wind energy;</u> should be used to supply power to a pumping system and fountain to increase oxygen to water for wastewater treatment of “water management project” in the community.
    - <u>Biodiesel</u>; should be used as fuel for “sustainable agriculture” project’s water pump.
4. Community renewable energy can play an important role in meeting national, regional and local targets, throughout a various range of issues from carbon to employment.

- Economic aspect

1. Increase income for the community by zoning of land utilization; permitting other organizations to use space in the community for Corporate Social Responsibility (CSR) activity with win-win condition – those organizations must provide various options of economic value to the community.
2. Assign staff to research on budget related to RE such as;
    - Apply for budgeting funds for Research and Development (R&D) of CRE project.
    - Follow the updated news and information about budget disbursement of government agencies.

The recommendation is generalized as “Checklist and Flowchart diagram” in Figure 5.2 as follow:

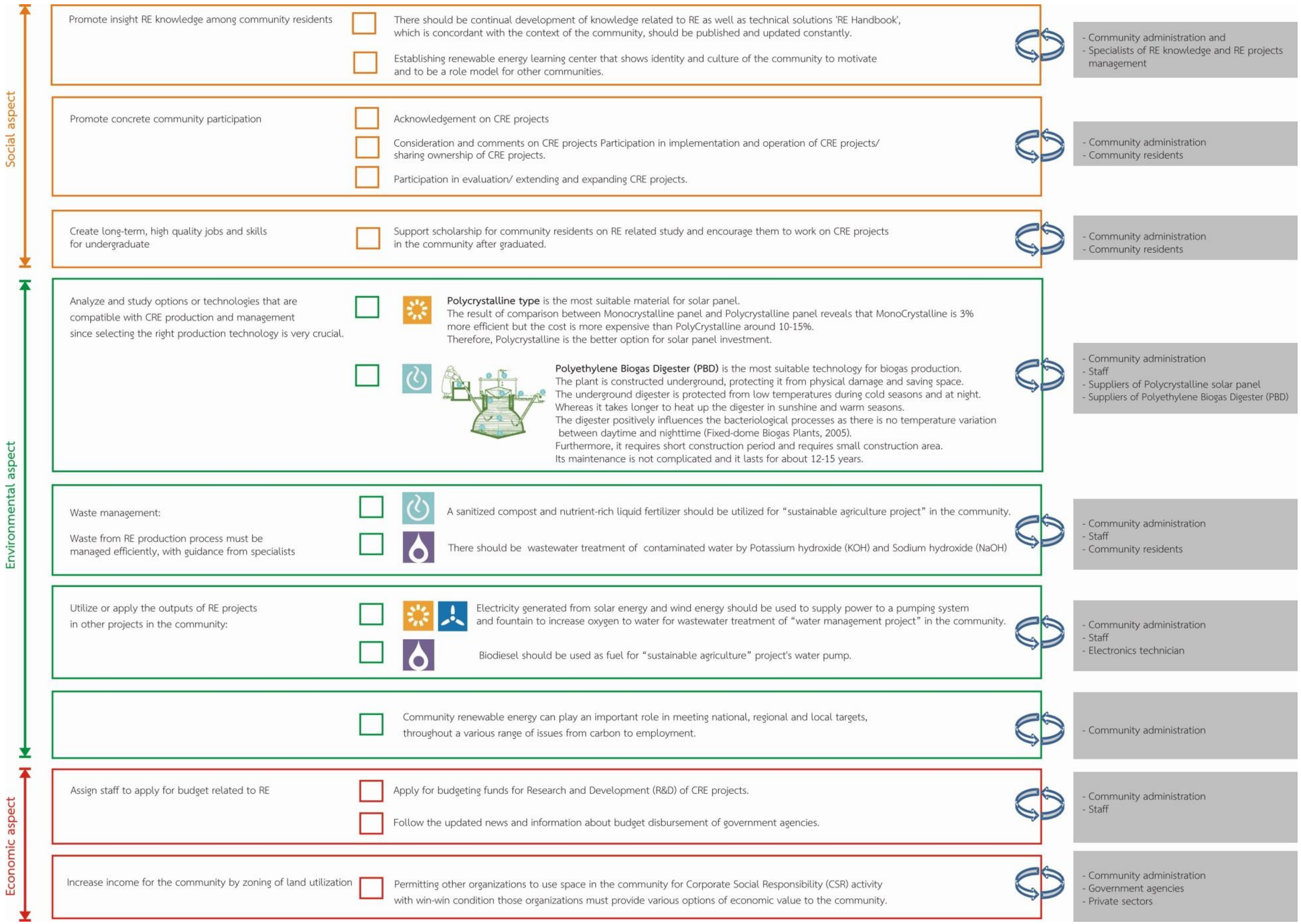

Figure 5.2: Checklist and Flowchart diagram for BMPs of sustainable CRE projects in Sathya Sai School Thailand

5.3 Conclusion:
Review of the objectives of the study and accomplishments

5.3.1 Objective no.1: To study community participation methods and community benefits in CRE projects in Sathya Sai School Thailand.

5.3.1.1 Community participation methods

CRE projects started from the very determined community director who had put great effort in making community members aware of global warming crisis and encouraging them to participate in global warming solution by using RE as the main tool. The participation of community residents in CRE projects is by realization of RE's values since they have principles which influence their thoughts and consideration in life that is they should always ask two questions before acting on any activity; "What am I going to do, good for me?" and "What am I going to do also good for everyone?" (Jumsai, 2003).

As the result, community participation methods in CRE projects are summarized as follow;

- **Participation with 'awareness'** on the importance of RE.
- **Education-based community**; community members agreed that RE is a must and should be managed in the pattern of education-based community.
- **Education activities;** the integration of RE knowledge into community activities and invitation RE experts to teach and share RE knowledge enabled strong RE knowledge base among community members that they were able to share that knowledge to the society. However, since there was no official responsible person for each project, knowledge management of RE production process still lacked consistency.
- **Working group;** Staff contributed organic waste to produce biogas.
- **Community meeting;** Discussions and comments on CRE projects

CRE projects also received supports from stakeholders such as government agencies; Department of Alternative Energy Development and Efficiency (DEDE) Ministry of Energy, Faculty of Engineering, Silapakorn University; and private sectors who supported on technical knowledge and equipment and tools to produce energies.

5.3.1.2 Community benefits in CRE projects

Stakeholder participation and resident's participation with awareness give each project high social benefits and environmental benefits;

- **Social benefits:** creating networks for information exchange, strengthening relationship between community and energy supplier, increasing community cohesion, increasing RE education in the community, increasing understanding of climate change and renewable energy, increasing awareness of capability of community residents
- **Environmental benefits:** reducing greenhouse gas emissions and inspiring other sustainable development projects.
  - Solar energy project: Reduce CO2 emission = 5,757.885 KgCO2eq/year
  - Biogas project: Reduce CO2 emission 55.61 KgCO2eq/year
  - Biodiesel project: Reduce CO2 emission 1,957.34 KgCO2eq/year

5.3.2 Objective no.2: To identify strengths and weaknesses as well as keys to success of CRE projects management in Sathya Sai School Thailand.

5.3.2.1 Strengths and weaknesses of CRE project management

Qualitative comparative analysis between findings of research objective no.1 and Energy Management theory was used to identify the strengths and weaknesses of CRE project management. The accomplishment is described in the scope of 'Area of knowledge and skill for implementing energy management system'- *the responsibility of an energy team to implement the energy management system and a role of this team to improve energy performance securely (Partnership, 2013)* – and is classified according to the three pillars of sustainability; social, economic, and environment.

