Application program for renewable energy potential evaluation and appropriate technology selection

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Abstract

Thailand is an agricultural country with a good potential for efficient use of renewable energy, however, the country still faces issues associated with the selection of appropriate energy technologies in different areas. The suitable application program is developed in order to help the communities to analyse the appropriate energy technologies to utilize the renewable energy resources available in the target areas. It can help in complement the more efficient use of renewable energy in line with the potential for even more area as well as compliance with energy policies to create energy security in the country. The implementation of the application program with purposive sampling method was performed. The results of Kirk Patrick theory for four types of satisfaction analysis from the users showed that the satisfaction with program using, learning of the participants who used the program, behaviour changing after program using and the evaluation of the results to the agency were 3.55, 3.46, 3.48 and 3.33 respectively. The average value was 3.46.

Keywords: *Energy potential, appropriate technology, application program*

1. Introduction

All sectors in Thailand have continually experienced energy problems for certain periods of time due to the growing consumption as a result of economic and population growth. Oil, electricity or fuel for thermal energy generation in the household or industrial sector need proper development regarding their uses, management, procurement and access to energy sources to ensure appropriate consumption. At the same time, the development is also needed for providing new energy sources to meet the future demand. Electricity is essential to everyday life as it is needed for lighting, cooking and other activities. According to the record of Provincial Electricity Authority (PEA) [1], Thailand still has 1% of total area that has no access to power grid as they are located in the remote area. Therefore, if the community would make electricity available it would help alleviate this issue. Thailand has good potential of natural power such as solar energy with solar radiation of 18.2 MJ/m^2/day in some areas while other areas have potential for the power generation from wind. These make Thailand having potential of alternative energy at excellent level [2-5] and up until today, it seems that their benefits have not been maximized yet. This research uses Microsoft Visual Basic program for data analysis, database development and process development for proper renewable energy technologies selection [6-8] in the target area. This program focuses on community or household in remote areas or areas which could not get access to electricity from the grid. This study is focused on small scale electricity generation. The limitation is 50kW system or size suitable only in a small community due to investment limitations. Hence the community residents can own real investment or get some support from Sub-district administrative organization office. The concept in this research is the decentralized power plant system in the community. This program created to reduce reliance on experts. In terms of technology, this paper focused on existing technologies. The purposes of this research were to develop database of suitable technologies for renewable energy sources in the target area

and application program as a tool for renewable energy potential evaluation and suitable technology selection in the target area. This tool will also be evaluated after implementation in the target community.

2. Methodology

The process of implementation is divided into three parts. They comprise on 1) collection of potentiality and technologies of renewable energy for database development 2) development of the application program 3) implementation of the application program in three communities using purposive sampling method. Kirk Patrick theory was used to evaluate the user in four types of evaluation. The assessment was conducted in four ways; Reaction Evaluation, Learning Evaluation, Behavior Evaluation and Results Evaluation. After that data analysis was performed, SPSS t-test and one-way analysis of variance (One-way ANOVA) was used to analyze the data. The selection criteria were based on the following considerations; 1) selection of three provinces with high renewable energy potential: Suphanburi province (solar), Nakhon Ratchasima province (biomass) and Chumphon province (water). 2) selection of three local authorities that have potential for energy and participation in community energy planning with the Ministry of Energy: Sub-district administrative organization members Nong Sarai Don Chedi district Suphanburi province, Sub-district administrative organization members Meuang Pak Pak Thong Chai district, Nakhon Ratchasima province and Sub-district administrative organization members Kron, Sawee district Chumphon province. After that the method for using the applications program for Renewable Energy Potential Evaluation and Appropriate Technology Selection was introduced.Questionnaires and sampling program to prospect and trial program used with targets were performed. Moreover Satisfaction inquires from questionnaires for research was checked.

3. Results and discussion

Testing of application program, for, renewable energy potential assessment and appropriate technology selection. Energy potential was divided into two areas: electricity generation and thermal energy technologies, based on information processing in various areas by data analyzing. The potential for electricity generation consists of four technologies, namely PV, biomass gasifier, wind turbines and micro hydro power. The thermal energy technologies consist of seven technologies including solar dryers, Solar water heater, Solar cooking, Solar herb extractor, Solar water distillatory, Biomass gasifier and Small bio-gas plant. The results of potential for electricity generation and selection of appropriate technologies analysis are summarized in Table 1.

Table 1 Results of potential for electricity production and appropriate technologies analysis
in the target area.

