

Potential of Agricultural Residues for Small Biomass Power Generation in Thailand

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Abstract

The demand for energy in Thailand has been continually increasing as the economic and social country grows. Approximately 60% of Thailand's primary energy is imported, mostly petroleum products. In 2008 Thailand's total energy consumption was 80,971 ktoe and the net price of energy imported was up to 1,161 billion Baht which is equivalent to 12.8% of GDP at the current price. The energy consumption or energy demand has been growing at an annual compounded growth rate of 6.42% and the peak electric power demand and electricity consumption was recorded at 22,568 MW and 148,264 GWh and grew at a rate of 7.0% and 7.5% per annum during the period from 1989 to 2008. The gross agriculture production in 2008 was recorded at 135.4 Mt which represents agriculture residue for energy at 65.73 Mt, which is equivalent to energy potential of about 561.64 PJ or 13,292 ktoe an increase in average of 5.59% and 5.44% per year respectively. The agricultural residues can converted to 15,600 GWh/year or 1,780 MW of power capacity. So, if government sector plan to install small biomass gasification for electricity generation 200 kW for Community. The residue agricultural is available for 8,900 plants nationwide. The small biomass power generation for electricity generation not only to reduce the energy imports, it also makes the job and income for people in rural areas as well. This paper's aim is to report the energy situation in Thailand and has studied 5 main agricultural products with high residue energy potential namely sugarcane, paddy, oil palm, cassava, and maize appropriate for small electricity production. These agricultural products can be found planted in many rural areas throughout Thailand. Finally, discuss the situation, methods and policies which the government uses to promote small private power producers supplying electricity into the grid.

Keywords: biomass, agricultural residues, energy potential, gasification

1. INTRODUCTION

The total energy consumption in Thailand has been continually increasing. Most of the energy Thailand uses is imported such as petroleum products. Although Thailand can provide some of its own energy

recourses such as natural gas and crude oil, the domestic energy recourses are not sufficient because of the increasing demand and the limitation of these energy resources. Over 80% of the total energy consumption of the country was absorbed by three main economic sectors namely the power, transport, and manufacturing sectors. Electric power is one of the major input factors in economic development. The process requires a lot of energy. When fuel prices increase the power price is increased accordingly. Use of alternative energy or renewable energy in the country is essential. Thailand is an agricultural country. Agriculture is a nationwide distribution. At present, biomass can be used to generate electricity from small electricity generation facilities. It is an effective way of eliminating agricultural waste and another way to reduce fossil fuel use. Now there are many supports from the government for small electricity producers such as the Small Power Producer and Very Small Power Producer Programs (SPP and VSPP) that allows selling the power to the grid under long term contracts, providing an “adder” on top of the normal tariff, soft loans, investment subsidies, etc. Currently the demand for electricity is increasing continuously but large power plants are difficult to build because of the local people’s opposition. While a small biomass power plant uses less space for installation, the life cycle of the biomass is relatively short and the process is not complicated, the local people can manage them by themselves. Small biomass power plants are another way to solve the energy crisis in future. Is important to reduce energy imports and reduce greenhouse gas emissions to the atmosphere as well. This paper’s aim is describing the energy situation in Thailand, the potential of biomass energy from agricultural residue appropriate for small electricity production, and the current policies of the government for promotion of power production for small power producers, which use biomass and renewable energy as the fuel to produce the electricity.

2. ENERGY AND ELECTRICITY SITUATION IN THAILAND

Approximately 60% of Thailand’s primary energy is imported, mostly petroleum products. Thailand can provide some of its own energy resources, such as natural gas, crude oil from the Gulf of Thailand and lignite from the Northern part of country, but these domestic energy resources are not sufficient because of the demand for energy has been continually increasing and the limitation of its energy resources. In 2008 Thailand’s total primary energy consumption was 80,971 ktoe [1]. Energy consumption is one of the major input factors in economic development. To support economic growth and meet energy requirements in the future, alternative energy resources are needed.