1. Initiating an Energy Management Program; knowing requirements and main concepts; obtaining leadership in organization responsibility; creating an energy team; improving an energy policy.

Strength

- **Social aspect:**
  - Can be a model of CRE for other communities.
  - Having RE Leaning Center in the community as a center for exchanging and sharing knowledge on RE.

2. Conducting an Energy Review; gathering energy information; discovering main uses of energy; evaluating energy consumption and costs; carrying out energy evaluations; identifying potential chances.

Weakness

- **Economic aspect:**

  There is no statistic record. The observation on financial data of CRE projects can show analysis that;

1. RE produced in the community was not adequate for selling. It could only reduce small expenses.

   Biogas project:

   During field research, anaerobic digestion equipment had been broken for 6 months, so there was not much information about it except the information that the donated anaerobic digestion equipment did not work efficiently so it was merely used for education benefit to introduce equipment to community residents. However, if biogas produced high efficiently, LPG cooking gas cost would reduce 1,971 baht/year.

2. The cost of maintenance was higher than income gained, not worth for business investment.

   Solar energy project: Operation by filling distilled water to storage battery. Maintenance by changing storage battery every 2 years; battery marque 'DEEP CYCLE 3K EB65V' price 4,500 baht/piece. 1 solar panel be consumes 2 storage batteries; total storage batteries = 48 pieces

   = 48 x 4,500 baht = 216,000 baht. So, operation and maintenance cost is 108,000 baht/year

3. Energy Management Planning; establishing a baseline;; defining performance metrics; improving action plans; assessing opportunities and choosing projects.

Weakness

- No developing action plan as CRE projects received donated RE tools and equipment from government agencies that have never measured energy production capacity in each area, and have never surveyed the actual needs of the community and its residents.

4. Implementing Energy Management; getting resource commitments; raising awareness and set up training; convey the message to all stakeholders; implementing action plans.

Strengths

- **Social aspect:**
  - Participation with 'awareness' on the importance of RE stimulated eagerness of community members and strengthen unity among community members through CRE project activities.
- **Economic aspects:**
  - Encouraging reduction of conventional energy use which lead to reduction of imported energy of the country
- **Environmental aspect:**
  - Reinforcement on RE usage reduces the use of conventional energy, which causes pollution and global warming.

Weaknesses

Community residents, 170 Respondents who gave preference questionnaire feedback, realized the limitations of CRE project management issues on 'Safety of CRE projects production' of biodiesel project (41%) and 'Readiness of equipment and personnel' of biodiesel project (37%) and wind energy project (52%).

- **Economic aspects:**
  - High operation and maintenance cost.
    - Solar energy project: 108,000 baht/year
    - Biodiesel project: 121,913.75 baht/year
- **Technical aspect:**
  - The community lacks personnel who have technical knowledge about biogas production.

5. Measurement and Verification; comprised of knowledge and skills needed for monitoring, measurement, verification, tracking, and documentation of energy use and conservation.

Weakness

- The skills and knowledge required for monitoring, measurement, verification, tracking, and recording energy use and savings are not measured and verified

6. Management Review; executing a progress review; improving targets as well as action plans required to maintain ongoing improvement; recognizing achievement and major contributors.

Weakness

- Progress is not reviewed. Additionally, goals and action plans required for ensuring continuous improvement are not adjusted. Furthermore, successes and key contributors are not recognized

5.3.2.2 Key to success of CRE project management

It needs to increase economic benefit of CRE Project since the special characteristic of the community is education-based community which has no financial benefits from sharing RE knowledge. Moreover, CRE projects information on economic aspect, it revealed that income from CRE projects is excessively less than operation and maintenance cost;

- Solar energy project: operation and maintenance cost is 108,000 baht/year but income by reduce electricity cost is only 37,800 baht/year.
- Biogas project: cooking fuel (LPG) costs 103,850 baht/year. If biogas production is highly efficient, LPG cooking gas cost would be reduced 1,971 baht/year. (More detail, see APPENDIX A Table 2)

Hence, if CRE projects management can use appropriate RE technologies to reduce operation and maintenance cost, the CRE projects would plausibly achieved partial BMPs' sustainable community renewable energy.

5.3.3 Objective no.3: To provide recommendation for CRE projects to achieve Best Management Practices of sustainable community renewable energy from the case study of Sathya Sai School Thailand.

The accomplishments of research objective no.3 are described in subtopic 5.2 in Chapter 5.

5.4 Limitations of the study

During field research on June 10-15, 2013, anaerobic digestion equipment of Biogas project had been broken for 6 months, so there was not much information about it except the information that the donated anaerobic digestion equipment did not work efficiently so it was merely used for education benefit to introduce equipment to community residents.

5.5 Recommendation for further research

Further research could be conducted to determine innovative technologies for reducing CO_2 emissions and reducing operation and maintenance cost. In addition, research in the future could be carried out to evaluate the best practice of RE knowledge management that is being offered jointly through educational institutions and corporations. The kind of management could set up the foundation from a basic understanding of renewable energy to accelerating renewable energy deployment towards a sustainable future.

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APPENDIX

APPENDIX A: FIELD OBSERVATION RESULTS

Community Renewable Energy (CRE) projects information

This research focuses on BMPs of sustainable community renewable energy, therefore the result of field observation on CRE projects is classified according to the technical specification and the three pillars of sustainability; social, economic, and environment; as describes below.

Table 1: CRE projects information on technical specification aspect

Category	Type of RE	CRE projects information
Technical	Solar energy	 24 Solar panels; 18 Single crystalline solar cells type and 6 multicrystalline solar cells type. Total generating capacity of 5.25 Kilowatt (kW)
	Wind energy	 2 Wind Turbines; specifications are as follows: - Designed to IEC 61400-1 - Class S winds: 7.5 m/s average wind speed; turbulence intensity - Rotational direction: Clockwise viewed from an upwind location - Speed regulation: Electric drive pitch control with battery backup - Aerodynamic brake: Full feathering of blade pitch (The General Electric Company, 2007). Total generating capacity of 20 Watt

Category	Type of RE	CRE projects information
	Biogas	 Anaerobic Digestion technology Total generating capacity 0.3 – 0.5 m^3 gas/ m^3 digester volume per day
	Biodiesel	  Use methanol 25% of biodiesel production (used-cooking oil) and NaOH 5 g/litre of biodiesel. Total production capacity is 4,950 Litres/year

Table 2: CRE projects information on technical specification aspect

Type of RE	*Social aspect*
Solar energy Wind energy Biogas Biodiesel	**Community participation** Teacher, Students, Guardians **Offer skills training with work based in rural communities** Renewable energy study for student grade 7 **Technological understanding** Renewable energy guidance by student grade 8 **Creates long-term, high quality jobs and skills** Support undergraduate scholarship to community residents studying in RE program. **Consequences for other benefits** Renewable energy learning centers were established to build the skills and RE knowledge.
More information	**Solar energy:** **Constraint/ Problem** 1. Battery deterioration 2. Capacity of inverter is not giving sufficient backup. **Wind energy:** **Suggestion and comment** Need more standardized method of batch production. **Biogas:** **Community participation** 5-6 bags/day of food waste are distributed by guardians. **Offers skills training with work based in rural communities** 1. Students must finish their food otherwise they will be punished. 2. Replanting some vegetables such as morning glory. **Biodiesel:** **Suggestion and comment** Need more standardized method of batch production.