Area	PV	Biomass gasifier	Micro hydro power generator	Wind turbines
Nhong Sarai	1	N/A	N/A	N/A
Mueng Pak	2	1	N/A	N/A
Kron	2	N/A	1	N/A

It was found that, these three target areas had different energy potential; Sub-district administrative organization members Nong Sarai*,* Don Chedi district and Suphanburi

province have high solar potential and the most appropriate technology is PV. Biomass, micro hydro power generation and wind have insufficient capacity to produce electricity.

Sub-district Administrative Organization members Meuang Pak, Pak Thong Chai district, Nakhon Ratchasima province has high biomass potential and the most appropriate technology is biomass gasifier. Solar energy potential is the second significant. Micro hydro power and wind had insufficient capacity to produce electricity.

Sub-district Administrative Organization members Kron, Sawee district, Chumphon province has high water potential and the most appropriate technology is micro hydro power generation. In addition, the area has good solar potential and the appropriate technology is PV while, wind and biomass have insufficient capacity to produce electricity.

Data analysis for the selection of appropriate technology in Sub-district administrative organization members Nong Sarai, Don Chedi district, Suphanburi province shows high potential for solar energy. Table 2 shows the results.

Table 2 The analysis of energy potential for electricity production and the appropriate technology in the area sub-district Nong Sarai, Don Chedi district, Suphanburi province.

Renewable Energy Technologies	Input	Volume	Potentiality
-Biomass gasifier	Sugarcane plantation area (Rai)	5	N/A
	Rice plantation area (Rai)	50	
	Corn plantation area (Rai)	0	
	Cassava plantation area (Rai)	0	
	Para Rubber plantation area (Rai)	0	
	Oil palm plantation area (Rai)	0	
-PV	Solar Radiation Energy (MJ/day)	18.80	The first priority - System installed capacity 2 kW - Electricity produced 8.08 kWh/ day. - Investment 150,000 baht - Costs of energy production 5.23 baht / unit - Payback period is 13 Years
-Wind turbine	wind speed (m/s)	3.35	N/A
-Micro hydro power Generator	The height of the water (m)	0	N/A
	Water steam flow rate (l/s)	0	

Notes - Cultivated area is cultivated area of representative samples in sub-district administrative organization members Meuang Pak, Pak Thong Chai district, Nakhon Ratchasima province area.

From the analysis and data processing for capabilities for electricity production of local community in sub-district administrative organization members Nong Sarai, Don Chedi district, Suphanburi province area using the program it was found that these areas have

highest solar energy potential, with solar radiation intensity of 18.80 MJ per square meter. The most appropriate technology to produce electricity is solar cell and the installed capacity of 2 kW system produces 8.08 kilowatts per day. The total investment is 150,000 baht, with cost of energy production at 5.23 baht per kWh and a payback period of 13 years. Wind energy, biomass and hydropower potential are not enough for electricity production.

Table 3 The results of the analysis of potential energy for electricity generation and the appropriate technology in sub-district administrative organization members Meuang Pak, Pak Thong Chai, Nakhon Ratchasima province area.

Renewable Energy Technologies	Input	Volume	potentiality
-Biomass gasifier	Sugarcane plantations (Rais)	0	The first is appropriate
	Planted area (Rai)	65	- The capacity installed
	Corn acreage (Rai)	0	in the system 50 kW.
	Cassava plantations(Rai)	0	- Electricity produced
	Rubber plantations(Rai)	0	440.64 kWh/ day.
	Oil palm plantations(Rai)	0	- investment 1,105,200 baht
			- Costs of energy production
			0.78 baht/ unit
			- The payback period is
			2 years
-PV	Light intensity(MJ)	17.78	The second is appropriate
			- The capacity installed
			in the system 2 kW.
			- Electricity produced
			7.90 kWh/ day.
			- investment 150,000 baht
			- Costs of energy production
			5.35 baht/ unit
			- The payback period is
			13 years
-Wind turbine	wind speed(m/s)	2.46	N/A
-Micro hydro	The height of the water(m)	3	N/A
power generator	Water steam flow rate (l/s)	5	

Notes   - Cultivated area is Cultivated area of representative samples in sub-district administrative organization members Meuang Pak, Pak Thong Chai district, Nakhon Ratchasima province.
 - Water sources information is Lamchore Canal in sub-district administrative organization members Meuang Pak, Pak Thong Chai district, Nakhon Ratchasima province.

