The Growth of SMEs through New Agricultural Opportunity : Case of the Development of Bio-energy SMEs in Thailand

Decharut Sukkumnoed
Faculty of Economics, Kasetsart University

Although Thailand is one of top exporters in the world agricultural market, the growth rate of agricultural sector in the last three decades has been comparatively low compared to the national economic growth. The struggles for introducing higher value added export products has been raised as the main strategy for boosting economic growth in Thai agricultural sector. With the nation-wide policy to promote One Tambol One Product since 2002, moving towards higher-end markets has been succeed in developing thousands of new SMEs all over the country, both in the forms community-based and private enterprises. All these enterprises can certainly be one of the main engines for agricultural growth and poverty alleviation in Thailand.

Concurrently, Thailand has faced energy crisis, started from 2004 and peaked in 2008, leading to higher import burden for the economy. In 2008, Thailand's import burden for energy was reached 1 trillion THB and equal to 20% of national import value (Decharut Sukkumnoed, 2008). On one hand, this leads to the higher cost in almost all sectors within the economy, including agricultural sector. On the other hand, the energy price surge has brought the good opportunity for bio-energy development in the country.

The public concern over the effects of global climate change also leads to the stronger support for bio-energy as one of the highest potential renewable energy development in Thailand. Moreover, the race of the carbon-credit, through Clean Development Mechanism under the Kyoto protocol, make the bio-energy projects much more attractive for investment. As a result, within the last five years, the number of SMEs in bio-energy businesses has mushroomed in the country.

The rapid growth in bio-energy projects represents strong opportunity for bio-energy SMEs to be another strategic direction for boosting economic growth in agricultural sector. This paper will examine the policy frameworks and implementations for bio-energy SMEs development projects in this country.

The paper will firstly present the potential of bio-energy development in Thailand. The second part will be the analysis of bio-energy potential in Thailand. Third, the paper will introduce the development of bio-energy in Thailand, before presenting government's mater plan for renewable energy and policy mechanism in the forth section. Then, in the fifth section, the opportunity of bio-energy SMEs and the successful cases will be analyzed. Later, the key success factor of bio-energy SMEs will be shown. Last, the conclusion and policy recommendations will be made for supporting the development of bio-energy SMEs.

1. Potential of Bio-energy Development in Thailand

For Thailand, main fuels of bio-energy are agricultural products, by-products, and wastes, or so-called biomass resources. Several domestic biomass resources, such as bagasse, rice husk are known as the alternative energy sources for heat and power in the country. The agricultural waste, such as pig manures or other organic wastes can also turn to be energy through bio-chemical process or anaerobic digestion process. The utilization of molasses and palm oil to produce bio-fuels, namely bio-ethanol and bio-diesel, has also been expanded very fast during the four years.

In general, the process in turning biomass into energy can be divided in four main forms, as described below (summarized from Science and Technology Research Institute of Thailand, 2008);

- **Combustion:** the biomass can be burn, i.e. pass through the combustion process, and transform into energy in form of heat and power, or in form of other fuels, such as charcoal and fuel gases. The combustion process can be both direct combustion (with normal oxygen condition in the chemical reaction), and gasification or carbonization (with limited oxygen in the chemical reaction). The energy outputs of direct combustion are heat and power. The energy output of gasification is fuel-gases, which can be used and fuel for heat and power and the outputs for carbonization process is charcoal.
- **Anaerobic Digestion:** Anaerobic digestion is a bio-chemical or fermentation process without oxygen using anaerobic micro-organisms. The output of the digestion process is biogas, which composed of methane. All organic wastes, without strong chemical contamination, can be turned to be biogas, and later transform into both heat and power.
- **Ethanol Fermentation**: Like anaerobic digestion, ethanol fermentation is a bio-chemical or fermentation process; but using yeast to transform sugar or starch into ethanol, which can be used as bio-fuel in blending with gasoline. The main raw materials for ethanol fermentation in Thailand are molasses and cassava.
- **Trans-esterification :** Trans-esterification is a chemical reaction which transform vegetable oil into glycerol and methyl-ester. Methyl-ester, or so-called bio-diesel, can be used for blending with diesel or, in come cases, used directly in diesel engine. The main raw materials for bio-diesel in Thailand are palm oil and used vegetable oil.

Potential of Biomass Resources

Thailand has abundant biomass resources. Rice, sugar, palm oil, and wood-related industries constitute the main potential biomass energy resources. According to the Department of Alternative Energy Development and Efficiency (DEDE), an estimated 64.5 million tons of agricultural and wood residuals are produced each year in Thailand (Table 1). Presently, most of these residues are disposed of through open burning and dumping, except for bagasse, rice husk, fiber and shell of palm oil, and shell of coconut. The remaining biomass resources, which can be used for energy purposes, is about 42 million tons, which equals 605 PJ or 2.5 times higher than the present biomass used for energy purposes. Later, DEDE also estimated the unused potential of all agricultural residuals, as shown in Table 2, and found that the overall resource potential of biomass is equal to 721,935.9 TJ or 9,630 MW in terms of electric power.

