A COMMUNITY-BASED ENERGY BANK FOR ELECTRICITY GENERATION USING RENEWABLE FUELS: A CASE OF RURAL COMMUNITY IN TAK PROVINCE, THAILAND

ธนาคารพลังงานชุมชน สำหรับการผลิตไฟฟ้าโดยใช้พลังงานทดแทน กรณีศึกษา ชุมชนชนบทในจังหวัดตาก

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Abstract

Thailand set a high goal for alternative energy, including renewables. The promotion of renewable energy in Thailand in recent years is visible, but most of them are not sustainable, for lack of awareness and technical capacity contributing to short-lived investment. Using a mixed method, this project aims to evaluate the development of energy mix and energy potential. Including the promotion of community energy banks. To be sustainable using the form of investment. For community-based renewable electricity production in a rural community in Tak province, Thailand of which some communities did not have full access to the central grid—and qualitatively seek advice from stakeholders of the investment models being proposed to them. The assessment indicated economic viability for biomass and biogas projects. Consequently, stakeholders and energy experts agreed to an energy bank proposal, which balanced inflows and outflows of raw materials, revenue and electricity. A participatory management system, based on technical capacity building, was proposed and a tri-party joint investment was identified.

Keywords: Renewable Energy, Sustainability, Energy Bank

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บทคัดย่อ

ประเทศไทยได้ตั้งเป้าหมายที่สูงในการใช้พลังงานทางเลือกรวมไปถึงพลังงานทดแทน ซึ่งการส่งเสริมการใช้พลังงานหมุนเวียนในประเทศไทยในช่วงไม่กี่ปีที่ผ่านมามีความชัดเจน แต่ส่วนใหญ่ไม่ยั่งยืนเนื่องจากขาดความตระหนักและความสามารถด้านเทคนิคที่นำไปสู่การลงทุนระยะสั้น โครงการนี้มีวัตถุประสงค์เพื่อประเมินการพัฒนาพลังงานผสมและศักยภาพด้านพลังงาน รวมถึงการส่งเสริมธนาคารพลังงานชุมชน เพื่อความยั่งยืนโดยใช้รูปแบบการลงทุน สำหรับการผลิตกระแสไฟฟ้าทดแทนจากชุมชนในชุมชนชนบทในจังหวัดตาก ประเทศไทย ซึ่งบางชุมชนไม่ได้มีการเข้าถึงเครือข่ายของส่วนกลางได้อย่างเต็มที่ โดยใช้วิธีการวิจัยแบบผสมและวิธีเชิงคุณภาพจากการขอคำแนะนำของผู้มีส่วนได้เสีย ในรูปแบบการลงทุนที่ได้รับการเสนอให้กับชุมชน การประเมินโครงการแสดงให้เห็นศักยภาพทางเศรษฐกิจสำหรับพลังงานชีวมวลและก๊าซชีวภาพ ดังนั้นผู้มีส่วนได้เสียและผู้เชี่ยวชาญด้านพลังงานเห็นด้วยกับข้อเสนอของธนาคารพลังงานที่ให้เงินทุนไหลเข้าและการไหลออกของวัตถุดิบโดยสมดุลกับรายได้และการผลิตไฟฟ้า ระบบการจัดการแบบมีส่วนร่วมบนพื้นฐานของการสร้างขีดความสามารถทางเทคนิค ได้รับการเสนอ และการระบุบุคคลเข้าร่วมลงทุน

คำสำคัญ: พลังงานทดแทน การพัฒนาอย่างยั่งยืน ธนาคารพลังงาน

Introduction

By 2040 the desire for using energy of the world's people will increase by 30% of the present. (Siamintelligence, 2011). Hence, countries move to explore and promote alternative energy, including renewable options to pamper ever-rising demand for energy. Yet leaders of renewable power developers remain mostly in developed countries as Table 1 thanks mainly to resource endowment and development capacity. Only China and India from developing country appear on the list, indicating that there might be some challenges that need to be overcome in promoting renewable energy.

The same challenges may exist in Thailand. Being an oil dependent country, Thailand imports about 80% of the energy supply (Department of Alternative Energy Development and Efficiency, n.d.), fossil fuels specifically, thus making the Thai economy vulnerable to the price and supply volatility of the world oil markets (BP, 2012). Also, being a small importing country, Thailand has had gambled its economic development and social betterment on oil imports. Though Thailand has not been able to disassociate itself from fossil fuels, energy policies have been focusing on both supply and demand sides to reduce this dependency.