Table 3: CRE projects information on economic aspect

Type of RE		*Economic aspect*
Electricity	Solar energy	**Financial support** No financial support **Investment cost** - Received 2 solar panels contributed by Department of Alternative Energy Development and Efficiency (DEDE), Ministry of Energy, Thailand ; 250 Watt/panel - Received 18 solar panels (single crystalline solar cell) contributed by Japan; 200 Watt/panel - Received 1 solar panel (multicrystalline solar cells) contributed by private company; 250 Watt/panel - Received 3 solar panel (multicrystalline solar cells) contributed by private company; 300 Watt/panel **Operation and Maintenance cost (baht/year)** Operation by filling distilled water to storage battery. Maintenance by changing storage battery every 2 years; battery marque *'DEEP CYCLE 3K EB65V'* price 4,500 baht/piece. 1 solar panel be consumes 2 storage batteries; total storage batteries = 48 pieces = 48 x 4,500 baht = 216,000 baht So, operation and maintenance cost is 108,000 baht/year **Investment return (baht/year)** **Income** Reduce electricity cost around 37,800 baht/year as following details. Lopburi Province receives around 5 hours of sunlight per day, Production time 5 hours/ day, Total electricity generation 5,250 watt x 5 hour x 30 days = 787.5 Kwh Total electricity generation = 9,450 Kwh Reduce electricity cost 4 baht/unit; 787.5 x 4 = 3,150 baht/month = 37,800 baht/year **Outcome** Electricity cost 695,238.24 baht/year (data in 2012). So, the community received economic benefit by reduce electricity cost = 695,238.24 - 37,800 = 657,438.2 baht/year However, operation and maintenance cost of solar energy is still higher than the income; operation and maintenance cost is 108,000 baht/year but economic benefit is only 37,800 baht/year.
	Wind energy	Investment cost - Received 2 wind turbines contributed by private sector, Thailand ; 20 Watt/turbine

Type of RE		*Economic aspect*
Cooking fuel	Biogas	**Financial support** No financial support **Investment cost** - Received anaerobic digestion equipment from Department of Alternative Energy Development and Efficiency (DEDE), Ministry of Energy, Thailand - Cooking fuel (LPG) 103,850 baht/year **Operation and Maintenance cost (baht/year)** During field research, anaerobic digestion equipment had been broken for 6 months, so there was not much information about it except the information that the donated anaerobic digestion equipment did not work efficiently so it was merely used for education benefit to introduce equipment to community residents. **Investment return (baht/year)** **- Income** If biogas production is highly efficient, LPG cooking gas cost would reduce around 1,971 baht/year. **- Outcome** No outcome
Gasoline (Transportation)	Biodiesel	**Financial support** No financial support **Investment cost (baht)** - Received used-cooking oil 7,303 liters/year Waste cooking oil contributed by 1. Two private hotels in Bangkok 2. Guardian 10-20 liters 3. Community's canteen **Operation and Maintenance cost (baht/year)** 1. Use methanol 25% of biodiesel production (used-cooking oil) = 1,825.75 litres/year Methanol cost 65 baht/litre = 118,673.75 baht/year 2. NaOH = 5 g/litre of biodiesel = 36 kg/year (7,303x5/1000) = 3,240 baht/year Total cost = 121,913.75 baht/year **Investment return** **- Income (baht/year)** 1. Sold glycerin 4,370 baht/year 2. Biodiesel product 4,950 Litres/year Reduce fuel cost 148,500 baht/year (30 baht/litre) and sold biodiesel 6,720 baht/year Total income 155,220 baht/year **- Outcome (baht/year)** No outcome

Table 4: CRE projects information on environmental aspect

Type of RE		*Environmental aspect*
	Solar energy	**Waste type** No waste deterioration 1%/year/panel **Waste management** Change solar panel every 50 years **Reduce CO2 emission** Reduce CO_2 emission = 9,450 Kwh x 0.6093 tCO2e/MWh = 5,757.885 $KgCO_2eq$/year (Emission factor 0.6093 tCO2e/MWh) (UNFCCC, 2006)
Electricity	Wind energy	**Waste type** Wind turbine damaged by storm **Waste management** No data **Reduce CO2 emission** No data
Cooking fuel	Biogas	**Waste type** Liquid and solid organic fertilizer **Waste management** No treatment **Reduce CO2 emission** 55.61 KgCO2eq/year (Emission factor 0.4232 $KgCO_2eq$/kg LPG) (TGO, 2013)
Gasoline (Transportation)	Biodiesel	**Waste type** • KOH • NaOH • Water contaminated by biodiesel • Glycerin **Waste management** No wastewater treatment **Reduce CO2 emission** 1,957.34 $KgCO_2eq$/year (Emission factor 0.3954 $KgCO_2eq$/litre diesel, GHGs factor of diesel 3.098,2 kg CO2 eq/toe) (Recoil the power of used cooking oil, 2012)

APPENDIX B: INTERVIEW

Interviewees are key-persons of the community which are community directors, staffs involved in CRE projects, and representative of community residents.

Community directors

Staffs involved in CRE projects

Representative of community residents

INTERVIEW QUESTIONS

(COVER PAGE)

A STUDY OF COMMUNITY RENEWABLE ENERGY PROJECTS
MOVING TOWARDS BEST MANAGEMENT PRACTICES BASE ON SUSTAINABLE
COMMUNITY RENEWABLE ENERGY IN SATHYA SAI SCHOOL THAILAND

   

Interviewee : ....

Occupation : ....

Job description on Community Renewable Energy projects :

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Interview Date : ....

INTERVIEW QUESTIONS

1. Community Participation

Question guideline:

- *How did you work with other organizations/community groups in establishing the CRE projects?*
- *What is the general attitude of the community towards the CRE projects?*

2. Benefits/Impacts of CRE projects

Question guideline:

- *What economic, social and environmental benefits were created for the community from the CRE projects?*
- *Were there any negative environmental impacts on the community that resulted from the CRE projects?*

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3. Keys to Success

Question guideline:

What are the "keys to success" for the CRE projects?

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4. Best Management Practices (BMPs) of sustainable community renewable energy

Question guideline:

What do you think about CRE projects achieve BMPs of sustainable community renewable energy?