However, not all resource potentials are be commercially viable, especially with the regard to the difficulties in collecting agricultural residuals, such as leaf and top of sugar cane or rice straw, and their financial returns. Peter du Pont analyzes the commercial conditions of biomass resource utilization in Thailand and estimates that, within 2011, 2,463 MW of biomass resource will be commercial available. He also discounts this commercial potential by technological factor (25% lower) and institutional factor (50% lower) and concludes that 897 MW of new installed biomass power should be practically achievable during 2005-2011.

The Ministry of Energy expects the power generation potential of Biomass resources to be as high as 4,400 MW of power and 7,400 kTOE of heat and sets up a clear target to stimulate biomass power generation up to 2,800 MW by 2011 and then later expand to 3,700 MW by 2022.

Table 1 Assessment of the Biomass Energy Potential of Agricultural Residuals in Thailand in 2000

Products and Production (Million Tons)		Residuals	Quantity (Thousand Tons)	Utilization Rate (%)		Quantity (Thousand Tons)		Energy (PJ)	
				Used	Unused	used	Unused	used	Unused
Sugarcane	53.5	Bagasse	15,567	79.3	20.7	12,344	3,222	177.76	46.40
		Leaf & Top	16,155	0.0	98.6	0	15,929	0.00	277.01
Rice	24.2	Rice husk	5,560	50.7	49.3	2,819	2,741	40.23	39.11
		Upper Straw	10,805	0.0	68.4	0	7,391	0.00	75.67
Palm oil	3.26	Empty Bunch	1,394	3.0	58.4	42	814	0.75	14.54
		Fiber	479	85.8	13.4	411	64	7.24	1.13
		Shell	160	58.8	3.7	94	6	1.76	0.11
		Leaf Stem	8,479	0.0	100.0	0	8,479	0.00	83.35
		Stamen Bunch	759	0.0	100.0	0	759	0.00	12.39
Coconut	1.40	Fiber	507	28.9	59.5	146	595	2.37	4.89
		Shell	224	41.3	37.8	93	85	1.69	1.52
		Bunch	69	14.4	84.3	10	58	0.15	0.89
		Leaf	315	15.9	80.9	50	255	0.80	4.08
Cassava	19.1	Stem	1,678	0.0	40.7	0	683	0.00	12.58
Maize	4.29	Corncob	1,170	19.3	67.0	226	784	4.08	14.14
Groundnut	0.14	Shell	45	0.0	100.0	0	45	0.00	0.56
Cotton	0.03	Stem	116	0.0	100.0	0	116	0.00	1.69
Soybean	0.32	Shell	849	0.7	76.0	6	646	0.12	12.55
Sorghum	0.14	Leaf, Stem	178	11.8	64.8	21	115	0.40	2.22
TOTAL RESIDUALS			64,509			16,262	42,494	237.31	604.82

Source: DEDE, 2003, *Alternative Energy Situation*. www.dede.go.th

Table 2 Assessment of Unused Biomass Energy Potential of Agricultural Residuals in Thailand in 2001/2002

Raw Material	Production (million ton)	Residuals	Quantity (million ton)	Calorific Value (MJ/Kg)	Energy (TJ)	Power (MW)
Sugarcane	60.013	Bagasse	3.616	14.40	52,056.04	764.21
		Leaf & Top	17.087	17.39	310,762.62	4,105.92
Rice	26.514	Rice husk	3.006	14.27	42,901.65	566.83
		Upper Straw	8.106	10.24	83,011.61	1,096.78
Palm Oil	4.089	Empty Bunch	1.002	17.86	18,253.88	241.18
		Fiber	0.081	17.62	1,419.21	18.75
		Shell	0.007	18.46	136.85	1.81
		Leaf Stem	10.648	9.83	104,667.44	1,382.91
		Stamen Bunch	0.953	16.33	15,558.20	205.56
Cassava	16.868	Stem	0.604	18.42	11,128.34	147.03
Maize	4.466	Corncob	0.816	18.04	14,736.44	194.71
Groundnut	0.129	Shell	0.042	12.66	527.50	6.97
Cotton	0.036	Stem	0.116	14.49	1,685.94	22.27
Soybean	0.292	Shell	0.591	19.44	11,488.51	151.79
Sorghum	0.145	Leaf, Stem	0.118	19.23	2,262.18	45.14
Wood	10.268	Wood residual	2.670	14.98	39,991.81	528.39
Total Residuals					***721,935.91***	***9,630.18***

Source: DEDE, 2003, *Alternative Energy Situation*. www.dede.go.th

1.2 Potential of Biogas Resources

Apart from solid biomass residues, wastewater containing organic matters from livestock farms, landfill site, and agro-industries has increasingly been used for energy production. The biogas systems can be locally produced and installed by several techniques such as UASB and Fixed Film Technology. The production of biogas can alleviate not only the energy costs by substituting the on-site use of fuel oil, LPG, or electricity, but also the local water pollution problems (Amartayakul and Greacen, 2002).