Table 1 Top five world renewable energy producers

	Renewable power capacity (not including hydro)	Renewable power capacity (including hydro)	Wind power	Biomass power	Geothermal power	Solar PV	Solar hot water/Heat
1	United states	China	China	United states	United states	Germany	China
2	China	United states	United states	Brazil	Philippines	Spain	Turkey
3	Germany	Canada	Germany	Germany	Indonesia	Japan	Germany
4	Spain	Brazil	Spain	China	Mexico	Italy	Japan
5	India	Germany/India	India	Sweden	Italy	United states	Greece

Source: Renewable Energy Consumption Rising (2011)

Although this dependency has long been recognized, the disassociation has not been actualized despite clear policy initiatives to increase shares of renewables in total energy supply—see Figure 1. The first turn in policy came around in late 1980s when shares of fuels were increased to 70% when natural gas was introduced for electricity production. This change was induced primarily by cost reduction and environmental concerns: natural gas was considered 'clean'; others were dirty. Subsequently, the world energy crises, local environmental movement and development rights of local communities intensify to scrutinize supply management of energy development and services. Mistrust is also critical. (Sirikoon, 2010). As a result, construction of a new energy facility has become increasingly difficult—to the extent that construction of a dual-purpose dam or a biomass electricity facility, for example, is next to impossible nowadays. Yet, Thailand has been quite successful in promoting access to such final energy as electricity, thanks partly to the early-day energy infrastructure development and government investment that laid a solid foundation and extensive systems of distribution. Therefore today, less than one percentage of areas in Thailand has no access to the centralized system of electricity distribution.

Even though the above challenges might seem perplex, and reasoning maybe numerous, one would continue to wonder how Thailand could light itself up for the near-future development, now that supply management has become stressful, and embarking on new 'cleaner' and 'greener' energy seems to have faced a new challenge, but with old paradigm of fear and frustration. Added to that was high capital costs; shortage of manpower (Heruela, 2006; Dyson and jeneifer, 2008; Johansen and Royrvik, 2014) and high raw material procurement costs for promoting renewable energy. The national development plans have always given high blessing to promoting alternative energy. (Office of the National Economic and Social Development Board, 2012). With high goals for alternative energy shown in Figure 1, government policies and plans of energy development, such as the Power Development Plan (PDP), Alternative Energy Development Plan (AEDP) Oil and Natural Gas Plan, and Thailand Energy Efficiency Development Plan, though ambitious and having positive outlook, will in reality put under acid test of realizing goals in practice. (Phoochinda, 2015).

At the heart of the community-based energy regime is sustainable development, to which the Sufficiency Economy contributes. Chunam (n.d.); Phoochinda (2009) and Noratus (2007), for example, identified self-reliance on energy as a major step in sustainable livelihood. Kriyapak (2009) stressed the importance of participation and understanding of renewable energy as key success. Carlisle, Elling and

Penney (2008) went more deeply into cultivating love for nature; meanwhile Wattana stressed the importance of understanding of policy, ecosystems and safety (also, Upretia and Horst 2004). According to Phoochinda (2009 and 2010), lessons learnt from cases indicated a wide range of necessary and sufficient conditions to promoting a sustainable community-based system, including technical and knowledge capacity and adherence to the sufficiency economy principles. The self-reliance has however long recognized as an important necessary condition in community development. (See, for instance, Natsupa (2005) and Maneeprauk (2001)). Sriwichailampan (2012) contented that participation ensures successful community development.

Community-based energy is new and not easy to promote. One reason is the mixed success in promoting renewable energy through various forms of government intervention. The solar power development given to remote villages in 2000 (Watjanatepin et al., 2008) fell short of expectation after the batteries met their life span, as villagers did not learn how to take good care of them. The solar roof-top project in 2008 (Chanovit, 2014), and more recently, the Ministry of Energy's community-based development projects did not survive its fate after the projects ended. Lack of capacity building contributes to project failures. Sustainability of a project is certainly a critical issue—with serious implications for renewable energy drive at the policy level. Also, the main reasons contributing to project failure are lack of participation and built-in measures to ensure project sustainability. The research question is therefore how to overcome these challenges—especially how to ensure project sustainability.