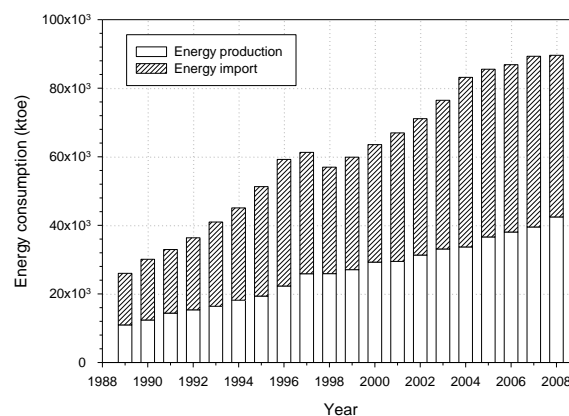


Figure 1. Energy consumption in Thailand

Figure 1 shows the energy consumption in Thailand during the period from 1989 to 2008. The energy consumption or energy demand has been growing at an annual compounded growth rate of 6.42%. The energy consumption is the sum of energy import and energy production which has been growing at an annual compounded growth rate of 7.49% and 6.53% per annum respectively from 1989 to 2008. Over 80% of the total energy consumption of the country was absorbed by three main economic sectors namely the power, transport, and manufacturing sectors. The economic condition and the world oil prices have pushed Thailand's net energy import to 1,161 billion Baht in 2008 equivalent to 12.8% of GDP at current price [2] as shown in Figure 2.

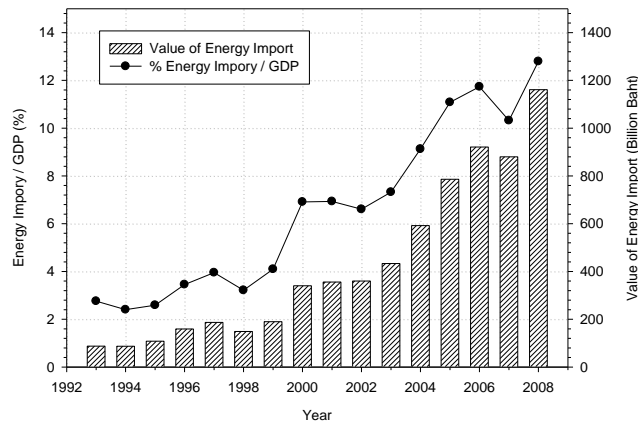


Figure 2. Value of energy import and percent of energy import/GDP

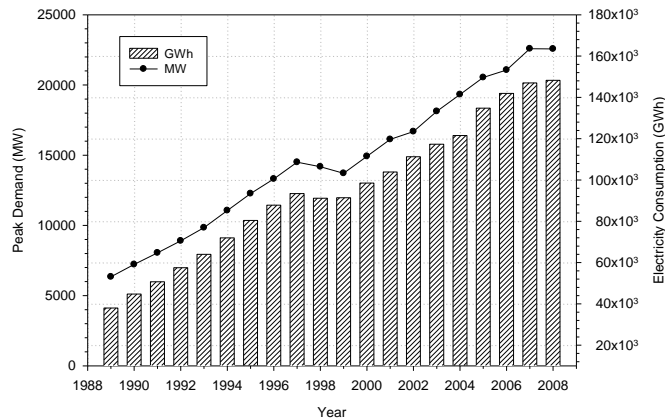


Figure 3. Peak electric demand and consumption

Electric power is one of the major input factors in economic development. Figure 3 shows the electricity consumption and peak electric power demand in Thailand from 1989 to 2008. In 2008 the peak electric power demand and electricity consumption was recorded at 22,568 MW and 148,264 GWh and peak electric power demand and electric consumption grew at a rate of 7.0% and 7.5% per annum from 1989 to 2008 respectively. Electric consumption will be continued increasing occurring in the power demand. It was observed that the electricity consumption and peak electric power demand decreased sharply because of the economic crisis during 1998 and 1999. Electricity forecasting has become one of the most important aspects

of electricity utility planning and it's very important today that we are planning to use alternative energy or renewable energy for the country's future.

3. POTENTIAL OF BIOMASS ENERGY FROM AGRICULTURAL RESIDUAL

Thailand is one of the world leaders in agricultural production. Biomass resources, especially agricultural residues, are abundant in the country. Sajakulnukit et al. [3] studied biomass residues from 10 main agricultural residues which possess energy potential. In 1997 the country's total agricultural waste was 61 million tons. The study further estimated an amount of 41 million tons of biomass residues, which is equivalent to about 426x10⁹ MJ of energy, was unused. Another independent study by EC-ASEAN COGEN Program estimated that energy potential from 4 main agricultural residues, namely bagasse, rice husk, palm oil wastes, and wood residues, was 11,200 GWh/yr or 2985 MW of power capacity [4]. There are several other agricultural residues in the country that can also be used for energy. This paper has studied 5 main agricultural products with high residue energy potential namely sugarcane, paddy, oil palm, cassava, and maize, planted in rural areas, and appropriate for small electricity producer. The energy potential estimation was performed based on residue product ratio (RPR) and as received calorific values as shown in Table I.