DEDE estimates that the biogas production potential of three main sources, animal farm, landfill, and agro-industrials, equals 2,179 Mm^3/year (Table 3). If it is assumed that 1 m^3 of biogas can produce 1.2 kWh of electricity with 8 operation hours a day, the potential power generation would be around 900 MW. However, there are two important notes to keep in mind. First, in various cases, biogas energy is better used or should be used in other forms of energy, such as LPG on-site consumption. Second, if better biogas technology and waste management would be explored, instead of landfill biogas, the biogas potential would probably be much higher.

Another source of resource potential estimation is presented by David Donnelly, the general manager of Clean Energy Development Co, Ltd., (Clean THAI), a firm which develops and finances biogas system fuels by waste products from cassava-processing industries and pig farms. With the existing SPP's electricity purchasing price, the commercial potential of biogas exceeds 1,200 MW. It consists of 300 MW from cassava waste water, 900 MW from cassava wet cake (or a fibrous waste byproduct of tapioca production), 50 MW from pig farms, and 15 MW from palm oil factories.

Peter du Pont uses this estimation as commercially viable power by counting only the 365 MW biogas productions from cassava waste water, pig farms and palm oil factories, which have already been implemented in actual cases in Thailand. He also estimates that, from this commercial potential, 245 MW of biogas power plants should be practically achievable in 2011.

Table 3 Assessment of the Biogas Energy Potential of Waste in Thailand in 2000

Waste	Quantity	Biogas Production (mill. m^3 / year)	Energy (PJ)
1. **Animal waste** (dry manual thousand ton /year)	**2,886.55**	**559.54**	**11.75**
1.1 Cattle	1,015.10	238.91	5.01
1.2 Buffalo	441.63	96.95	2.04
1.3 Swine	879.95	134.67	2.83
1.4 Chicken	512.87	81.57	1.71
1.5 Others[1]	37.00	7.43	0.16
2. **Domestic Landfill Waste** (Thousand ton/year)	**11,842.24**	**1,184.00**	**23.09**
2.1 Greater Bangkok	2,832.58	283.26	5.52
2.2 Other Municipalities	3,656.30	365.63	7.13
2.3 Outside Municipal area	5,353.36	535.34	10.44
3. Agro-industrial Waste water (thousand m^3 / year)	**205,942.30**	**435.33**	**10.45**
3.1 Tapioca Starch Industry	55,005.09	166.27	3.99
3.2 Sugar Industry	76,203.54	89.37	2.15
3.3 Palm Oil Industry	3,256.00	67.72	1.63
3.4 Seafood Canning	17,385.37	47.30	1.14
3.5 Others[2]	54,092.30	64.67	1.55
4. Total Biogas Potential		**2,178.87**	**45.29**

Source: DEDE, 2003a, *Alternative Energy Situation*. www.dede.go.th

Note: 1. Others include Duck and Elephant

2. Others include frozen seafood Industry, slaughterhouses, pineapple canning industry, carbonated soft drink industry, beer and liquor industry, and milk industry.

1.3 Potentials of Bio-ethanol

As mentioned earlier, raw materials for bio-ethanol in Thailand presently are molasses and cassava. Nowadays, almost 1.5 million tons of molasses, the by-product of sugar processing, is used to produce one million liters/day of ethanol. The rest of 250,000 liters of ethanol is now produced from cassava.

However, the supply of molasses is quite limited. In 2008, the total amount of molasses was 3.2 million tons. In other words, half of molasses' supply is now used for producing bio-ethanol. Therefore, the further expansion of bio-ethanol production, therefore, requires new raw material, namely sugarcane juice. Otherwise, the potential for bio-ethanol will be soon limited, as already seen the seasonal shortage in some periods.

Thailand is one of the top exporters in the world sugar market. From 7 million tons of sugar (or equal to 70 million tons of sugarcane), 5 million tons are export to the world market. The domestic consumption of sugar is only 2 million tons. The problem of relying on export market is the world price fluctuation, leading to lower returns for sugarcane farmers. Therefore, the shifting of sugarcane juice from producing raw sugar export to bio-ethanol for domestic consumption is highly possible, especially if the price of bio-ethanol was more attractive and stable.

Concurrently, there is also a huge potential to produce more ethanol from cassava. Now Thailand has exported around 20 million tons of cassava products, which more than half of this export (or around 10.5 million tons) is still in forms of cassava pellets for animal feeds. Only 7.7 million tons has been used for domestic consumption and only around 0.5 million liters has been used for ethanol production. Therefore, we can shift part of cassava from animal feed export to bio-ethanol for domestic consumption, if the price conditions were favorable.