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APPENDIX C: PREFERENCE QUESTIONNAIRE (IN THAI)

แบบสอบถามความพึงพอใจ ของคณะครูและนักเรียนชั้นมัธยมศึกษาปีที่ 1 – 6 โรงเรียนสัตยาไส ประเทศไทย เกี่ยวกับกิจกรรมโครงการพลังงานทดแทน เพื่อมุ่งสู่วิธีปฏิบัติการจัดการที่เป็นเลิศ

แบบสอบถามชุดนี้จัดทำขึ้นเพื่อศึกษาโครงการพลังงานทดแทน เพื่อมุ่งสู่วิธีปฏิบัติการจัดการที่เป็นเลิศ ภายใต้ชุมชนพลังงานทดแทนอย่างยั่งยืน โรงเรียนสัตยาไส ประเทศไทย ซึ่งเป็นส่วนหนึ่งของการทำวิทยานิพนธ์ของนิสิตหลักสูตรศิลปศาสตรมหาบัณฑิต สาขาวิชาสิ่งแวดล้อม การพัฒนา และความยั่งยืน (หลักสูตรนานาชาติ/ สหสาขาวิชา) บัณฑิตวิทยาลัย จุฬาลงกรณ์มหาวิทยาลัย

ผลที่ได้จากการสำรวจความพึงพอใจฯในครั้งนี้ จะถูกนำไปวิเคราะห์เพื่อจัดหาข้อเสนอแนะเกี่ยวกับวิธีปฏิบัติการจัดการที่เป็นเลิศสำหรับชุมชนพลังงานทดแทนอย่างยั่งยืนภายในโรงเรียนสัตยาไส ดังนั้นจึงใคร่ขอความร่วมมือจากท่าน โปรดกรอกแบบสอบถามตามความเป็นจริง ทั้งนี้ข้อมูลทั้งหมดจะไม่มีผลกระทบต่อผู้ตอบแบบสอบถามแต่ประการใด

หากมีข้อสงสัยประการใด สามารถติดต่อได้ที่อีเมลล์ pkitisittichai@live.com

หมายเหตุ: เนื่องจากผู้ตอบแบบสอบถาม มีอายุตั้งแต่ 13 – 60 ปี และมีพื้นฐานความรู้ ความเข้าใจเกี่ยวกับพลังงานทดแทนที่แตกต่างกัน รูปแบบภาษาที่ใช้ในแบบสอบถามจึงไม่เป็นทางการมากนัก
เพื่อให้การสื่อสารสามารถเข้าใจได้ง่ายที่สุด และเพื่อให้ได้ผลการสอบถามที่ตรงตามความเป็นจริงมากที่สุด

ขอบพระคุณทุกท่านที่ให้ข้อมูล

แบบสอบถาม ประกอบด้วย 2 ส่วน ได้แก่

ส่วนที่ 1 ข้อมูลของผู้ตอบแบบสอบถาม

ส่วนที่ 2 ความพึงพอใจในกิจกรรมโครงการพลังงานทดแทนในโรงเรียนสัตยาไส เพื่อมุ่งสู่วิธีปฏิบัติการจัดการที่เป็นเลิศ

คำชี้แจง โปรดทำเครื่องหมาย ✓ ในช่องที่ตรงกับความเป็นจริง หรือความคิดเห็นของท่าน

ส่วนที่ 1 ข้อมูลของผู้ตอบแบบสอบถาม

เพศ

❒ ชาย ❒ หญิง

สถานภาพ

❒ ครู
❒ นักเรียนชั้น ม. 1
❒ นักเรียนชั้น ม. 2
❒ นักเรียนชั้น ม. 3
❒ นักเรียนชั้น ม. 4
❒ นักเรียนชั้น ม. 5
❒ นักเรียนชั้น ม. 6

กิจกรรมพลังงานทดแทนประเภทใดที่ท่านมีส่วนร่วม (สามารถตอบได้มากกว่า 1 ข้อ)




❒ พลังงานแสงอาทิตย์ ❒ พลังงานลม ❒ ไบโอแก๊ส ❒ น้ำมันไบโอดีเซล

ส่วนที่ 2 ความพึงพอใจเกี่ยวกับกิจกรรมโครงการพลังงานทดแทน เพื่อมุ่งสู่วิธีปฏิบัติการจัดการที่เป็นเลิศ

คำชี้แจง โปรดทำเครื่องหมาย ✓ ในช่องที่ตรงกับความเป็นจริง หรือความคิดเห็นของท่าน

1. แบบสอบถามความพึงพอใจเกี่ยวกับโครงการพลังงานแสงอาทิตย์

รายการ	ระดับความพึงพอใจ				
	มาก ที่สุด	มาก	ปาน กลาง	น้อย	น้อย ที่สุด
<u>ด้านการดำเนินโครงการฯ</u> **1. ความเหมาะสมของสถานที่ตั้งแผงโซล่าร์เซลล์** ● พอใจหรือไม่ ที่แผงโซล่าร์เซลล์ตั้งอยู่บนดาดฟ้า อาคารสถาบันน้ำ 					
2. ความปลอดภัยของอุปกรณ์ ● รู้สึกปลอดภัยกับแผงโซล่าร์เซลล์หรือไม่ (แสงสะท้อนเข้าตา ไฟรั่ว) 					
3. ความพร้อมในด้านเครื่องมือ อุปกรณ์ และบุคลากร ● พอใจหรือไม่ ที่มีผู้บริจาคแผงโซล่าร์เซลล์ เพื่อใช้ในการศึกษาการผลิตไฟฟ้าจากพลังงานแสงอาทิตย์					

รายการ	ระดับความพึงพอใจ				
	มากที่สุด	มาก	ปานกลาง	น้อย	น้อยที่สุด
4. การประชาสัมพันธ์โครงการพลังงานแสงอาทิตย์ให้ประชาชนทั่วไปได้รับรู้ ● พอใจหรือไม่ ที่มีคนภายนอกมาเยี่ยมชมการใช้พลังงานแสงอาทิตย์ภายในโรงเรียน และโครงการโซล่าร์ฟาร์ม ● พอใจหรือไม่ ที่มีการจัดนิทรรศการพลังงานแสงอาทิตย์ภายในบ้านดิน (ศูนย์การเรียนรู้พลังงานทดแทน)					
<u>ด้านประโยชน์ของโครงการฯ</u> **5. ได้รับความรู้เรื่องกระบวนการผลิตไฟฟ้าจากพลังงานแสงอาทิตย์** ● ฟังครูหรือผู้บรรยายท่านอื่น สอนเรื่องการผลิตไฟฟ้าจากพลังงานแสงอาทิตย์ แล้วเข้าใจหรือไม่					
6. สร้างงานและทักษะการผลิตไฟฟ้าจากพลังงานแสงอาทิตย์ที่มี ประสิทธิภาพ ● พอใจหรือไม่ หากการผลิตไฟฟ้าจากพลังงานแสงอาทิตย์ สามารถสร้างงานระยะยาว (ได้ทำงานเป็นผู้ผลิตกระแสไฟฟ้า) ● พอใจหรือไม่ หากท่านต้องอธิบายเกี่ยวกับการผลิตไฟฟ้าจากพลังงานแสงอาทิตย์ ให้คนอื่น					
7. ส่งเสริมการใช้พลังงานทดแทนได้อย่างเป็นรูปธรรม ● พอใจหรือไม่ ที่โรงเรียนสามารถผลิตไฟฟ้าจากพลังงานแสงอาทิตย์ ได้จริง และนำไปใช้เป็นไฟส่องทางเดินไปหอชายและหอหญิง ● พอใจหรือไม่ ที่โครงการการผลิตไฟฟ้าจากพลังงานแสงอาทิตย์ ได้รับการสนับสนุนจากบริษัทเอกชน และกรมพัฒนาพลังงานทดแทนและอนุรักษ์พลังงานพลังงาน กระทรวงพลังงาน					

