Current Situation of Biomass Energy and Development of Biocoke Technology in Thailand

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Key Words: Biomass, Renewable Energy, Alternative Energy, Biocoke

1. Introduction

Biomass is a renewable source of energy. Biomass resources include wood, wood residues, agricultural wastes, agro-industrial wastes, food processing wastes, municipal solid wastes (MSW), livestock manure, etc. Thailand is an agriculture-based country, 47% of the total area were used for agricultural plantations1). Five major agricultural commodities of Thailand are rice, natural rubber, cassava, sugarcane and palm oil2). Currently, Thailand has become the world’s leader of rice, natural rubber and palm oil exporters3). In addition, part of agricultural products are transformed into value-added products in agro-industry. Thus, large amount of waste has been generated after harvesting and agro-industrial processing. These wastes have a potential to utilize as biomass energy. Similar to many countries, Thailand’s energy consumption has continuously increased year by year as shown in Fig. 14)-6). However, the domestic sources of energy supply are limited. Thailand needs to generate more energy from its own renewable resources, especially biomass resources from agricultural waste, agro-industry waste and MSW for energy security reason. Recently, the Ministry of Energy (MoE), launched the 20-year Alternative Energy Development Plan 2015 (AEDP2015) for the period of 2015 to 2036 to set the renewable targets for assuring increasing-energy demand7). Biomass was set as a major share of renewable energy consumption targets in the AEDP2015. Therefore, this paper provides an overview of the current status, policies and development of biomass energy in Thailand to identify the potential, obstacles, and challenges faced by the development of biomass energy in Thailand. The development of new biomass energy called biocoke in Thailand is also introduced.

2. Current Policy on Biomass Energy in Thailand

In 2008, the Thai government initiated the 15-year Renewable Energy Development Plan (REDP2008) for the period of 2008-2022 which aimed to increase the share of renewable energy to 20% of final energy consumption by 20228). Then, the REDP2008 was revised to the 10-year Alternative Energy Development Plan (AEDP2012) for the period of 2012-2021 by increasing the renewable energy consumption target to 25% of final energy consumption by 20219). In 2015, Thailand’s Ministry of Energy announced the Thailand Integrated Energy Blueprint (TIEB) which focused on energy security by supplying energy from diversified energy resources in response to the energy demand, the economical aspect and ecological aspect by increasing domestic renewable energy production and producing energy with high performance technologies. Five master energy plans, which are the Power Development Plan, the Energy Efficiency Development Plan, the Alternative Energy development Plan, the Oil Development Plan and the Gas Development Plan, were included in the TIEB7). The 20-year Alternative Energy Development Plan (AEDP2015) was developed for the period of 2015-2036 and focused on promoting energy production within the full potential of domestic renewable energy resources by increasing the renewable energy consumption target to 30% of final energy consumption by 20367). Fig. 2 shows the concept and
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Biomass energy has set as a major target in the AEDP. Biomass, which consists of biomass for heat and power, biogas for heat and power, and biofuels in transportation, are shared about 80% of the plan. This plan aims to increase the renewable energy consumption from biomass to 22,100 ktoe for heat consumption and 5,570 MW for power consumption by 2036. However, AEDP has been considered to revise again since 2018. The revision plan has been approved under the public hearing process since July 2019 and new AEDP will be announced soon.

In terms of the policy to support biomass energy, Thailand launched the pricing incentive policy in 2006 for investor who invested in power generation from biomass called adder program by adding more payment on the top of electricity price in Thailand for a period of 7 years (0.5 Baht for projects of 1 MW or less than 1 MW and 0.3 Baht for project of more than 1 MW). However, under AEDP2015, the Feed-in-Tariff (FiT) program has been employed to promote biomass energy since 2015. The Feed-in-Tariff (FiT) for very small power producers (VSPP) of biomass energy projects in Thailand (as of 2017) is summarized in Table 1. In the FiT program, biomass energy projects are supported for a period of 20 years. FiT rates for power generation from biomass project are vary from 4.24 - 5.34 Baht/kWh. The highest rates are provided for VSPP which produce less than 1 MW. Additional subsidies are provided for biofuel projects and projects in Southern Territory Area which includes 3 Southern provinces (Yala, Pattani, Narathiwas) and 4 districts in Songkhla province. In addition, the Board of Investment of Thailand (BOI) promotes the utilize of renewable energy such as biomass for generation of heat and power generation by offering 8-year corporate tax exemption and exemption of import duty for machinery, raw material and essential materials used in manufacturing export products.

| Capacity (MW) | FIT<sub>1</sub> (Baht/kWh) | FIT<sub>2017</sub> | FIT<sub>Total</sub> | Subsidy Period (year) | FIT Premium (8 years) | Project in Southern Territory Area (Throughout Project Period) |
|--------------|----------------|-----------------|-----------------|----------------------|----------------------|---------------------------------------------|
| ≥ 1 MW       | 3.13           | 2.21            | 5.34            | 20                   | 0.5                  | 0.5                                         |
| 1 - 3 MW     | 2.61           | 2.21            | 4.82            | 20                   | 0.4                  | 0.5                                         |
| > 3 MW       | 2.39           | 1.85            | 4.24            | 20                   | 0.3                  | 0.5                                         |