With all these raw material potentials, around 8.2 million liters/day from sugarcane juice, plus 0.4 million liters/day from molasses can be expected. Moreover, 1.2 million liters/day of ethanol from cassava is also highly possible. Therefore, almost 10 million liters of ethanol can be produced, which equal to 50% of gasoline consumption in Thailand, without any area expansion required (Winai arrchkongharn et al, 2009).

1.4 Potentials of Bio-diesel

The potential of bio-diesel in Thailand, is quite limited compared to bio-ethanol. In 2008, Thailand produced 1.7 million tons of palm oil, which 1.0 million tons is used for domestic consumptions, 0.4 million ton for export, and 0.3 million ton for bio-diesel production. The consumption of bio-diesel in Thailand has been jumped from 0.2 million liters/day in 2007 to 1.5 million liters/day in 2008, leading to shortage of raw material for the beginning of 2008. Therefore, it is not possible to expand the bio-diesel production without area expansion and yield improvement of oil palm (Winai arrchkongharn et al, 2009). Thai government has set the plan to increase oil palm plantation from 3 million rais to 5.5 million rais aiming to produce bio-diesel up to 4.5 million liters/day (equal to 10% of diesel consumption in Thailand) in 2022 (Ministry of Energy, 2009).

The production of bio-diesel from used vegetable oil is also another possibility. Although the overall potential of used vegetable is around 700,000 liters/years, which is still quite small compared to bio-diesel from palm oil, it is useful mechanism to divert the used vegetable oil from unsafe cooking (due to the increasing risks of cancer) to bio-diesel production. It is also opportunity for community SMEs .

2. History of Bio-energy Development in Thailand

The starting point for bio-energy in Thailand is the introduction of "firm and non-firm Small Power Producers (SPP)" pricing scheme in 1992. This is the first time that Thai electricity market was opened to private producers for the first time. In fact, the SPP scheme is rather a general scheme, since this pricing scheme is used for both renewable and non-renewable power producers. It does not categorize the power producers according to types of technology and fuels, but on the basis of their guaranteed generation availability. Unsurprisingly, with the seasonal characteristics of their biomass resources, most of the current and foreseeable bio-energy power producers were non-firm SPPs.

In 2002, the Thai government decided to use the Energy Conservation Fund (Encon Fund) for providing the first 5-year subsidy to renewable SPPs on the basis of a single-round bidding program. Renewable SPPs candidates had to submit a bid for the required amount of subsidy and the lowest bids were accepted up to either the specific amount of sold capacity or the limited subsidy budget. There are several biomass power producers who won the bid and get the subsidy right now.

At the same time, the Thai government also set up another scheme for very small power producers (VSPP) with less than 1 MW capacity sold to the grid. Due to their smaller size, they have great difficulties in applying for firm or non-firm SPPs. The VSPP pricing scheme is similar to the net metering system in the USA, where the excess capacity generated by renewable producers will spin back the existing customer's electricity meter and the customer can save it for future use. The establishment of VSPPs is one of the most important steps for development of bio-energy SMEs in Thailand, because it ensures that VSPPs can access to the grid. Later, in 2007, Thai government expands the VSPP from 1 MW to 10 MW.

Table 4 presents the current situation of bio-energy power producers in Thailand. In 2008, there are 91 bio-energy power producers selling power to the grid, of which 60 producers is VSPPs or so-called bio-energy SMEs. In total, the installed capacity of bio-energy in Thailand has reached 1,574 MW. Around one-third of total bio-energy installed capacity is VSPPs' installed capacity. Moreover, there are more than 200 bio-energy power producers who already get the approval to sold to the grid. Most of these coming bio-energy power producuers are VSPPs or bio-energy SMEs and bio-energy SMEs will share almost half of total bio-energy installed capacity soon.

Table 4 Status of Bio-energy Power Producers in 2008

Producers	**Already Sold to the Grid**		**Approved for Grid Access**	
	No.	**MW**	**No.**	**MW**
SPP	31	1,046.2	41	1,298.7
VSPP	60	528.2	182	1,232.0
Total	91	1,574.4	223	2,530.7

Source: Office of Energy Policy and Planning, 2009.

For bio-diesel, the introduction of bio-diesel starts in 1999 as small experimental projects in several community of Thailand. However, the nation-wide campaign for bio-diesel retail did not occur until 2005. In the beginning of 2008, Thai government announces the policy of B2 requirement standard, i.e. requires 2% of bio-diesel blending in all diesel products sold in the retail market. This leads to the big expansion of bio-diesel utilization, as later shown in Figure 1.

For bio-ethanol, the production and marketing of bio-ethanol in Thailand starts in 2003 as a governmental pilot project. In 2005, bio-ethanol was ready to serve for nation-wide market in form of gasohol E10 (blending 10% of bio-ethanol with gasoline). Thai government reduced the excise tax for bio-ethanol and gasohol in order to lower gasohol compared to gasoline. The price gap between gasohol and gasoline was widen in 2007, leading to steadily increase in bio-ethanol consumption in the later years, as shown in Figure 1.

