Bamboo: An Innovative Alternative Raw Material for Biomass Power Plants

Charcrit Sritong, Annop Kunavongkrit, and Chotihirun Piumsombun

***Abstract*—According to the 15-Year Renewable Energy Development Plan (REDP 2009-2022), Ministry of Energy Thailand, Thailand has promoted the establishment of the small power plant within communities to both public and private sectors. However, a crucial problem in establishing the community power plant is the lack of raw materials for the process of generating electricity. Because the raw materials are located in all regions of Thailand, and transportation costs are too high, it is not worth the investment. Therefore, this research aims to introduce alternative raw materials for generating electricity - the Gimsung bamboo and Tong bamboo. Their key specifications for providing energy are as follows: Moisture 14.30% and 5.80%, Ash 3.70% and 2.70%, Volatile Matter 63.10% and 71.70%, Fixed Carbon 18.90% and 19.80%, and Higher Heating Value 15.700 kJ/kg and 17.585 kJ/kg. In addition, the results showed that the Gimsung and Tong bamboo provided higher energy than the use of current raw materials. Moreover, the growth rate was 30 cm per day, and the CO_2 absorption rate was lower than the use of current raw materials. In summary, bamboo is an appropriate alternative raw material for generating the electricity of community power plants which conforms to the 15-Year Renewable Energy Development Plan (REDP 2009-2022).**

***Index Terms*—Bamboo, biomass, innovation, power plant, raw material.**

I. Introduction

In the past 20 years (1990-2010), the energy consumption of Thailand has continuously increased by an average of 4.4 percent per year. At this present time, the current energy consumption is about 2.3 times the energy consumption in 1990. This has grown along with economic expansion which has averaged 4.5 percent per year. Furthermore, energy consumption in the industrial sector and commercial buildings is higher than the growth rate of GDP, having increased by 3.0 and 3.7 times respectively [1].

In addition, because of the current energy situation in Thailand, the Ministry of Energy has attempted to seek alternative renewable energy sources such as nuclear power. However, there has been opposition by the people because most of them have no trust in the technology and safety of nuclear power plants. Therefore, the government has solved this problem by using a policy of community involvement, and has launched a renewable energy strategic plan of Thailand - the 15-Year Renewable Energy Development Plan (REDP 2009-2022). However, the results from the survey show that the use of renewable energy is only 2% [2].

Moreover, the essential problems of establishing renewable energy power plants are as follows [3]:

1) The most important problem for the biomass power plant is its acceptance by the community surrounding it. If the biomass power plant is not recognized by this community, problems can be caused in all aspects of the operation.
2) Raw material costs have increased year on year; this rate of increase is about 20-30% per year. However, the return on the sale of electricity to the Ministry of Energy in Thailand does not have an adjusted price according to the price of raw materials.
3) Raw material planting of eucalyptus and lead trees involves a large planting area. In addition, it takes the long period of around three to five years to harvest them as raw material.
4) The volume of fast growing trees used as raw material is insufficient.
5) The technology of biomass power plants must not pollute the community and must be accepted by the community.
6) The payback period of biomass power plants per capacity is also an important issue.

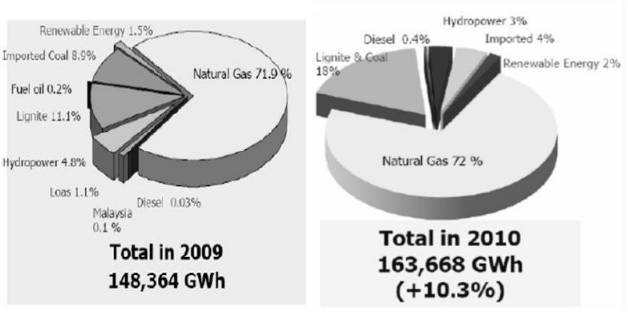

Fig. 1. Primary energy sources for producing electricity [2]

Recognizing these problems, Thailand has promoted the use of alternative raw materials for electricity production in biomass power plants. These raw materials are divided into two types. The first type of raw material is the fast growing tree such as Eucalyptus, Augustus, Mimosa, Acacia, and Acacia mangium Willd. The second type of raw material is the waste from agriculture and forestry such as Rice Husk, Rice Straw, Wood Waste, Palm Fiber, Tapioca Rhizome, and Corncob. However, these raw materials which are supported by the government require high investment in collecting them because they are located in different regions or have different growing seasons. Because of the above mentioned problems, this research aims to introduce bamboo as an alternative raw material of renewable energy in electricity production in order to reduce the production costs so that entrepreneurs of

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C. Sritong is with Technopreneurship and Innovation Management-Chulalongkorn University, Bangkok, Thailand (charcrit_sritong@hotmail.com).