From the analysis and data processing for capabilities of electricity production of local community in sub-district administrative organization members Meuang Pak, Pak Thong Chai district, Nakhon Ratchasima province, the tested program found that biomass potential was the most appropriate. Using biomass, the most appropriate technology for the production of electricity is biomass gasifier. The installed system with a capacity of 50 kilowatt, produces electricity energy of 440.64 kWh per day, The total investment was1.1052 million baht, with a cost of energy production at 0.78 baht per kWh of electricity and a payback period of two years. The next appropriate energy is solar energy, with solar radiation intensity of 17.78 MJ/m^2. For solar energy, the most appropriate technology for producing electricity is solar cell. The installed capacity of the system was 2 kW, and electricity production was 7.9 kWh per day. The total investment was150, 000 baht, with cost of energy production at 5.35 baht

per kWh of electricity and a payback period of 13 years. Wind turbine potential and Micro hydro power generator potential is not enough for electricity production.

Table 4 The results of the analysis of potential energy for electricity generation and the appropriate technology in sub-district administrative organization members Kron, Sawee district Chumphon province.

Renewable Energy Technologies	Input	Volume	Potentiality
-Biomass gasifier	Sugarcane plantations(Rai)	0	N/A
	Planted area(Rai)	0	
	Corn acreage(Rai)	0	
	Cassava plantations(Rai)	0	
	Rubber plantations(Rai)	20	
	Oil palm plantations(Rai)	10	
-PV	Light intensity(MJ)	16.86	The second is appropriate - The capacity installed in the system 2 kW. - Electricity produced 7.49 kWh/ day. - investment 150,000 baht - Costs of energy production 5.64 baht/ unit - The payback period is 15 years
-Wind turbine	wind speed(m/s)	3.45	N/A
-Micro hydro power generator	The height of the water(m)	60	The first is appropriate - The capacity installed in the system 6 kW.
	Water steam flow rate (l/s)	8	- Electricity produced 67.81 kWh/ day. - investment 135,000 baht - Costs of energy production 0.58 baht/ unit - The payback period is 2 years

Notes - Cultivated area is Cultivated area of representative samples in sub-district administrative organization members Kron, Sawee district, Chumphon province.
- Water sources information is Loichuen waterfall in Moo 19, Lamae sub-district, Lamae district, Chumphon province.

From the analysis and data processing for capabilities of electricity production of local community in sub-district administrative organization members Kron, Sawee district, Chumphon area, the tested program found that the hydro potential is the first appropriate and that the most appropriate technology for the production of electricity is micro hydro power generator. The installed capacity of the system is 6 kW, and it can produce 67.81 kWh of electricity per day. The total investment was 135,000 baht, cost of energy production at 0.58 baht per kWh and a payback period of two years. The next appropriate energy is solar energy, with solar radiation intensity of 16.86 MJ/m^2, of which the most appropriate technology for producing electricity is solar cell. The installed capacity of the system was 2 kW system, producing electricity of 7.49 kWh per day. The total investment was 150,000 baht, cost of

energy production was 5.64 baht per kWh and a payback period of 15 years. Here, wind energy potential and biomass potential is not enough for electricity production.

Application program test for thermal energy generation

Application program test for thermal energy generation to select the appropriate technology was performed by selecting one target area of the sub-district administrative organization members Nong Sarai, Don Chedi district, Suphanburi province. The analysis of the energy potential for the use of thermal energy and the appropriate technology selection is summarized in table 5.

Table 5 Energy potential analysis results of thermal energy generation and appropriate technology in Nong Sarai, Don Chedi district, Suphanburi province.

No.	Technology	Potential
1	Solar Dryer	Potential
2	Solar Water Heater	N/A
3	Solar Cooker	N/A
4	Extractor	N/A
5	Solar Still	N/A
6	Biomass Stove	Potential
7	Biogas Plant	N/A

It was found that the appropriate technology is Solar dryer. And also wood from waste is enough to use for biomass stove.

Table 6 Energy potential analysis results for solar drying technology in sub-district administrative organization members Nong Sarai, Don Chedi district, Suphanburi province.

Output	Weight (kg.)	Number of dryers	Weight (kg./dryer)	Drying Time (Hour)	Price (baht)
Meat					
fish meat	10	1	12	35	70,000
Vegetable					
Chilli Pepper	10	2	5	39	50,000
Fruit	-	-	-	-	-
Herb	-	-	-	-	-
Grain	-	-	-	-	-

Sub-district administrative organization members Nong Sarai, Don Chedi district, Suphanburi have high solar potential (solar radiation intensity of 18.80 MJ/m^2), hence it can bring such potential to be used for processing and value added productivity. The community can select the technology to suit all types and sizes and also basic data of solar dryers to produce the product, size and price in order to make the effective plan.

One solar dryer with 35 hours drying time can be used to dry 10 kg fish, and the cost of solar dryer was 70,000 baht. To dry 10 kg chilli pepper two solar dryers can be used with 39 hours drying time and the cost of solar dryers were 50,000 baht.