รายการ	ระดับความพึงพอใจ				
	มากที่สุด	มาก	ปานกลาง	น้อย	น้อยที่สุด
• พอใจหรือไม่ ที่โรงเรียนสามารถลดโลกร้อน เพราะใช้พลังงานทดแทน (พลังงานแสงอาทิตย์)					
8. ความคุ้มค่าของการนำผลผลิตไปใช้ประโยชน์ • พอใจหรือไม่ ที่โรงเรียนได้ใช้ไฟฟ้าที่ผลิตจากพลังงานแสงอาทิตย์ สำหรับไฟริมทางเดินไปหอพักชายและหอพักหญิง					
• พอใจหรือไม่ หากภายในโรงเรียนจะมีปริมาณแผงโซล่าร์เซลล์ มากขึ้น และนำไปใช้สำหรับไฟริมทางเดินทั่วโรงเรียน และบริเวณต่างๆในโรงเรียนมากขึ้น					
• พอใจหรือไม่ หากโรงเรียนจะขายไฟฟ้าที่ได้จากพลังงานแสงอาทิตย์ให้กับการไฟฟ้าส่วนภูมิภาค (สร้างรายได้ให้โรงเรียน)					
9. ลดค่าไฟฟ้าภายในโรงเรียน • พอใจหรือไม่ ที่โรงเรียนไม่ต้องเสียค่าไฟริมทางเดินไปหอพักชายและหอพักหญิง					
10. สร้างสัมพันธภาพที่ดีระหว่างชาวบ้านและนักเรียน • พอใจหรือไม่ หากมีคนอื่นเข้ามาช่วยผลิตไฟฟ้าจากพลังงานแสงอาทิตย์					

ข้อเสนอแนะที่ต้องการให้มีการจัดการเพิ่มเติมเกี่ยวกับพลังงานแสงอาทิตย์

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2. แบบสอบถามความพึงพอใจเกี่ยวกับโครงการพลังงานลม

รายการ	ระดับความพึงพอใจ				
	มากที่สุด	มาก	ปานกลาง	น้อย	น้อยที่สุด
<u>ด้านการดำเนินโครงการฯ</u> **1. ความเหมาะสมของสถานที่ตั้งกังหันลม** ● พอใจหรือไม่ ที่กังหันลมติดอยู่หน้าสถาบันน้ำ 					
2. ความปลอดภัยของอุปกรณ์ ● พอใจกับเสียงกังหันลมหมุนและความปลอดภัยของกังหันลมหรือไม่					
3. ความพร้อมในด้านเครื่องมือ อุปกรณ์ และบุคลากร ● พอใจหรือไม่ ที่มีการตรวจเช็คสภาพกังหันลมไม่บ่อยมากนัก ● พอใจหรือไม่ ที่มีครูดูแลกังหันลมไม่มากนัก					
4. การประชาสัมพันธ์โครงการพลังงานลมให้ประชาชนทั่วไปได้รับรู้ ● พอใจหรือไม่ ที่มีคนภายนอกมาเยี่ยมชมการผลิตไฟฟ้าจากพลังงานลม					
● พอใจหรือไม่ ที่มีการจัดนิทรรศการพลังงานลมภายในบ้านดิน (ศูนย์การเรียนรู้พลังงานทดแทน)  					

รายการ	ระดับความพึงพอใจ				
	มากที่สุด	มาก	ปานกลาง	น้อย	น้อยที่สุด
<u>**ด้านประโยชน์ของโครงการฯ**</u> **5. ได้รับความรู้เรื่องกระบวนการผลิตไฟฟ้าจากพลังงานลม** ● ฟังครูหรือผู้บรรยายท่านอื่น สอนเรื่องการผลิตไฟฟ้าจากพลังงานลม แล้วเข้าใจหรือไม่					
6. สร้างงานและทักษะการผลิตไฟฟ้าจากพลังงานลมอย่างมีประสิทธิภาพ ● พอใจหรือไม่ หากการผลิตไฟฟ้าจากพลังงานลมสร้างงานระยะยาว (ได้ทำงานเป็นผู้ผลิตกระแสไฟฟ้าจากพลังงานลม) ● พอใจหรือไม่ หากท่านต้องอธิบายเกี่ยวกับการผลิตไฟฟ้าจากพลังงานลมให้คนอื่น					
7. ส่งเสริมการใช้พลังงานทดแทนได้อย่างเป็นรูปธรรม ● พอใจหรือไม่ ที่โรงเรียนสามารผลิตไฟฟ้าจากพลังงานลมได้จริง และนำไปใช้เป็นไฟส่องทางเดินไปหอชายและหอหญิง ● พอใจหรือไม่ ที่โครงการการผลิตไฟฟ้าจากพลังงานลม ได้รับการสนับสนุนจากบริษัทเอกชน และกรมพัฒนาพลังงานทดแทนและอนุรักษ์พลังงานพลังงาน กระทรวงพลังงาน ● พอใจหรือไม่ ที่โรงเรียนสามารถลดโลกร้อน เพราะใช้พลังงานทดแทน (พลังงานลม)					
8. ความคุ้มค่าของการนำผลผลิตไปใช้ประโยชน์ ● พอใจหรือไม่ ที่โรงเรียนได้ใช้ไฟฟ้าที่ผลิตจากพลังงานลมสำหรับไฟริมทางเดินไปหอพักชายและหอพักหญิง ● พอใจหรือไม่ หากภายในโรงเรียนจะมีปริมาณกังหันลมมากขึ้น และนำไปใช้สำหรับไฟริมทางเดินทั่วโรงเรียน และบริเวณต่างๆในโรงเรียนมากขึ้น ● พอใจหรือไม่ หากโรงเรียนจะขายไฟฟ้าที่ได้จากพลังงานลมให้กับการไฟฟ้าส่วนภูมิภาค (สร้างรายได้ให้โรงเรียน)					

รายการ	ระดับความพึงพอใจ				
	มากที่สุด	มาก	ปานกลาง	น้อย	น้อยที่สุด
9. ลดค่าไฟฟ้าภายในโรงเรียน ● พอใจหรือไม่ ที่โรงเรียนไม่ต้องเสียค่าไฟริมทางเดินไปหอพักชายและหอพักหญิง					
10. สร้างสัมพันธภาพที่ดีระหว่างชาวบ้านและนักเรียน ● พอใจหรือไม่ หากมีคนอื่นเข้ามาช่วยผลิตไฟฟ้าจากพลังงานลม					

ข้อเสนอแนะที่ต้องการให้มีการจัดการเพิ่มเติมเกี่ยวกับพลังงานลม

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2. แบบสอบถามความพึงพอใจเกี่ยวกับโครงการไบโอแก๊ส (แก๊สชีวภาพจากขยะเศษอาหาร)

รายการ	ระดับความพึงพอใจ				
	มากที่สุด	มาก	ปานกลาง	น้อย	น้อยที่สุด
<u>ด้านการดำเนินโครงการฯ</u> **1. ความเหมาะสมของสถานที่ตั้งศูนย์ผลิตไบโอแก๊ส** ● พอใจหรือไม่ ที่เครื่องผลิตไบโอแก๊สตั้งอยู่หลัง โรงอาหาร 					
2. ความปลอดภัยของอุปกรณ์ ● รู้สึกปลอดภัยกับเครื่องผลิตไบโอแก๊สหรือไม่  					
3. ความพร้อมในด้านเครื่องมือ อุปกรณ์ และบุคลากร ● พอใจหรือไม่ ที่นำเศษอาหารมาใช้ในการผลิตแก๊สทำอาหาร ● พอใจหรือไม่ หากนำเศษหญ้า เศษฟางข้าว จากแปลงเกษตรมาใช้ในการผลิตไบโอแก๊ส					
4. การประชาสัมพันธ์โครงการไบโอแก๊สให้ประชาชนทั่วไปได้รับรู้ ● พอใจหรือไม่ที่มีคนภายนอกมาเยี่ยมชมการผลิตไบโอแก๊ส					
● พอใจหรือไม่ ที่มีการจัดนิทรรศการไบโอแก๊สภายในบ้านดิน (ศูนย์การเรียนรู้พลังงานทดแทน)					