With all the governmental policy supports, the development of bio-energy in Thailand during the last five years is very impressive. Figure 1 shows that the rapid increasing of bio-diesel and bio-ethanol uses. Now the consumption of bio-diesel and bio-ethanol are now both over one million liters/day. The expansion of bio-energy also finds in biomass power plants in Thai power sector, as seen in Figure 2. Presently, the installed capacity of biomass is now above 1,500 MW or almost 5% of total installed capacity in the country.

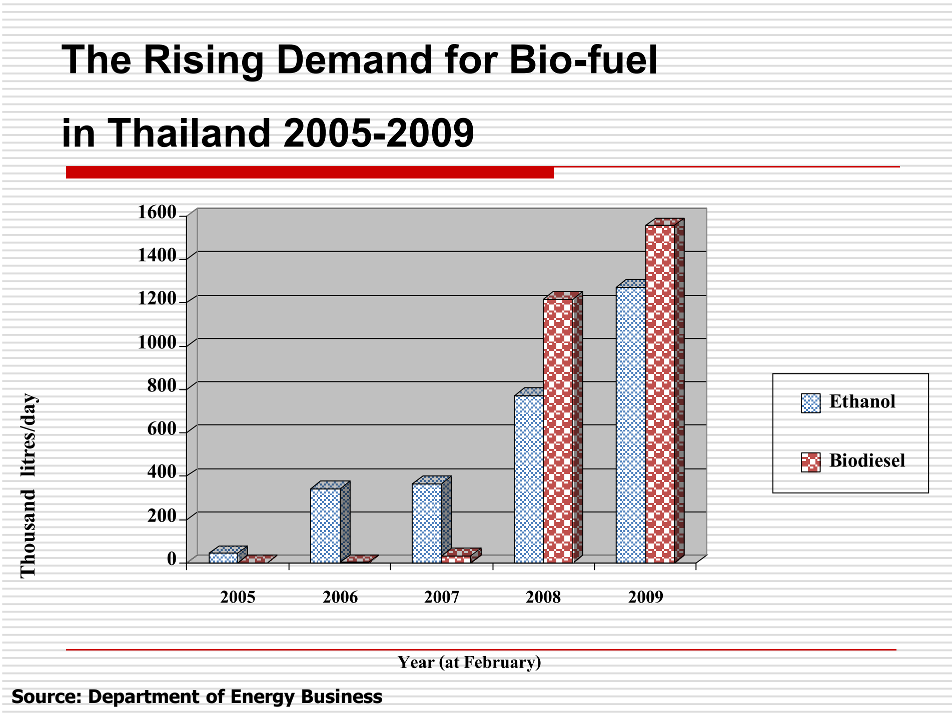

Figure 1 The Rising Demand for Bio-fuel in Thailand 2005-2009

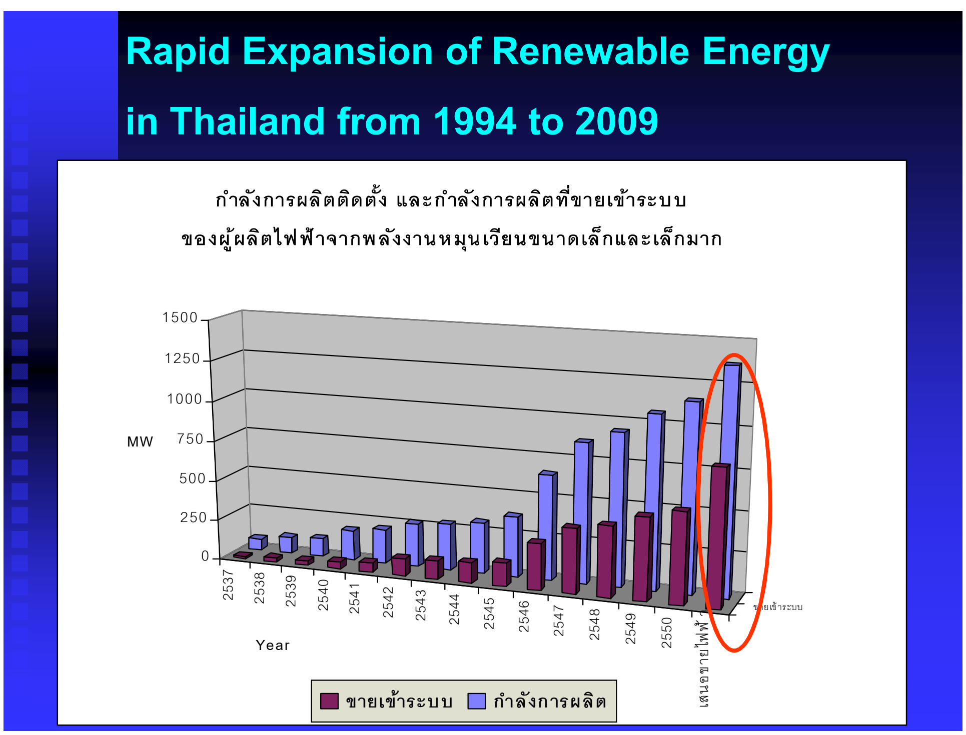

Figure 2 The Rapid Expansion of Bio-energy Power Producers from 1994 to 2009
Source: Calculated from Office of Energy Policy and Planning (2009)

3. The Master Plan for Renewable Energy 2022

In 2009, Thai Ministry of Energy launched long-term master plan for renewable energy 2008-2022, in order to promote more renewable energy development and low carbon society. In the national master plan, the target in 2022 for each renewable energy technology, including bio-energy was set up. Table 5 presents the target of bio-energy development in the master plan.