Table 1. RPR, calorific values and factor of agricultural residues

Product	Residue	RPR	Surplus availability factor	LHV (MJ/kg) (as received)	Residue weight factor	Energy potential factor
Sugarcane	Bagasse	0.250	0.207	6.430	0.350	2.364
	Top & trash	0.302	0.986	6.820		
Paddy	Husk	0.230	0.469	12.850	0.414	4.086
	Straw (top)	0.447	0.684	8.830		
Oil palm	Empty bunches	0.428	0.584	16.440	3.108	28.675
	Fiber	0.147	0.134	16.190		
	Shell	0.049	0.037	17.000		
	Fronde	2.604	1.000	7.970		
Cassava	Male bunches	0.233	1.000	14.860	0.036	0.609
	Stalk	0.088	0.407	16.990		
Maize	Corn cob	0.250	0.670	16.630	0.168	2.786

*Sources: Bhattachaya et al. (1989); DEDP (1992, 1994, 1995); Black and Veatch (1999).

Residue production ratio is the ratio of the amount of residue generated to the total amount of agricultural product produce and surplus availability factor is the ratio of surplus (presently wasted) amount to the amount of residue generated. Most calorific values or low heating value (LHV) were obtained from the tests conducted in the laboratories of the Department of Energy Development and Promotion (DEDP) of Thailand. The residue weight factor and energy potential factor are used to convert gross weight of agricultural products to residue weight and energy potential, the example in case of sugarcane, residue weight factor = $(RPR_{\text{bagasse}} \times \text{surplus availability factor}_{\text{bagasse}}) + (RPR_{\text{top \& trash}} \times \text{surplus availability factor}_{\text{top \& trash}})$ and energy potential factor = $(RPR_{\text{bagasse}} \times \text{surplus availability factor}_{\text{bagasse}} \times LHV_{\text{bagasse}}) + (RPR_{\text{top \& trash}} \times \text{surplus availability factor}_{\text{top \& trash}} \times LHV_{\text{top \& trash}})$.

In 2008 the gross agriculture production namely paddy, maize, cassava, sugarcane and oil palm was recorded at 135.4 Mt. The residues available for energy and energy potential of agricultural residues are

65.73 Mt and 561.64 PJ or 13,292 ktoe respectively. Figure 4 shows the trend of each product in Thailand. The agricultural production of paddy, maize, cassava, sugarcane and oil palm increases in average of 1.5%, 0.27%, 1.1%, 5.1%, 12.98% and 2.99 % per year respectively and the total of production increases in average of 3% per year. Table II shows each type of agricultural production, Table III shows a residue available for energy, Table IV shows energy potential and Table V shows the summary of estimate agricultural residues and energy potential from 1989 to 2008. The total of agricultural residues available for energy and energy potential are increases in average of 5.59% and 5.44% per year as shows in Figure 5. The information from status of biomass potential in 2007 [13], there are many types of biomass with more than 50% non-exploited. So, there are 5 main agricultural residues about 67.7 Mt. The non-exploited residue available for energy and energy potential are 32.87 Mt and 280.82 PJ. In case of small electricity generation, it is assumed that the average LHV is 18 MJ/kg. At full generation rate use in a gasifier/gas engine generator, giving an overall efficiency of conversion to electricity of about 20%, this takes no account of the potentially useful heat available from the gasifier/gas engine [14]. The agricultural residues can converted to 15,600 GWh/year or 1,780 MW of power capacity. So, if the Thailand government is having planned to install small biomass gasification for electricity generation 200 kW for Sub-district Administrative Organization (SAO). The residue agricultural is available for 8,900 plants nationwide.