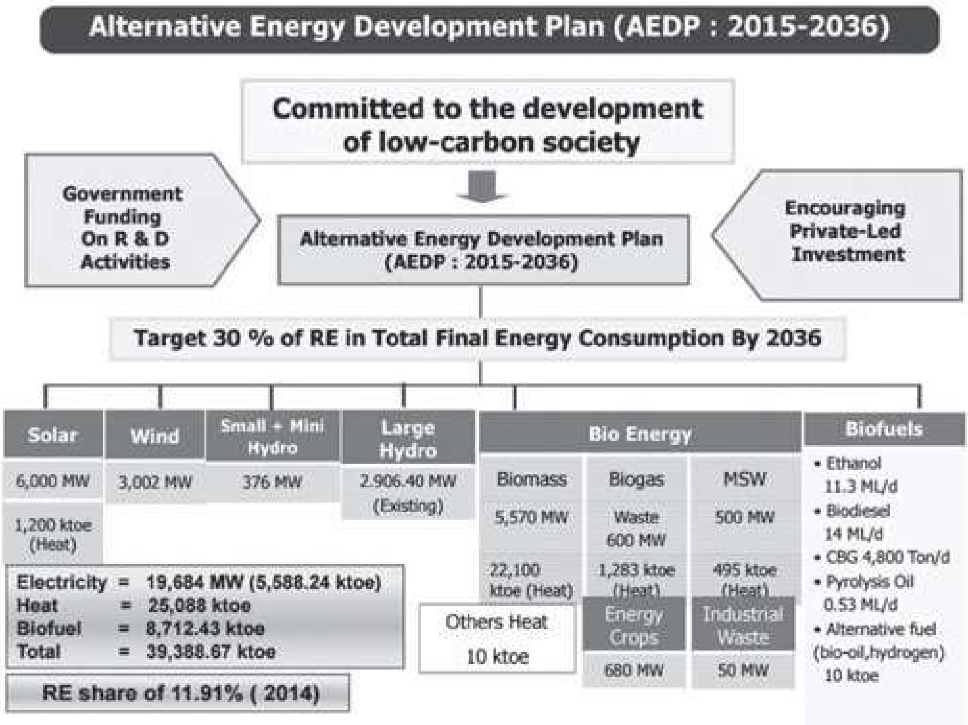

Figure 1 Alternative Energy Development Plan and Targets
Source: Department of Alternative Energy Development and Efficiency (2015)

With mountainous area of 1,240 sq. kilometers, Maechan Sub-district situates about 40 kilometers from Umphang District of Tak Province in the Northwestern part of Thailand—the district is already known for its remoteness. Maechan is 776 meters above sea level, having the Tee Loh Soo Waterfall as its renown natural attraction. Its population, Karen, number 12,328 in 2014; the population density was 9.94 persons/kilometer. Estimated 6.6% have no access to electricity, which is generated from hydro, PV and a small grid. Basic, conventional energy is used in cooking, such as biomass, charcoal, firewood and rice husk for cooking. Only 1/3 of households reportedly use liquefied petroleum gas (LPG) in cooking.

As mentioned above, the researcher has studied A community-based energy bank for renewable fuels: A case of rural community in Tak Province as a guideline to develop and promote renewable energy including self-reliance in part of energy in rural community.

Objectives

The general objective of this research project is to identify and test a measure that could ensure community-based alternative energy project sustainability. Specifically, this study has two objectives:

1. To identify actual and assessed potential energy mix development in a representative remote community in Tak Province.
2. To promote and verify an energy bank model, as a market-based instrument, that could ensure energy development sustainability, with choices of investment regimes.

Methods

This study used a mixed method. To fulfill the above objectives, the project gathers primary data from fragmented community-based renewable energy initiatives on the use and raw material availability, and assesses feasibilities of standardized scaled up. Specifically, out of 3,751 household, quota sampling randomly selected 351 households, and all were interviewed to collect household socio-economic data, household fuel use and fuel use for agricultural purposes. The project conducted SWOT/TOWS analyses to identify appropriate energy development strategies for Maechan Sub-district. Moreover, 29 resource persons from officials of the Department of Alternative Energy Development and Efficiency, local administration, representatives of energy NGOs and village heads were purposely selected to take part in the data collection and verify options—as stated below. With lessons learnt from five randomly selected renewable projects in Thailand to draw lessons learnt, and optional strategies drawn from TOWS, they further assessed economics returns and associated investment options for renewable energy projects in the studied areas.