Satisfaction of the users for "Application Program for Renewable Energy Potential Evaluation and Appropriate Technology Selection"

The Comparative Study of the satisfaction of users was done by a survey of 55 sets of the questionnaires which were separated into two parts as follows

Part 1 Overview of the respondents' data which was in the form of a checklist.
Part 2 Satisfaction level form rating scales of LiKirt model which consisted of four fields

- Field 1: Satisfaction with program usage
- Field 2: Learning of the participants who used the program
- Field 3: Behaviour changing after using program.
- Field 4: Evaluation of the results to the agency.

Overview of respondents revealed that 52.73% were female and 47.27% were male. In addition, 45.45% were aged between 20-30 years, 36.36% were aged between 31-40 years, 14.55% were aged between 41-50 years and 3.64% were older than 50 years. In terms of qualification, 80% had a bachelor's degree, 12.73% owned a bachelor degree (12.73 percent) and 7.27 % attained higher education levels. In terms of occupation, 34.55% were civil servants, 41.82% were private employees, 12.73% dependent on agriculture and 10.91% were others. As those experienced in the use of data analysis, 70.91% had experience while 29.09% had no experience. Lastly, in terms of experience in energy planning, 41.82% were experienced while 58.18% had no experience.

Satisfaction of users for the Application Program for Renewable Energy Potential Evaluation and Appropriate Technology Selection overview found satisfaction at moderate level($\bar{X}$ = 3.46). Sort satisfaction of users of particular programs found that the behaviour modification program after the trial was very satisfied ($\bar{X}$ = 3.55) including secondary evaluation results of the institution ($\bar{X}$=3.46), Learning of the program participants ($\bar{X}$=3.48) and the applications ($\bar{X}$=3.33), respectively.

The Application Program for Renewable Energy Potential Evaluation and Appropriate Technology Selection for community can be easily used. Moreover, the program also included precision. The data from the analysis process can be used for planning for development of the energy in the community. However should be developed to achieve diversity in the form of potential energy, and more in order to achieve variety and choice to the community in planning energy. In addition, it should be updated to the date in particular, the information regarding the price, technology, vendors and budget for the investment. To promote or encourage the community to use the program should integrate with provincial energy office as of the energy planning operator in the area. In addition, the community is accessible in all areas and can have skill to transfer the knowledge. As a result, the community will be able to analyze the potential and plan their own energy and also can process of working with the staff of the Provincial Energy Office. Therefore, the Application Program for Renewable Energy Potential Evaluation and Appropriate Technology Selection is another alternative to enhance and develop the energy plan for the community to be more effective and beneficial for countries' development in the energy field.

4. Conclusions

From the implementation of the Application Program, it was found that the application program can be processed accurately and potential energy is corresponding to the data presented from the Department of Alternative Energy Development and Efficiency. The results from the research are very useful for the community as it can help community to

develop the energy plan. The satisfaction survey from the users also showed the value of 3.46 which means that the users are satisfied to this Application Program. However, the application program could be improved more to achieve diversity of potential energy.

References

[1] Community Power Plant: Future Community Demand, Energy Plus, Department of Renewable Energy Development and Conservation, Ministry of Energy.
[2] Development Plan for Alternative Energy and Renewable Energy 25% in 10 Years(2012-2021), Department of Renewable Energy Development and Conservation, Ministry of Energy.
[3] S. Janjai, 2010, "Solar Radiation Maps from Satellite Data for Thailand",
Solar Energy Research Laboratory, Department of Physics, Silpakron University.
[4] S. Janjai, 2010, Full report The development of wind energy potential map for Thailand, Department of Physics, Faculty of Science , Silpakron University.
[5] Material yield ratio for leaves of sugarcane and corn residues from soybean
and sorghum. Factor of energy and factors which are not material to apply for sugarcane leaves and straw, rice, cassava, corn, soybeans, sorghum and waste from, Behaviour and patterns of energy use in agriculture, 1992, Department of Energy Development and Promotion.
[6] Athanasios Angelis-Dimakis, et. Al., Methods and tools to evaluate the availability of renewable energy sources, Renewable and Sustainable Energy Reviews 15 (2011) 1182-1200.
[7] Shirley Thompson and BhanuDuggirala, The feasibility of renewable energies at an off-grid community in Canada, Renewable and Sustainable Energy Reviews 13 (2009) 2740-2745.
[8] Zishuo Huang, Hang Yu, ZhenweiPeng, Mei Zhao, 2014. Methods and tools for community energy planning: A review, Renewable and Sustainable Energy Reviews 42 (2015) 1335-1348.