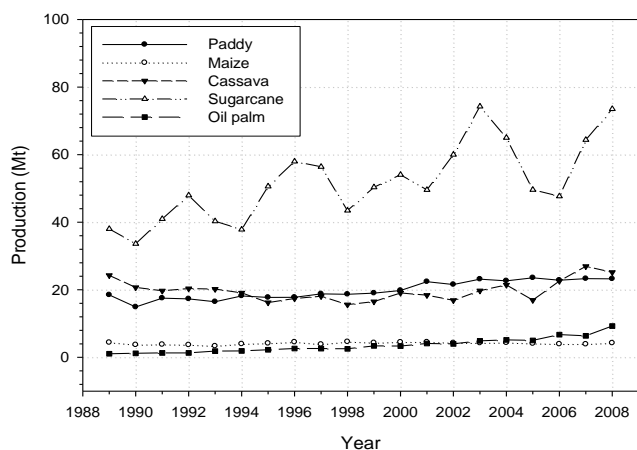


Figure 4. The trend of each agricultural product in Thailand in 1989 to 2008

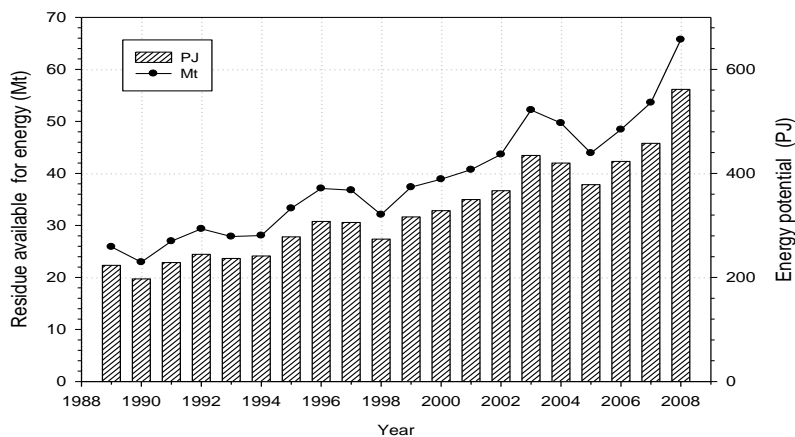


Figure 5. Thailand agricultural residues and energy potential in 1989 to 2008

Table 2. Production of agriculture in 1989 to 2008

Year	Production (Mt)					Total (Mt)
	Paddy	Maize	Cassava	Sugarcane	Oil palm	
1989	18.48	4.39	24.26	38.00	1.08	86.21
1990	14.90	3.72	20.70	33.62	1.18	74.12
1991	17.52	3.79	19.71	40.95	1.31	83.28
1992	17.30	3.67	20.36	47.95	1.32	90.60
1993	16.48	3.33	20.20	40.29	1.83	82.13
1994	18.16	3.97	19.09	37.82	1.92	80.96
1995	17.73	4.15	16.22	50.60	2.25	90.95
1996	17.78	4.53	17.39	57.97	2.61	100.29
1997	18.79	3.83	18.08	56.39	2.58	99.67
1998	18.66	4.62	15.59	43.46	2.52	84.86
1999	19.02	4.29	16.51	50.33	3.41	93.55
2000	19.79	4.47	19.06	54.05	3.34	100.72
2001	22.41	4.50	18.40	49.56	4.10	98.96
2002	21.57	4.26	16.87	60.01	4.00	106.71
2003	23.14	4.25	19.72	74.26	4.90	126.27
2004	22.65	4.34	21.44	65.00	5.18	118.61
2005	23.54	4.09	16.94	49.59	5.00	99.16
2006	22.84	3.92	22.58	47.66	6.72	103.72
2007	23.31	3.89	26.92	64.37	6.39	124.87
2008	23.24	4.25	25.16	73.50	9.27	135.41