Together with a management option—i.e., an energy banking system—results were presented and discussed among local stakeholders and experts to verify, discuss and validate the proposed projects that are economically viable, and gauge the acceptability of the most favorable project—and associated form of investment regime most acceptable to stakeholders. With this information obtained, the researchers assessed most economical and sensible regime.

Results

Initially, rounds of household survey were conducted to survey available raw materials and uses, household demand, renewable energy project samples, successes and failures. Results revealed that in the studied areas the generation of electricity using PV took highest share (40.20%), followed by hydro (29.10%) and conventional grid (24.20%)—for those that have access to the grid. Main electricity usages were for lighting, battery charging and TVs. In addition, types of household fuel use were: gas for cooking (32.80%); charcoal (44.40%); wood (82.30%) and rice husk (3.40%). This profile of energy use certainly indicates a conventional livelihood of rural communities in Thailand. While a fraction of households have access to such modern energy for cooking, such as LPG, most of them still rely on wood and charcoal as a main source of energy. These has an affeet to the forests.

The next step was to estimate potential raw material for energy production. The potential of biofuels, totaled 13,067 ton/year from rice, corn and cassava, or 1.22 ktoe, were identified for Maechan. Energy from livestock was very low, totaled 0.13 ktoe—and the procurement of dung would be very difficult as animals were allowed to roam free. Biodiesel has been used in agriculture, 53% of householders reported, but in surveyed communities this potential was insignificant because there was rather small amount of used cooking oil, which found its own use: fed to pigs and there was no oil crop in the villages. Hence, biomass has highest potential for fuel or electricity generation for communities and secondly, biogas.

Renewable energy wasn't new for country side but it hardly brought to utilization, nevertheless. Present data revealed that biomass was once used to generate 10kw (1.4 kg. KWh) of electricity to cool medicines in a local hospital. The fridge broke down and not fixed, so it is no longer used. Two villages use hydro power of 50 KW capacity to service 380 households. Water supply variability and stress, however, have put the system at risk, especially during the hot season. Lastly, PV systems installed in 1999 were no longer in use at the time of the survey because the batteries broke down. The PV system was distributed for free to villagers—with no technical capacity building. Sustainability is certainly questioned.

The study took up this sustainability issue by taking two subsequent steps: first, exploring the board strategy to promoting a renewable energy that fitted the local context, and second, formulated a generic form of energy banking system. Subsequently, SWOT/TOWS analyses were conducted and revealed two strategies, for Maechan sub-district. Firstly, a supportive strategy was recommended for 'educating' villagers on renewable energy, including on technical skills, and potential capacity for designing, selecting and formulating a community-based project. Secondly, the alternative strategy—specifically, an energy banking system—was identify for ensuring project sustainability. The supportive and alternative strategies would, respectively, fill the knowledge and technical capacity gap, and a management system, to ensure project sustainability.

These data were used to formulate two candidate renewable projects (i.e., electricity production using biomass and biogas), which were taken back to stakeholders for review and comment, lest there were different views and options. The biomass project of 400 kW with 20-year lifetime and assumptions, produced (see details in Table 2 below) an NPV of -1,230,695.74 and a BCR of 0.95—indicating a rather low project feasibility. Similarly, a biogas project feasibility was calculated using data and assumptions in

Table 3 below. Results based on 1,025 hogs, showed an NPV of -19,078,163.46 and a BCR of 0.06—deeming it infeasible to implement this option. From the two optional projects, the stakeholder group meeting decided on biomass project feasibilities, based on a large number of criteria, namely, technical feasibility, availability of raw materials, ease of implementation, participatory feasibility, financial feasibility and most importantly the proposed associated sustainability (i.e., the banking system) to manage the projects. In addition, biomass systems influenced the social rate of return on investment shot up to 2.48, when social impacts of the project are considered. This indicated the 'go' signal for social consideration, though financial assessment was not feasible.