<sup>1</sup> FIT<sub>2017</sub> is subjected to be adjusted by core inflation

<sup>2</sup> Includes 3 Southern provinces (Yala, Pattani, Narathiwas) and 4 districts in Songkhla province
3. Current Status of Biomass Energy in Thailand

Thailand’s final alternative energy consumption has increased continuously as shown in Fig. 1[4]. This is because the government has set the policy on the development of alternative energy by increasing the alternative energy consumption target in all sectors since 2008. The domestic alternative energy consumption in Thailand are in the form of electricity, heat and biofuels. In 2017, Thailand alternative energy consumption shared 14.5 % (11,731 ktoe) of the total final energy consumption which resulted in the decrease of the value of energy import about 155,787.7 million Baht[6]. Fig. 3 shows the share of final alternative energy consumption in 2017. The greatest share was heat energy consumption, which shared 62.4% of total alternative energy consumption, followed by electricity and biofuels (bioethanol and biodiesel) which shared, respectively, 21.1% and 16.5%. The total heat consumption was 7,322 ktoe. Biomass was the greatest share 90.4% of total heat consumption, followed by biogas, MSW and solar energy which shared, respectively, 8.6%, 0.9%, and 0.1% as shown in Fig. 4[6].

Fig. 5 shows the share of total installed capacity of power generation by using alternative energy in 2017. The total installed capacity of power generation by using alternative energy was 10,238 MW. Biomass power plants was the greatest share 30.8% of the total installed capacity, followed by large hydro power, solar energy, wind, biogas, MSW energy and small hydro power which shared, respectively, 28.4%, 26.3%, 6.1%, 4.7%, 1.9% and 1.8%. In term of the investment on alternative energy projects by government and private sector, the total investment in 2017 was 13,614.7 million Baht[6]. The greatest shared was the investment in the biomass energy project which shared 80.6%, followed by MSW, solar energy, biogas, small-hydro power, biofuels and wind which shared, respectively, 9.8%, 4.0%, 2.8%, 2.0%, 0.7% and 0.1% as shown in Fig. 6[6]. This information confirms that biomass energy plays important role in the utilization of alternative energy in Thailand. The government policy on alternative energy development and the fluctuation of fossil fuels price in global market are the major driving force for the utilization of biomass

Fig. 3   Share of alternative energy consumption in 2017[6].

Fig. 4   Share of heat consumption by using alternative energy in 2017[6].
energy. Previously, industrial sector usually use fossil fuels such as fuel oil, diesel, LPG, and coal because of their high heating value, convenient to use and reasonable prices. However, fossil fuels price was fluctuated during the past decade, part of industrial sectors has replaced fossil fuels by biomass energy to reduce cost of production.

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The potential of biomass energy in Thailand is summarized in Table 2. It has been reported that the remain biomass potential in 2014 was approximately 31.4 million ton and the estimated remain biomass potential which includes agricultural plantation plan of Ministry of Agriculture is 79.9 million ton. The estimated potential of biomass for heat generation and power generation

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Fig. 5 Share of total installed capacity of power generation by using alternative energy in 2017.

Fig. 6 Share of investment in the biomass energy project.

Table 2
are approximately 15,783 ktoe and 6,040 MW, respectively\textsuperscript{13}. This is confirmed that wastes from agricultural harvesting and agro-industry have a potential to utilize as biomass energy. The largest estimated remain biomass is from oil palm leaves and branch, followed bagasse, sugarcane and leaves, rice straw, wastes form cassava and rubberwood root. However, it is difficult to collect and transport large amount of sugar cane leaves, rice straw and wastes from cassava residues to utilize for heat generation and power generation. Bagasse and sugarcane residues has already planed to utilize for power and generation by the sugar production factory. Therefore, residues from oil palm and rubberwood is expected to develop and utilize as biomass energy in industrial sector. The rapid growing tree has proposed to utilize as biomass energy. The potential of rapid growing tree such as Eucalyptus, Casuarina, Leucaena and Acacia is estimated at 18.72 million ton \textsuperscript{15,16). Most of industrial factories and power generation in Thailand use biomass energy by direct combustion or converse to wood pellet for pyrolysis and gasification\textsuperscript{11,17). However, it is necessary to continuously supply large amount of biomass to the wood pellet production factories, industrial factories and power generation factories for economical reason. Recently, industrial factories and power generation plants have increased their demand of biomass energy. As a result, prices of biomass increased dramatically and biomass energy shortages have been found in some areas. Therefore, factories and power generation plants which use biomass energy have to stop operation because of insufficient biomass resources. Therefore, the potential of biomass resources and efficient technology for conversion biomass resources to biomass energy are necessary to develop\textsuperscript{16-24). Biocoke which is bio-solid fuel produced from biomass resources has firstly proposed by Kindai University\textsuperscript{25). Biocoke is a promising method to converse small amount of wastes which are difficult to collect and transport from plantation site to factory to high efficient biomass energy.