A. Kunavongkrit is with The Office of the Commission on Agricultural Resource Education-Chulalongkorn University Bangkok, Thailand.

community power plants can produce electricity for sale to the government [4].

II. Research Objectives

1) Determine the specific properties of bamboo as a raw material for electricity production of biomass power plants in Thailand.
2) Compare the characteristics of bamboo and other raw materials used in electricity production of biomass power plants in Thailand.

III. Material Testing

Two types of bamboo as a new type of raw material in electricity production were tested in this research. They were Gimsung bamboo (Scientific name: Bambusa Deecheyama) and Tong bamboo (Scientific name: Dendrocalamus asper). Testing consisted of three main steps as follows:

1) To test the energy of each raw material by determining the volatile matter, fixed carbon, ash and high heating value (HHV).
2) To compare the energy of 14 existing raw materials and two new raw materials (bamboo).
3) Conclude the results.

IV. Literature Review

The approach to resolving the lack of raw material of biomass power plants in Thailand consists of six main issues as follows [5]:

1) Establish public hearings for public comments and participation in power plant projects.
2) Provide agricultural information to communities so that they can manage their lands for growing bamboo and take part in generating electricity of power plants.
3) Provide knowledge on the benefits of growing bamboo which can supplement their income.
4) Establish contract farming which insures both the bamboo price and purchasing quantity. This will benefit both the buyer who can control the raw material cost and quantity, and the agriculturist who can meet market demand and raw material cost.
5) Specify the quantity or proportion of growing bamboo by themselves and purchasing from communities.
6) Evaluate the satisfaction level of agriculturists who participate in the bamboo-growing projects.

The six approaches above indicate that bamboo can be an appropriate alternative raw material to resolve the lack of raw material for biomass power plants in Thailand. Moreover, existing bamboo in Thailand consists of 15 genus and 82 species [6]. The bamboo which is selected as the raw material in producing electricity should have thick wood. Two types of bamboo which are commonly planted in Thailand are Gimsung bamboo and Tong bamboo [7].

V. Research Results

The raw materials which were tested and compared with the bamboo in this study consisted of rice husk, rice straw, cane trash, parawood, palm shell, palm trunk, corncob, tapioca rhizome, bagasse, palm fiber, empty fruit bunch, palm leaf, corn stalk, and eucalyptus bark. The two types of bamboo which were tested were Gimsung bamboo as shown in Fig. 2 and Tong bamboo as shown in Fig. 3. The specific properties of this testing consisted of Moisture, Ash, Volatile Matter, Fixed Carbon, and Higher Heating Value (HHV). The ASTM E 870 and D 5865 were used as the instruments of testing. The results of this research are shown in Table I .

Fig. 2. Gimsung bamboo (Scientific name: Bambusa Deecheyama)

Fig. 3. Tong bamboo (Scientific name: Dendrocalamus asper)

From the testing, the results showed that the palm shell had the highest heating value 18.446 kJ/kg. Moreover, the specific properties of combustible substance - volatile matter and fixed carbon - were considered in producing electricity by the gasification technique. The rice husk had the highest fixed carbon 18.88% and the palm shell had the highest volatile matter 68.31%. Furthermore, the palm lead had the lowest ash 0.72%.

TABLE I: SPECIFIC PROPERTIES OF THE RAW MATERIALS FOR BIOMASS POWER PLANTS.