รายการ	ระดับความพึงพอใจ				
	มาก ที่สุด	มาก	ปาน กลาง	น้อย	น้อย ที่สุด
<u>ด้านประโยชน์ของโครงการฯ</u> **5. ได้รับความรู้เรื่องกระบวนการผลิตไบโอแก๊ส** ● ฟังครูสอนเรื่องไบโอแก๊สแล้วเข้าใจหรือไม่					
6. สร้างงานและทักษะการผลิตไบโอดีเซลอย่างมีประสิทธิภาพ ● พอใจหรือไม่ หากการผลิตไบโอแก๊สสามารถสร้างงานระยะยาว (ได้ทำงานเป็นผู้ผลิตแก๊สทำอาหาร) ● พอใจหรือไม่ หากท่านต้องอธิบายเกี่ยวกับไบโอแก๊สให้ผู้อื่น					
7. ส่งเสริมการใช้พลังงานทดแทนได้อย่างเป็นรูปธรรม ● พอใจหรือไม่ ที่โรงเรียนสามารถผลิตไบโอแก๊สได้จริงและนำไปใช้เป็นแก๊สทำอาหารในครัว ข้างโรงอาหารด้วย ● พอใจหรือไม่ ที่แก๊สที่ผลิตเองถูกนำไปใช้ในการเรียนวิชาทำอาหาร ● พอใจหรือไม่ ที่โครงการไบโอแก๊สได้รับการสนับสนุนจากกรมพัฒนาพลังงานทดแทนและอนุรักษ์พลังงานพลังงาน กระทรวงพลังงาน					
● พอใจหรือไม่ ที่โรงเรียนสามารถลดโลกร้อน เพราะใช้พลังงานทดแทน (ไบโอแก๊ส)  กรมพัฒนาพลังงานทดแทน และอนุรักษ์พลังงาน กระทรวงพลังงาน 					

รายการ	ระดับความพึงพอใจ				
	มากที่สุด	มาก	ปานกลาง	น้อย	น้อยที่สุด
8. ความคุ้มค่าของการนำผลผลิตไปใช้ประโยชน์ ● พอใจหรือไม่ หากโรงเรียนผลิตไบโอแก๊สได้เยอะมาก จึงต้องขายไบโอแก๊สให้กับคนอื่น (สร้างรายได้ให้โรงเรียน)  					
9. ลดค่าใช้จ่ายแก๊สหุงต้มภายในโรงเรียน ● พอใจหรือไม่ ที่โรงเรียนไม่ต้องเสียค่าแก๊สทำอาหาร					
10. สร้างสัมพันธภาพที่ดีระหว่างชาวบ้านและนักเรียน ● พอใจหรือไม่ หากมีคนอื่นเข้ามาช่วยผลิตไบโอแก๊ส ● พอใจหรือไม่ หากมีกิจกรรมอื่นๆที่ทำให้คนอื่นเข้ามาบริจาคเศษอาหาร เพื่อนำมาผลิตน้ำมันไบโอแก๊ส					

ข้อเสนอแนะที่ต้องการให้มีการจัดการเพิ่มเติมเกี่ยวกับไบโอแก๊ส

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4. แบบสอบถามความพึงพอใจเกี่ยวกับโครงการไบโอดีเซล

รายการ	ระดับความพึงพอใจ				
	มากที่สุด	มาก	ปานกลาง	น้อย	น้อยที่สุด
<u>ด้านการดำเนินโครงการฯ</u> **1. ความเหมาะสมของสถานที่ตั้งศูนย์ผลิตไบโอดีเซล** ● พอใจหรือไม่ ที่อาคารตั้งอยู่ติดแปลงเกษตร บริเวณหลังโรงเรียน 					
2. ความสวยงาม ความปลอดภัยของสถานที่ ● พอใจหน้าตาอาคารเรียนไบโอดีเซลหรือไม่ ● พอใจสภาพพื้นอาคารหรือไม่ (น้ำมันเลอะทำให้พื้นสกปรกและลื่น) ● พอใจหรือไม่ ที่น้ำด่างถูกทิ้งลงพื้นดินข้างอาคารเรียน  					
3. ความพร้อมในด้านเครื่องมือ อุปกรณ์ และบุคลากร ● อุปกรณ์พอใช้หรือไม่ มีครูและเจ้าหน้าที่ที่เกี่ยวข้องเพียงพอหรือไม่ 					

รายการ	ระดับความพึงพอใจ				
	มากที่สุด	มาก	ปานกลาง	น้อย	น้อยที่สุด
4. การประชาสัมพันธ์โครงการไบโอดีเซลให้ประชาชนทั่วไปได้รับรู้ ● พอใจหรือไม่ ที่มีคนภายนอกมาเยี่ยมชมการผลิตไบโอดีเซล ● พอใจหรือไม่ ที่มีการจัดนิทรรศการไบโอดีเซลภายในบ้านดิน (ศูนย์การเรียนรู้พลังงานทดแทน)					
<u>ด้านประโยชน์ของโครงการฯ</u> **5. ได้รับความรู้เรื่องกระบวนการผลิตไบโอดีเซล** ● ครูสอนเรื่องไบโอดีเซลแล้วเข้าใจหรือไม่ 					
6. สร้างงานและทักษะการผลิตไบโอดีเซลอย่างมีประสิทธิภาพ ● พอใจหรือไม่ หากการผลิตไบโอดีเซลสามารถสร้างงานระยะยาว (ได้ทำงานเป็นผู้ผลิตไบโอดีเซล) ● พอใจหรือไม่ หากท่านต้องอธิบายเกี่ยวกับไบโอดีเซลให้คนอื่น					
7. ส่งเสริมการใช้พลังงานทดแทนได้อย่างเป็นรูปธรรม ● พอใจหรือไม่ที่โรงเรียนสามารถผลิตไบโอดีเซลได้จริง และนำไปเติมน้ำมันให้กับรถทุกคันในโรงเรียน ● พอใจหรือไม่ที่โครงการไบโอดีเซลได้รับการสนับสนุนจากกรมพัฒนาพลังงานทดแทนและอนุรักษ์พลังงานพลังงาน กระทรวงพลังงาน ● พอใจหรือไม่ที่โรงเรียนสามารถลดโลกร้อน เพราะใช้พลังงานทดแทน (ไบโอดีเซล)					