Table 3. Residues available for energy in 1989 to 2008

Year	Residue available for energy (Mt)					Total (Mt)
	Paddy	Maize	Cassava	Sugarcane	Oil palm	
1989	7.64	0.74	0.87	13.28	3.37	25.90
1990	6.16	0.62	0.74	11.75	3.67	22.95
1991	7.25	0.64	0.71	14.31	4.09	26.98
1992	7.16	0.62	0.73	16.76	4.10	29.36
1993	6.82	0.56	0.72	14.08	5.68	27.87
1994	7.51	0.66	0.68	13.22	5.98	28.06
1995	7.33	0.70	0.58	17.68	7.01	33.30
1996	7.35	0.76	0.62	20.26	8.12	37.12
1997	7.77	0.64	0.65	19.71	8.01	36.78
1998	7.72	0.77	0.56	15.19	7.84	32.09
1999	7.87	0.72	0.59	17.59	10.61	37.38
2000	8.18	0.75	0.68	18.89	10.39	38.90
2001	9.27	0.75	0.66	17.32	12.73	40.74
2002	8.92	0.71	0.60	20.98	12.44	43.65
2003	9.57	0.71	0.71	25.95	15.24	52.18
2004	9.37	0.73	0.77	22.72	16.11	49.69
2005	9.74	0.69	0.61	17.33	15.55	43.91
2006	9.45	0.66	0.81	16.66	20.87	48.44
2007	9.64	0.65	0.96	22.50	19.86	53.62
2008	9.61	0.71	0.90	25.69	28.82	65.73

Table 4. Energy potential in 1989 to 2008

Year	Energy potential (PJ)					Total (PJ)
	Paddy	Maize	Cassava	Sugarcane	Oil palm	
1989	75.49	12.24	14.76	89.81	31.10	223.41
1990	60.89	10.37	12.60	79.46	33.88	197.19
1991	71.58	10.56	11.99	96.78	37.69	228.60
1992	70.70	10.23	12.39	113.34	37.78	244.43
1993	67.35	9.27	12.29	95.23	52.44	236.58
1994	74.20	11.05	11.62	89.40	55.13	241.39
1995	72.44	11.57	9.87	119.59	64.64	278.10
1996	72.65	12.63	10.58	137.02	74.88	307.77
1997	76.77	10.67	11.00	133.29	73.91	305.65
1998	76.25	12.86	9.49	102.73	72.34	273.68
1999	77.70	11.94	10.04	118.96	97.87	316.51
2000	80.85	12.46	11.60	127.76	95.86	328.53
2001	91.56	12.53	11.19	117.14	117.47	349.90
2002	88.12	11.86	10.26	141.84	114.74	366.83
2003	94.55	11.84	12.00	175.51	140.58	434.49
2004	92.54	12.09	13.05	153.62	148.59	419.90
2005	96.18	11.40	10.31	117.20	143.45	378.54
2006	93.32	10.91	13.74	112.64	192.56	423.18
2007	95.24	10.84	16.38	152.13	183.23	457.82
2008	94.94	11.84	15.31	173.73	265.83	561.64

Table 5. Summary of agricultural residues and energy potential in 1989 to 2008

Year	Residue available	Energy potential	
	for energy (Mt)	(PJ)	(ktoe)
1989	25.90	223.41	5,287.29
1990	22.95	197.19	4,666.84
1991	26.98	228.60	5,410.27
1992	29.36	244.43	5,784.86
1993	27.87	236.58	5,599.04
1994	28.06	241.39	5,712.91
1995	33.30	278.10	6,581.81
1996	37.12	307.77	7,283.78
1997	36.78	305.65	7,233.62
1998	32.09	273.68	6,477.07
1999	37.38	316.51	7,490.77
2000	38.90	328.53	7,775.15
2001	40.74	349.90	8,280.91
2002	43.65	366.83	8,681.65
2003	52.18	434.49	10,282.82
2004	49.69	419.90	9,937.52
2005	43.91	378.54	8,958.81
2006	48.44	423.18	10,015.15
2007	53.62	457.82	10,834.97
2008	65.73	561.64	13,292.17

4. CONCLUSIONS

Due to the current energy crisis, energy electricity demand and fuel prices continually increasing every year and the government's issuance of policies to promote energy efficiency and renewable energy, it can be seen that biomass-based power generation seems to be quite possible in both the technological aspects and the potential of biomass. However, for sustainable achievement, the Thai government does not only create confident mechanisms but also continually encourages the IPPs and SPPs with power purchase agreements, incentive investments, as well as research for new pilot plants.

Small electricity production from biomass agricultural residue is one solution to solve the domestic demand for the electricity in the future. It is feasible because small biomass power plants can be installed throughout the country, the local people can manage them by themselves and agricultural residues are plentiful in rural areas. In addition it would considerably decrease the burning of our forests and the disposal of agricultural residue saving the environment from SO₂ and NO_x emissions emitted into the atmosphere. Although energy policies adopted by the government are in the right direction, the pace of implementation is slow. It is very important for the government to disseminate information through public campaign to educate the public about alternative energy.

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