Properties of biomass material in Thailand.	Moisture %	Ash %	Volatile Matter %	Fixed Carbon %	Higher Heating Value kJ/kg
Rice Husk	12.05	12.73	56.98	**18.88**	14.638
Rice Straw	10.12	10.42	60.87	18.80	13.275
Bagasse	50.76	1.75	41.99	5.86	9.664
Cane Trash	**9.34**	6.23	67.78	16.90	16.342
Parawood	45.32	1.70	45.67	7.71	10.112
Palm Fiber	38.57	4.55	42.53	14.39	13.279
Palm Shell	12.12	3.66	**68.31**	16.30	**18.446**
Empty Fruit Bunch	58.67	2.09	30.52	8.90	9.265
Palm Trunk	48.34	1.34	38.98	11.70	9.370
Palm Leaf	78.34	**0.72**	16.42	4.60	3.889
Corncob	40.11	0.95	45.55	13.68	11.198
Corn Stalk	41.69	3.80	46.98	8.14	11.634
Tapioca Rhizome	59.78	1.69	31.09	8.10	7.423
Eucalyptus Bark	60.09	2.33	28.02	9.56	6.723
Bamboo Gimsung (Bambusa Deecheyama)	**14.30**	**3.70**	**63.10**	**18.90**	**15.700**
Bamboo Tong (Dendrocalamus asper)	**5.80**	**2.70**	**71.70**	**19.80**	**17.585**

VI. SUMMARY OF COMPARISON BETWEEN EXISTING AND NEW RAW MATERIALS OF BIOMASS POWER PLANTS

1) In the HHV comparison between the palm shells (the highest HHV of the existing raw materials) and the new raw materials, the Gimsung and Tong bamboo, the results showed that the HHV of both bamboos, 15.700 kJ/kg and 17.585 kJ/kg respectively, were close to the HHV of palm shells.
2) In the combustible substances-volatile matter and fixed carbon-comparison between the palm shells (the highest energy of the existing raw materials) and the new raw materials, the Gimsung and Tong bamboo, the results showed that the volatile matter and fixed carbon of both bamboos were higher than the palm shells. The volatile matter of the bamboos was 63.10% and 71.70% respectively and the fixed carbon of both bamboos was 18.90% and 19.80%, respectively.
3) In the ash comparison between the palm leaf (the lowest amount of ash of the existing raw materials) and the new raw materials, the Gimsung and Tong bamboo, the results showed that the amount of ash of the palm leaf was lowest, 0.72%, while both bamboos had ash of 3.70% and 2.70% respectively. However, the HHV, volatile matter and fixed carbon of palm leaf were much lower than both bamboos.

VII. CONCLUSION

The results of this research show that the energy gained from Gimsung bamboo and Tong bamboo, with their specific properties and growth rate, is appropriate for producing electricity. Shanmughavel and Francis [8] argued that the growth rate of bamboo is approximately 30 cm height per day (without rain). In addition, bamboo has more benefits than other raw materials such as greater CO_2 absorption. The rate of CO_2 absorption and O_2 production of one bamboo tree per year is as follows: 1st year- 5th year: 41, 165, 413, 495 and 578 kgs of CO_2 respectively. After the 5th year onwards the rate of CO_2 absorption and O_2 production of bamboo remains the same over the next 200 years [9]-[11]. To sum up, bamboo can be an alternative raw material for producing electricity for biomass power plants in Thailand.

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Charcrit Sritong is currently a Ph.D candidate in the Technopreneurship and Innovation Management Program of Graduate School, Chulalongkorn University in Thailand. He has a B.Sc. degree (Industrial Physics and Medical Instrumentation) from King Mongkut's Institute of Technology North Bangkok in Thailand, and a MBA degree (Manufacturing Management) from Mahanakorn University of Technology in Thailand.

Annop Kunavongkrit currently is a Director of The Office of the Commission on Agricultural Resource Education (OCARE) at Chulalongkorn University in Thailand.

Chotihirun Piumsombun has a B.Sc. degree Science for Biology from Chulalongkorn University in Thailand and a Master degree for Master of Administration from Vancouver, British Columbia University in Canada. He currently is a President of the Police Major General Chuan-Ms.Proytip Piumsombun Foundation (Family-owned Charity Foundation for Prachinburi Province Education development).