From the national master plan, obviously, bio-energy is expected to grow very fast in the next fifteen years. As seen in the Table5, Biomass and biogas both for heat and power is expected to grow more than double during the period of 2008-2022. At the same time, the growth of bio-fuels is expected to be even faster than biogas and biomass. In overall, in 2022, the share of bio-energy will reach 14% of total energy consumption within the country (the existing share of 6.4% of total energy consumption).

Table 5 The Bio-energy Development Target in The National Master Plan for Renewable Energy

Bio-energy Items	**Potential**	**Existing 2008**	**Target**		
			2011	**2016**	**2022**
Heat	Unit: kTOE				
Biomass	7,400	2,781	3,600	5,000	6,700
Biogas	600	224	470	540	600
MSW	n.a.	1	15	24	35
Electricity	Unit: MW				
Biomass	4,400	1,610	2,800	3,220	3,700
Biogas	190	46	60	90	120
MSW	400	5	78	130	160
Bio-fuel	Unit: Mil. Liters/day				
Bio-ethanol	9.00	1.24	3.00	6.20	9.00
Bio-diesel	4.50	1.56	3.00	6.64	4.50

Source: adjusted from Department of Alternative Energy Development and Energy Efficiency (2009).

It is very important to note that, although in the national master plan for renewable energy includes other kinds of renewable energy such as wind, solar, and hydro energy, the bio-energy is still the most important part of this renewable master plan. For example, the 2022 target of heat production from biomass, biogas, and MSW in the master plan equals to 99.5% of total renewable target in terms of heat.

For the power sector, the 2022 target of biomass, biogas and MSW equals to 89.9% of total renewable target in the master plan. In terms of fuel, bio-fuel also shares more than 95% of total renewable target. In other words, the bio-energy is the most important sources of renewable energy in Thailand.

Thai government believes that the benefits of the national master plan for renewable energy can be seen in various forms; such as.

- **Reduce national import burden** for fuels and energy by 460,000 million THB/year in 2022
- **Increase the private investment for bio-energy and renewable energy** by 382,240 million THB/year
- **Create new jobs** around 40,000 jobs in 2022, which mainly concentrated in the agricultural and rural sectors
- **Save public investment burden** for fossil fuel power plants by 3,800 MW or equal to 100,000 million THB
- **Reduce carbon emission**, which may convert to around 14,000 million THB of carbon credit value per year.

To achieve the targets, Thai government also provides several incentives through different policy mechanisms. The main policy mechanisms for promoting bio-energy are described as followed (Ministry of Energy, 2009);

- **Very Small Power Producer Policy**; which allow very small power producers (with lower than10 MW capacity sold to grid) from renewable energy, including bio-energy, can easily access into the grid, i.e., entering into the reliable market.
- **The Price Adder Mechanism**; which provides an additional pricing incentive for renewable energy producers to produce and supply electricity to the grid. The adder are varied by energy technologies; such as 0.3 THB/kWh for biomass and 2.3 THB/kWh for electricity from community wastes.
- **Government Obligation for Renewable Standard**; which determine the share of bio-energy mixing in the conventional fuel consumption. For example, in 2008, Thai government started the requirement of B2 or mixing bio-diesel 2% in all diesel products sold in the country. In 2022, Thai government aims to announce B10, or bio-diesel 10% for all bio-diesel consumption.
- **Tax Reduction**; which used to lower the price of gasohol (gasoline + bio-ethanol) compared to normal gasoline price, leading to an increasing of gasohol (thus bio-ethanol) demand.
- **Tax Exemption** for imported machinery and equipments for renewable energy development.

- **Investment Subsidy**; which used in promoting some certain projects, such as biogas, biomass gasification, and community waste projects. The investment subsidy will pass through energy conservation fund taxed from petrol consumption. The governmental sharing in an overall investment varies by types of project (for example 45% sharing in cases of biogas).
- **Government and Local Government Support Project**; which pass through several governmental agencies to support small development projects; especially community-based bio-energy development projects.

4. The Opportunity for SMEs and Successful Cases

This increasing trend of bio-energy development in Thailand certainly provides an important opportunity for SMEs development in Thai energy sector. However, it is very important to note that some types of bio-development energy are not suitable for SMEs. For example, ethanol-processing plants require huge investment and, therefore, economy of scale. Presently, small ethanol-processing plant still faces the lack in appropriate technology in dehydrating to purify bio-ethanol. Very small power plant, such as 10 MW biomass power plants, still requires more than 400 million THB of investment. Obviously, there are some barriers to entry for bio-energy SMEs, especially investment burden and appropriate technology.