Table 2 The cost-benefit analysis of biomass energy production

Year	Benefit	Cost	$\frac{B_t}{(1+i)^t}$	$\frac{C_t}{(1+i)^t}$	$\frac{B_t}{(1+i)^t} - \frac{C_t}{(1+i)^t}$
0	0	11,000,000	0	11,000,000.00	-11,000,000.00
1	2,870,054.63	1,586,590	2,682,294.05	1,482,794.39	1,199,499.65
2	2,682,504.63	1,586,590	2,343,003.43	1,385,789.15	957,214.28
3	2,682,504.63	1,586,590	2,189,722.83	1,295,130.05	894,592.79
4	2,682,504.63	1,986,590	2,046,469.94	1,515,560.00	530,909.94
5	2,682,504.63	1,586,590	1,912,588.73	1,131,216.74	781,371.99
6	2,682,504.63	1,586,590	1,787,466.10	1,057,211.91	730,254.19
7	2,682,504.63	1,586,590	1,670,529.07	988,048.51	682,480.55
8	2,682,504.63	1,986,590	1,561,242.12	1,156,213.47	405,028.65
9	2,452,838.14	1,586,590	1,334,181.43	862,999.84	471,181.59
10	2,452,838.14	1,586,590	1,246,898.53	806,541.90	440,356.63
11	2,452,838.14	1,586,590	1,165,325.73	753,777.48	411,548.25
12	2,452,838.14	1,986,590	1,089,089.47	882,069.72	207,019.75
13	2,452,838.14	1,586,590	1,017,840.62	658,378.44	359,462.18
14	2,452,838.14	1,586,590	951,252.92	615,306.96	335,945.96
15	2,452,838.14	1,586,590	889,021.42	575,053.23	313,968.19
16	2,452,838.14	1,986,590	830,861.14	672,926.76	157,934.38
17	2,452,838.14	1,586,590	776,505.74	502,273.76	274,231.98
18	2,452,838.14	1,586,590	725,706.30	469,414.73	256,291.57
19	2,452,838.14	1,586,590	678,230.19	438,705.36	239,524.83
20	2,452,838.14	1,986,590	633,859.99	513,372.61	120,487.38
Total	**51,081,644.72**	**44,731,800.00**	**27,532,089.74**	**28,762,785.01**	**-1,230,695.27**

Note: Assumptions: 1. 400 KW; 20 years; using all biomass around 6,000 ton/year; 317 operating days; gasification technology; 7% discount rate, costs are based on current actual VSPP, very small power producer, data. BCR = 0.95.

Table 3 The cost-benefit analysis of biogas energy production

Year	Benefit	Cost	$\frac{B_t}{(1+i)^t}$	$\frac{C_t}{(1+i)^t}$	$\frac{B_t}{(1+i)^t} - \frac{C_t}{(1+i)^t}$
0	0	3,300,400	0	3,300,400.00	-3,300,400.00
1	201,601.44	2,448,000	188,412.56	2,287,850.47	-2,099,437.91
2	201,601.44	2,448,000	176,086.51	2,138,178.01	-1,962,091.50
3	201,601.44	2,448,000	164,566.83	1,998,297.20	-1,833,730.38
4	201,601.44	2,448,000	153,800.77	1,867,567.48	-1,713,766.71
5	201,601.44	2,448,000	143,739.04	1,745,390.17	-1,601,651.13
6	201,601.44	2,448,000	134,335.55	1,631,205.76	-1,496,870.21
7	201,601.44	2,448,000	125,547.24	1,524,491.37	-1,398,944.12
8	201,601.44	2,448,000	117,333.87	1,424,758.29	-1,307,424.41
9	201,601.44	2,448,000	109,657.83	1,331,549.80	-1,221,891.98
10	201,601.44	2,448,000	102,483.95	1,244,439.07	-1,141,955.12
Total	**2,016,014.40**	**27,780,400.00**	**1,415,964.15**	**20,494,127.61**	**-19,078,163.46**

Note: Assumptions: 10-year project; 12 sites in 12 villages; production of gas 5 m^3/day/site. BCR = 0.06.

This selected biomass electricity generation project was further revised and simulated for its sensitivity—given cost increase and lower efficiency. (As Table 4) The simulation results, together with financing options, were presented to experts in a final focus-group meeting. It was decided that the biomass project has the highest potential, given also accumulated experience elsewhere that could be beneficial for project implementation.

Project finance is a big issue for this kind of scheme—given its scale, risks, returns and high capital costs. There are generally seven financing options: government financing; private sector financing; community financing; government-community financing; government-private sector financing; private sector-community financing and tri-party joint financing. The discussion with stakeholders decided on a joint-venture between the government and villagers. Villagers are contented that the scheme falls in line with the government policy to promote biomass electricity production, and villagers are willing to raise meager fund to kick-start the project. Interestingly, in the discussion, role of the private sector—in both co-financing and full financing—was considered as an option, but finally rejected by villagers, for fear of monopoly.