รายการ	ระดับความพึงพอใจ				
	มากที่สุด	มาก	ปานกลาง	น้อย	น้อยที่สุด
8. ความคุ้มค่าของการนำผลผลิตไปใช้ประโยชน์ • พอใจหรือไม่ ที่โรงเรียนได้น้ำมันพืชที่ใช้แล้วฟรี แต่รถโรงเรียนต้องขับไปรับที่กรุงเทพทุกสัปดาห์ • พอใจหรือไม่ หากโรงเรียนได้รับบริจาคน้ำมันพืชใช้แล้ว จากผู้ปกครองหรือตลาด ร้านค้าใกล้โรงเรียน • พอใจหรือไม่ ที่ได้กลีเซอรอลนำมาขายต่อ หรือนำมาใช้เป็นวัตถุดิบผลิตสบู่ เครื่องสำอาง (ผลที่ได้จากการผลิตไบโอดีเซล นอกจากจะได้น้ำมันไบโอดีเซลแล้ว ยังได้กลีเซอรอลด้วย) • พอใจหรือไม่ หากโรงเรียนผลิตน้ำมันไบโอดีเซลได้เยอะมาก จึงต้องขายน้ำมันให้กับคนอื่น (สร้างรายได้ให้โรงเรียน)  					
9. ลดค่าใช้จ่ายน้ำมันเชื้อเพลิงในโรงเรียน • พอใจหรือไม่ที่โรงเรียนไม่ต้องเสียค่าน้ำมันรถ					
10. สร้างสัมพันธภาพที่ดีระหว่างชาวบ้านและนักเรียน • พอใจหรือไม่ หากคนอื่นเข้ามาช่วยผลิตไบโอดีเซล • พอใจหรือไม่ หากมีกิจกรรมอื่นๆที่ทำให้มีคนอื่นเข้ามาบริจาคน้ำมันพืชที่ใช้แล้ว เพื่อนำมาผลิตไบโอดีเซล					

ข้อเสนอแนะที่ต้องการให้มีการจัดการเพิ่มเติมเกี่ยวกับไบโอดีเซล

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ขอบพระคุณทุกท่านที่ให้ข้อมูล

RESPONDENTS

Population of the community aged 13 -60 year old is approximately 350 people. However, only 170 Respondents who gave the auther feedback in the preference questionnaire.

APPENDIX D: PREFERENCE QUESTIONNAIRE RESULTS

1. CRE projects management issue

CRE project management issue					
1. Location of CRE projects setting	Very satisfied	Satisfied	Medium	Dissatisfied	Very dissatisfied
Solar energy	53	44	3	0	0
Wind energy	35	54	10	1	0
Biogas	27	42	25	4	2
Biodiesel	37	41	17	4	1
2. Safety of CRE projects production	Very satisfied	Satisfied	Medium	Dissatisfied	Very dissatisfied
Solar energy	27	57	15	1	0
Wind energy	18	55	23	4	0
Biogas	24	48	26	2	0
Biodiesel	6	20	41	16	17
3. The readiness of equipment and personnel	Very satisfied	Satisfied	Medium	Dissatisfied	Very dissatisfied
Solar energy	55	24	16	5	0
Wind energy	6	17	52	20	5
Biogas	47	42	9	2	0
Biodiesel	9	29	37	23	2
4. Contribution received from stakeholders	Very satisfied	Satisfied	Medium	Dissatisfied	Very dissatisfied
Solar energy	73	22	5	0	0
Wind energy	62	34	4	0	0
Biogas	35	48	15	2	0
Biodiesel	67	28	5	0	0
5. Public relation of CRE projects	Very satisfied	Satisfied	Medium	Dissatisfied	Very dissatisfied
Solar energy	32	58	10	0	0
Wind energy	39	44	16	1	0
Biogas	54	37	9	0	0
Biodiesel	49	36	15	0	0
6. Implementation of CRE projects	Very satisfied	Satisfied	Medium	Dissatisfied	Very dissatisfied
Solar energy	73	19	8	0	0
Wind energy	60	29	10	1	0
Biogas	62	31	5	0	2
Biodiesel	43	40	16	1	0

2. The benefit of CRE projects issue

The benefits of CRE projects issue					
1. Social benefit: Level of understanding of RE production processes	Very satisfied	Satisfied	Medium	Dissatisfied	Very dissatisfied
Solar energy	54	34	11	1	0
Wind energy	18	56	26	0	0
Biogas	20	50	28	2	0
Biodiesel	25	47	28	0	0
2. Social benefit: Build a good relationship between residents of the community and their neighbors	Very satisfied	Satisfied	Medium	Dissatisfied	Very dissatisfied
Solar energy	71	24	5	0	0
Wind energy	64	28	7	0	1
Biogas	53	32	10	4	1
Biodiesel	68	25	7	0	0
3. Economic benefit: Reduce conventional energy costs	Very satisfied	Satisfied	Medium	Dissatisfied	Very dissatisfied
Solar energy	72	23	4	0	1
Wind energy	70	26	4	0	0
Biogas	67	28	5	0	0
Biodiesel	73	18	9	0	0
4. Economic benefit: Create job	Very satisfied	Satisfied	Medium	Dissatisfied	Very dissatisfied
Solar energy	65	27	8	0	0
Wind energy	52	38	10	0	0
Biogas	45	40	13	2	0
Biodiesel	63	32	5	0	0
5. Environmental benefit: CRE projects offer solution to help mitigate climate change crisis	Very satisfied	Satisfied	Medium	Dissatisfied	Very dissatisfied
Solar energy	75	20	5	0	0
Wind energy	68	28	4	0	0
Biogas	72	24	4	0	0
Biodiesel	68	27	4	1	0

APPENDIX E:
SCALE AND SUSTAINABILITY SCORE SHEET
OF CRE PROJECTS MANAGEMENT IN SATHYA SAI SCHOOL THAILAND

SCALE & SUSTAINABILITY SCORE SHEET

STEP 1

DESCRIBE THE PROGRAM OR PRACTICE THAT YOU ARE CONSIDERING SCALING AND SUSTAINING

What is it? Why is it important? How do you know it is of high quality and valued? What results are anticipated?

CRE projects management in Sathya Sai School Thailand

STEP 2

LIST THE CORE OR NON-NEGOTIABLE ELEMENTS OF THE PROGRAM OR PRACTICE

CRE projects included Solar energy project, Wind energy project, Biogas project, and Biodiesel project

STEP 3

RATE THE CURRENT STATUS OF THE KEY CATEGORIES OF SCALE & SUSTAINABILITY IN TERMS OF *BOTH* PLANNING AND IMPLEMENTATION [12]

	For Planning - There is:		For Implementation:
5 =	A comprehensive plan in place that all stakeholders "own"	5 =	All aspects have been fully implemented
4 =	A comprehensive plan in place that most stakeholders support	4 =	Most aspects have been fully implemented
3 =	A partial plan in place with some support	3 =	Some aspects have been implemented
2 =	A partial plan with modest support	2 =	Few aspects have been implemented
1 =	No plan	1 =	No aspects have been implemented

STEP 4

CONSIDER YOUR RATINGS FOR BOTH PLANNING AND IMPLEMENTATION IN EACH CATEGORY AND IDENTIFY WHAT IS NEEDED TO PROMOTE SCALE AND SUSTAINABITY

Fill in the right-hand column of the *Score Sheet*. This will lead you into development of strategies to further progress and fill gaps.

STEP 5

DEVELOP STRATEGIES FOR BOTH PLANNING AND IMPLEMENTATION BASED ON THE NEEDS YOU HAVE IDENTIFIED

Continue to monitor the categories of scale and sustainability throughout implementation and make mid-course corrections as necessary.

SCALE & SUSTAINABILITY SCORE SHEET – Part I: Scale

To what extent have the following elements been incorporated into your program or practice?