Fortunately, there are still a plenty of rooms for bio-energy SMEs, because several bio-energy technologies do not require economy of scale.

4.1 Biogas SMEs

The applications of biogas for SMEs can be in various forms; including for manures from livestock production, municipal solid waste, and organic wastes from agro-industry. All these applications can be done at small scale levels. Presently, there are around 50 bio-gas SMEs who sell electricity to grid. Some community-based biogas SMEs also succeed in promoting the use of biogas as an effective way to manage organic wastes. As shown in Figure 3, *Bo-hawe* community-based SMEs in *Lampang* province develop different types of small biogas reactors for turning organic wastes into biogas. The *Bo-hawe* municipality found this initiative is very useful and provide strong supports for the extension of biogas, leading to larger market opportunity for this biogas SMEs.

Figure 3 Biogas Innovation in *Bo-hawe* community-based SMEs

Recently, Thai researchers and local SMEs in *Pattalung* province succeeded in turning wastewater from rubber sheet production, which normally cause local environmental problems due to its bad smell, into biogas, as seen in Figure 4. Certainly, this innovation can lead to new huge opportunity for bio-energy SMEs, especially for the Southern part of Thailand. The benefits of biogas applications can be both in forms of household consumption in cooking stove, power generation and power sold to the grid, and fertilizer. Moreover, several biogas SMEs in Thailand also succeeded in selling of biogas technology. The renewable energy master plan (2008-2022) with strong policy supports will provide larger opportunity for biogas SMEs, especially for municipal wastes.

Figure 4 Biogas Innovation from Rubber Sheet Wastewater in Pattalung Province

4.2 Innovation in Charcoal Production SMEs

During the last four decades, the utilization rate of charcoal in Thailand has been dropped continuously due to the penetration of LPG cooking stove. However, after the energy price surge in the last five years and the expansion of Thai hot soup restaurants, the use of charcoal become more popular again. The innovations in charcoal production also play a key role in boosting charcoal production in the country. The energy efficiency in charcoal production improve from around 10-20% to nearly 30%. Different types of efficient charcoal stoves allow charcoal makers to use small wood sticks as raw material. Therefore, it helps biomass SMEs much easier access to raw material. The introduction of wood vinegar uses for organic farming also brings a new market to biomass SMEs. In various cases, the revenue from wood vinegar selling is even higher than the revenues from charcoal.

Figure 5 The Introduction of Efficient Charcoal Stove in *Loei* Province

Recently, Thai researcher, with the close collaboration of SMEs in mushroom production in *Nakorn Nayok* province, succeeded in applying charcoal production for steam production by using excess heat from the charcoal stove, shown in Figure 6. Instead to buying fuels from outside, through this process, the biomass SMEs can sell their charcoal , wood vinegar, and can get the steam for their mushroom production. This innovation can lead to the application of charcoal cooking stove for mushroom production and spa business.

Figure 6 The Biomass Innovation for SMEs in mushroom production in *Nakorn Nayok* province

4.3 Biomass Gasifier SMEs

Apart from charcoal production, the dry biomass resources can be used in forms of gasification, or the combustion in low oxygen condition, which produced fuel gases and can be used for both heat and power. Although gasification technology is quite new and complicated, the applications of this technology are growing rapidly. Now, the biomass gasification can be used for 50-200 kW power generation, which enough for the whole village. Thai government has a clear plan to support more biomass gasification for power generation and for post-harvest drying of farm products, providing more opportunity for bio-energy SMEs.

Biomass gasification can also produce in forms of gasifier cooking stove. Recently, Thai researcher with community-based SMEs in *Petchaboon* province succeeded in producing gasifier cooking stove from rice husk, shown in Figure 7. The gasifier cooking stove is much more convenient than conventional biomass cooking stove and reduce the household expenditure for LPG sharply (around 2,000 THB/household/year). After this gasifier cooking stove introduction, community-based SMEs in some provinces also succeed in applying and expanding biomass gasifier cooking stove production into business scale. With the fact that Thailand has to import a huge amount of LPG, the opportunity for biomass gasifier cooking stove is certainly open.

Figure 7 The Development of Gasifier Cooking Stove in *Petchaboon* province

4.4 Bio-diesel SMEs

Bio-diesel SMEs were among the first bio-energy in Thailand, since 1999. However, the oil price fluctuation and the lack of clear and appropriate bio-diesel standard create difficulties for small bio-diesel business. Fortunately, the recent government supports, such as bio-diesel standard and bio-diesel requirement can alleviate some problems, leading to more opportunity for bio-diesel development. At the same time, the continuous technology development in the recent years can improve the quality of bio-diesel from SMEs and more consumers' acceptance. The remaining difficulty is the maintaining of raw material procurement at reasonable cost, due to the competitive uses of used vegetable oil. Therefore, if raw material procurement can be secured, the success of bio-diesel SMEs can be more ensured. As seen in Figure 8, bio-diesel SMEs in *Songkhla* province can maintain the raw material procurement through community supports and, thus, succeed in maintaining bio-diesel business.