Whether this fear is well-founded or not is an interesting issue, but it is not in the scope of this project to dwell further into its detail. The issue, however, mirrors how performance of private sector conduct is perceived, whether or not is true is another matter. But on the other hand, given the project size and the subsistent economy of remote communities, one could only caution that investment capacity by villagers is at all realistic—or is it just an illusion. This is why government role becomes almost mandatory in promoting renewable energy for rural communities. Yet, as much as the government role is almost a necessary condition, the great potential of the private sector should perhaps be recognized and reaped. It goes without saying explicitly that favorable conditions should be created for attracting that potential—be it a tax incentive or social recognition, for instance. Eventually, it is almost apparent that a better financing option for the biomass electricity generation is a tri-party joint venture. An important point remains, nonetheless: how to ensure project sustainability?

Table 4 Sensitivity analyses of biomass and biogas projects

Item	NPV	BCR	Note
Biomass	12,699.68	1.00	Assuming 7% cost reduction, with same rate of return.
Biogas	26,342.80	0.71	Reduction in fixed and variable costs must be 85% and 94.10%, respectively to make NPV positive.

Succinctly, a banking system was proposed to stakeholders and well accepted. The concept and application of the banking system is not entirely alien to the Thai society. Examples are such as: a "Tree bank" (What is Tree Bank, n.d.); a "Garbage bank" (Department of Pollution Control, 2008); a "Land bank" (Phanhingong, n.d.) or even the Grameen Bank. The system is similar to a financial banking system. It contains input flows (raw materials, contributed by members of the scheme); output flows (i.e., electricity) and a management system to ensure that balance of inflows, outflows and running capital. Here, inflows are raw material procurement and revenue received from electricity sale to members (and possibly to non-members as well); outflows are electricity and payment to members and non-members. A financial banking-system-like, if well-managed, could ensure that balance. Stakeholders accepted the proposed model of management but asked to increase reserve from 30% of net revenue to 35%.

Discussion

This research indicated that community-based energy bank should produce electricity from biomass. It would suit most rural communities. According to Klomjit and Kaweeyan (2011), the study found that biomass energy is the optimal energy for electricity generation. This would currently help for global-warming and for sustainable community banking. The knowledge of energy and the techniques should be transferred to the community. From the development of community energy, Upretia and Horst (2004) and Heruela (2006) agreed that the development is an apparent process that provided the Knowledge of energy for local people so the development is not completely successful.

In the analysis of the project, it can be seen that the power generation from biomass obtained from the community-based energy bank has low possibility in terms of practicabitity. However, in part of the social analysis, the project gave the value the community at a high rate. This related to the study of Phoochinda (2015). The study found that the possibility for generating biomass power is low, but, it helps people in the community to earn income from selling the electricity.

Recommendations

1. Recommendations from the research

The regional governmental oganizations should be responsible in materialize the policies that aims to encourage renewable energy in the rural areas.

2. Recommendations for future research

Costs of logistics should be studied, in case of transporting production materials from other places to the bank.

End notes

Last, but not least, this exercise complements the on-going government policy and measures in promoting community-based renewable energy initiatives by proposing an energy banking system. The experiment, conducted with participation of remote rural communities and stakeholders in Maechan Sub-district of Tak Province, endorsed the widely recognized potential of raw materials in rural communities, especially biomass. It is imperative, however, to recognize that these materials may be scattered unevenly across communities, and may already have competing uses. Thus, the economic availability (not physical availability) must be recognized and thoroughly understood. Future surveys that could be useful for promoting renewable energy development in Thailand is to conduct a nation-wide estimate of this economic supply, and to compile a good data set for general public use. Such a data set should be accessed freely by any party, at no cost—or at subsidized cost to communities by the government being part of the budget.

It is very convincing from this project, also, that sustainability of community-based energy projects are the corner stone of promoting rural energy using public monies. A market-based measure such as an energy banking system is tested and accepted to be an alternative in ensuring the needed sustainability. Besides such necessary conditions as awareness-raising, renewable energy “education”, participation, this form of banking system could be considered in the promotion of alternative energy in Thailand—to ensure project success and sustainability.

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