For Planning (P) - There is:		**For Implementation (I)**	
5 =	A comprehensive plan in place that all stakeholders "own"	5 =	All aspects have been fully implemented
4 =	A comprehensive plan in place that most stakeholders support	4 =	Most aspects have been fully implemented
3 =	A plan in place with some support	3 =	Some aspects have been implemented
2 =	A partial plan with modest support	2 =	Few aspects have been implemented
1 =	No plan	1 =	No aspects have been implemented

	SCALE CATEGORY	RATINGS (P)	(I)	Total P + I	Evidence for the Rating	What Is Needed For Scale
I.	A model with demonstrated effectiveness or promise	3	3	6	(P) (I)	
II.	A program or practice not only in more places, but with high quality and depth of implementation in all those places	5	3	8	(P) (I)	
III.	A "logic model" or theory of action that identifies the steps leading to the model's desired outcomes	3	3	6	(P) (I)	
IV.	A justified hypothesis and/or research that supports the rationale behind the model	4	5	9	(P) (I)	
V.	Replication of identified core elements of the original model with contextual modifications. Ownership by local adapters	4	4	8	(P) (I)	
VI.	High demand for program or practice; fills an acknowledged need	5	3	8	(P) (I)	
VII.	A large number of supporters beyond "early adopters"	3	4	7	(P) (I)	
VIII.	Structural mechanisms by which the model can be spread	5	4	9	(P) (I)	
IX.	Personnel who are skilled in the model who can train others	5	5	10	(P) (I)	
X.	A strong implementation plan with monitoring and continuous improvement built in	1	2	3	(P) (I)	
	SCALE Total (P & I) →	**38**	**36**	**74**	**<--Combined Total (P+I)** *(out of 100)*	
	Total	(P)	(I)	(P+I)		

SCALE & SUSTAINABILITY SCORE SHEET – Part II: Sustainability

To what extent have the following elements been incorporated into your program or practice?

	SUSTAINABILITY ELEMENT	(P)	(I)	Total P + I	Evidence for the Rating	What is Needed for Sustainability?
I. LAWS, REGULATIONS, POLICIES						
a.	Supportive laws or regulations in place	3	3	6	(P) (I)	
b.	Institutionalized outcomes of the change (i.e., procedures, position descriptions, curriculum requirements)	2	2	4	(P) (I)	
	I. AVERAGE SCORES FOR CATEGORY	3	3	5		
II. STAKEHOLDERS (Key individuals)						
a.	Key stakeholders engaged	4	5	9	(P) (I)	
b.	Little active opposition	3	3	6	(P) (I)	
	II. AVERAGE SCORES FOR CATEGORY	4	4	8		
III. EXTERNAL PARTNERSHIPS (Key groups or organizations)						
a.	Key organizations engaged	4	4	8	(P) (I)	
b.	Key organizations perceive the program or practice as furthering their own goals	4	4	8	(P) (I)	
c.	Union contracts support the program or practice	5	5	10	(P) (I)	
	III. AVERAGE SCORES FOR CATEGORY	4	4	9		
IV. INTERNAL ORGANIZATIONAL CAPACITY						
a.	Organizational goals furthered by the change	4	4	8	(P) (I)	
b.	Well-defined procedures and systems for implementation	3	2	5	(P) (I)	
	IV. AVERAGE SCORES FOR CATEGORY	4	3	7		

SCALE & SUSTAINABILITY SCORE SHEET - PART II: Sustainability

	SUSTAINABILITY ELEMENT	(P)	(I)	Total P + I		Evidence for the Rating	What is Needed for Sustainability?
V. HUMAN CAPITAL							
a.	A clear and legitimate procedure of succession for those leading the effort	5	5	10	(P)		
					(I)		
b.	Staff with the skills and knowledge to implement the new program or practice	2	3	5	(P)		
					(I)		
c.	An institutionalized system for training personnel in the skills needed by the program or practice	3	3	6	(P)		
					(I)		
	V. AVERAGE SCORES FOR CATEGORY	3	4	7			
VI. FUNDING							
a.	On-going funding from diversified sources	2	2	4	(P)		
					(I)		
b.	Coordination of several funding sources to support the new program or building in the new program or practice within existing programs	3	1	4	(P)		
					(I)		
c.	Cost neutral strategies (reallocation of resources to the new program or practice including cutting funding to programs that are not working well)	1	1	2	(P)		
					(I)		
	VI. AVERAGE SCORES FOR CATEGORY	2	1	3			
VII. CULTURE							
a.	Program or practice furthers existing values and norms	5	5	10	(P)		
					(I)		
b.	Favorable attitudes toward the new program or practice	5	5	10	(P)		
					(I)		
	VII. AVERAGE SCORES FOR CATEGORY	5	5	10			
VIII. CONTINUOUS IMPROVEMENT (Formative Evaluation)							
a.	Continuous gathering of data to support the achievement of the change goal	1	1	2	(P)		
					(I)		
b.	Provisions for monitoring, learning lessons and consequently making mid-course corrections	2	1	3	(P)		
					(I)		
	VIII. AVERAGE SCORES FOR CATEGORY	2	1	3			

SCALE & SUSTAINABILITY SCORE SHEET - PART II: Sustainability

	SUSTAINABILITY ELEMENT	(P)	(I)	Total P + I		Evidence for the Rating	What is Needed for Sustainability?
IX. COMMUNICATIONS							
a.	On-going communications mechanisms including use of media and public relations	5	4	**9**	(P)		
					(I)		
b.	Transparency of progress to all constituencies	5	5	**10**	(P)		
					(I)		
	IX. AVERAGE SCORES FOR CATEGORY	**5**	**5**	**10**			
X. EVALUATION (Summative)							
a.	Assessment of the program or practice's accomplishments versus planned outcomes after a specified time period	5	3	**8**	(P)		
					(I)		
b.	Identified lessons learned	3	2	**5**	(P)		
					(I)		
	X. AVERAGE SCORES FOR CATEGORY	**4**	**3**	**7**			
	SUSTAINABILITY Total (P & I)	**34**	**32**	**66**	*(out of 100)*		
	Total	(P)	(I)	(P+I)			

VITA

Panichat Kitisittichai was born in 1981 in Lampang province, Thailand. In 2000, she studied Bachelor's Degree in Architecture (B.Arch) at the Faculty of Architecture, Chiang Mai University. She partook in a workshop on the Environmental Urban Planning and the Preservation of Cultural Value with the DUCED-TUCED: Danish-Thai University Consortium for Environment and Development Industry and Urban Areas in 2004. Despite the difficulty of making ideological coherence in the society nowadays, she believed that human consciousness can possibly be cultured in constructive ways to achieve a common goal. As a result, she conducted a research on "The Architecture for Infant and Childhood Development" for her undergraduate thesis. The major objective was to study the interrelations between environment and human being from their early conception in the womb to the age of 3, the most critical period for human brain and consciousness development, even to the cognitive stage. This research concluded that the properness of the architecture and the environment were important to the stimulation and the enhancement of human potentials. After her graduation in 2005, she worked as a professional architect at famous architectural design firms in Thailand. While she worked as professional architect, she partook seminars on energy saving and sustainable development and workshops on sustainability design. In 2011, she studied for the master of Arts (M.A) at Graduate school, Chulalongkorn University on Environment, Development, and Sustainability program where she contributed thesis title "A Study of Community Renewable Energy Projects Moving Towards Best Management Practices base on Sustainable Community Renewable Energy in Sathya Sai School Thailand" supervised by Assoc.Prof.Ariya Aruninta, Ph.D. In 2013, Miss Kitisittichai was promoted to senior architect and project architect as well as a candidate of Leadership in Energy and Environmental Design; Green Associate (LEED GA).

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