Figure 8 Bio-diesel SMEs in *Songkhla* Province

5. Key Success Factors

Obviously, the success of bio-energy SMEs in Thailand depends on various factors different levels. From the top view, **clear policy direction**, especially the National Master Plan for Renewable Energy, is very essential for establishing of necessary policy mechanisms and also for call for supports from related government and private agencies.

From the clear policy direction, the establishment of **effective policy mechanisms** has to be worked out and, later, appropriately implemented. In Thailand, pricing incentives, such as tax reduction or adders, is quite an effective mean to boost bio-energy development through higher and more stable returns.

Moreover, very small power producers or VSPP scheme and renewable requirements for bio-energy is also important policy measures for allowing bio-energy to access into energy markets. Since energy markets are normally monopoly or oligopoly markets, **access to energy market** is very essential for bio-energy development, especially for power and petrol market. The growth of organic farming and climate change concern also leads to the creation of new markets for bio-energy, such as wood vinegar from charcoal production.

Apart from the essential policy directions and mechanism, the supply-side factors are also important. As seen from various cases in Thailand, **the development and introduction of appropriate technologies for SMEs** is very crucial. The development of biogas and biomass techniques in these recent years has brought new opportunity and market. Therefore, it is very important to facilitate further development of bio-energy technologies and the exchange of knowledge and information.

Together with appropriate technologies, successful SMEs require **essential human resources,** especially the technical and engineering skills for each bio-energy implementation. Therefore, the development of human resources for bio-energy is highly recommended.

In addition, for bio-energy SMEs, **the logistics of raw materials** is very crucial. Although bio-energy's raw materials are plenty, the procurement of materials is not an easy job. Several bio-diesel SMEs cannot maintain their business, because they do not succeed in finding adequate amount of raw materials. Thus, bio-energy SMEs must pay serious attention in raw material management through the contract with suppliers and supports of farmers and communities.

The **attractive investment schemes** are also very important for the success of bio-energy SMEs, because all bio-energy SMEs' projects normally require an additional investment. With the limited financial resources, bio-energy SMEs require the short pay-back period, for example not longer than 5 years. Fortunately, from the recent experiences, the pay-back periods of investment in bio-energy SMEs' projects, as described in previous section, are normally less than 3 years, as shown in Table 6. Therefore, the bio-energy SMEs are quite attractive investment. The important points is to secure the source of fund for additional investment. Apart from government investment subsidy and supports, the support from commercial banks and other financial mechanism can be useful for SMEs development.

Table 6 Investment Returns from Some Selected Bio-energy SMEs projects.

Bio-energy	Investment Cost (THB)	Annual Return (THB/year)	Pay-back period (year)
Biogas			
From rubber sheet wastwater	15,000	3,600	3.0
From organic waste	5,000	2,000	2.5
Charcoal stove with wood vinegar	10,000	10,000	1.0
Charcoal stove with steam-making	15,000	7,200	2.2
Rice husk biomass gasifier	4,000	2,000	2.0

Source: Decharut Sukkumnoed, 2009.

Last but not least, **the community support** is also very helpful in development of bio-energy SMEs. In some cases, for example bio-diesel or biogas SMEs, community supports can lead to more secure raw material procurement, such as used oil and organic wastes. Community supports can also be useful for market expansions through the acceptance of bio-energy products and by products, for example, biogas or wood vinegar. In some cases, the community supports can even lead to the co-investment both in forms of collective investment by community members and investment supports from local administrative organizations.

7. Conclusion and Recommendations

The oil price surge and climate change brings a new opportunity for bio-energy development. SMEs also take this opportunity by learning in new technologies and operating new businesses. With strong government policy direction and mechanisms, the opportunity for bio-energy SMEs has been expanded and more ensured. The growth of bio-energy SMEs do not only bring economic opportunity for rural communities, but also solve several environmental problems, including managing organic wastes and reducing greenhouse gas emission. All these factors lead to an impressive growth of bio-energy SMEs in these recent years.

To maintain the momentum of bio-energy SMEs, Thai government needs to **provide more supports further appropriate technology development and learning process for human resource improvement**, which are the two key factors for recent growth. At the same time, Thai government and private sectors can **help bio-energy SMEs in finding new investment opportunities**, which is still one of main limitations for bio-energy SMEs development within the country. Moreover, concern over raw materials' logistic constraints must be addressed systematically. **The concept of holistic supply chain management for bio-energy** should be introduced and implemented at both national and local levels. Last, **community supports must be strengthened through several active participation means** to ensure that bio-energy development will yield the positive results for community, including poverty alleviation, in both short-term and long-term.

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