| Type of Biomass                   | Remaining biomass at year 2014 (ton/year) | Heat generation capacity (ktoe) | Power generation capacity (MW) | Estimated remaining biomass\textsuperscript{1} (ton/year) | Heat generation capacity (ktoe) | Power generation capacity (MW) |
|----------------------------------|------------------------------------------|-------------------------------|-------------------------------|----------------------------------------------------------|-------------------------------|-------------------------------|
| Oil palm Leaves and branch       | 14,606,671                               | 2,265                         | 867                           | 33,586,191                                               | 5,208                         | 1,993                         |
| Fiber                            | -                                        | -                             | -                             | 2,944,803                                                | 795                           | 304                           |
| Shell                            | -                                        | -                             | -                             | 619,959                                                  | 248                           | 95                            |
| Empty fruit bunch                | 606,541                                  | 104                           | 40                            | 1,402,455                                                | 240                           | 92                            |
| Sugar cane Bagasse               | -                                        | -                             | -                             | 21,280,000                                               | 3,712                         | 1,421                         |
| Residues and leaves              | 2,928,140                                | 1,073                         | 411                           | 5,265,619                                                | 1,929                         | 738                           |
| Cassava Rhizome                  | 2,838,125                                | 369                           | 141                           | 3,372,560                                                | 439                           | 168                           |
| Trunk                            | 1,052,636                                | 388                           | 149                           | 2,084,755                                                | 769                           | 304                           |
| Corn Trunk                       | 3,369,690                                | 784                           | 300                           | 3,369,690                                                | 784                           | 300                           |
| Cob                              | 80,889                                   | 18                            | 7                             | 80,889                                                   | 18                            | 7                             |
| Rice Straw                       | 4,124,630                                | 1,204                         | 461                           | 4,124,630                                                | 1,204                         | 461                           |
| Husk                             | 432                                      | 0.14                          | 0.05                          | 432                                                      | 0.14                          | 0.05                          |
| Rubber wood Root                 | 1,411,834                                | 287                           | 110                           | 1,411,834                                                | 287                           | 110                           |
| Coconut Bunch and leaves         | 249,026                                  | 91                            | 35                            | 249,026                                                  | 91                            | 35                            |
| Shell                            | 79,678                                   | 31                            | 12                            | 79,678                                                   | 31                            | 12                            |
| Fiber                            | 71,875                                   | 27                            | 10                            | 71,875                                                   | 27                            | 10                            |
| Total                            | 31,420,166                               | 6,642                         | 2,542                         | 79,994,394                                               | 15,783                        | 6,040                         |

\textsuperscript{1} Estimated remaining biomass potential which includes agricultural plantation plan of Ministry of Agriculture.
Technology and Kindai University. Fig. 7 shows the prototype of biocoke production machine for industrial utilization which is installed at Thai-Nichi Institute of Technology. The capacity of biocoke production machine is approximately 500 kg/machine/day. Therefore, the biocoke production may be suitable for the production of biomass energy from oil palm residues, rubberwood residues, cassava residues, sugarcane leaves which are difficult to collect and transport from plantation sites and rapid growing tree from small plantation site. The production of biocoke from agricultural residues, agro-industry residues and rapid growing tree such as rubberwood residues, palm oil residues, used coffee ground and leucaena woodchip has been investigated. The produced biocoke fuel for industrial utilization should have the following properties: bulk density is higher than 1.1 g/cm³, maximum compressive strength is higher than 20 MPa and calorific value is higher than 4,000 kcal/kg. The properties of produced biocoke are summarized in Table 3. It is confirmed that biocoke which is suitable for industrial utilization can be produced from agricultural residues, agro-industry residues and rapid growing tree. Fig. 8 shows the examples of biocoke for industrial utilization in Thailand. It is found that up to 20% biocoke can be used as co-fuel with coal coke without modification of cupola furnace. In addition, lower CO and SOx emission than normal operation using coal coke were observed.

5. Conclusion

Thailand is an agricultural country. Abundant wastes left after harvesting and agro-industrial processing. Oil palm leaves and branch, bagasse, sugarcane and leaves, rice straw, wastes form cassava and rubberwood root are major wastes have a potential to utilize as biomass energy in Thailand. However, the main obstacles are the collection and transportation from plantation site and transportation to factory or power generation plant. Biocoke technology is a promising method to converse small amount of wastes near plantation site to high efficient biomass energy.

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Fig. 9 Example of industrial utilization of biocoke for cupola furnace and boiler in Thailand.

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