Biogas Production from Agricultural Wastes in Thailand

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Abstract: The demand of energy has been increased over the years as the sequence by increasing of the world population. Currently, the energy consumption in Thailand was rising in relation to economic growth. Thai government announced its needs to increase the acquired share of alternative energy from 6.4% to 20.3% of commercial primary energy by 2022. In this situation, Thailand with the abundant and varieties of biomass and agricultural wastes should have the great challenge and opportunity for this supply to anaerobic digestion for biogas production accordingly by the strategy of government. Thus, this paper illustrated sources of biogas feedstock from biomass and agricultural wastes, status and potential of biogas production and utilization, biogas technology used, driving forces, and future perspectives in country.

Keywords: Agricultural wastes, Anaerobic digestion, Biogas, Biomass, Potential.

1. Introduction

The demand of energy has been increased over the years as the sequence by increasing of the world population and expansion of global industries especially for food and feed. Most of the energy consumption is from power generation, transportation, industry, and community sectors. Moreover, the most utility energy, are taken from fossil oil, gas and coal. Many developing countries have their own policy to find the alternative energy, and many researchers have attempted to find the suitable resources to produce an alternative energy such as biomass, solar energy, geothermal, hydro power, wind energy and ocean energy. The concept of the alternative energy is to get the other resources to replace or substituted of the need of petroleum and also to reduce the main issued of global warming. Since Thailand heavily depends on imported energy particular oil to fulfill the country's energy requirements. In order to a country's energy security and sustainable development as well as to minimize environmental impacts, Thailand is making attempts to promote and support the utilization of alternative energy and improvements in energy efficiency. The Thai government has clear policy to promote alternative energy in a significant scale for encouragement in increasing the proportion of alternative energy resources. Ministry of Energy's Strategy sets clear goal for alternative energy by sharing alternative energy to be increased from 6.4% in 2008 to 20.3% of the commercial supply by the year 2022 [1] .

Biomass is a group of organic materials currently made from plants and animals. It the fourth largest sources of energy in the world, providing about 14% of primary energy. Developing countries, as a whole, derives 35% of their energy from biomass and in many, it offers over 90% of the total energy used in form of traditional fuels, e.g. fuel wood and dung. Since 90% of the world's population may reside in developing countries by 2050, biomass energy is likely to remain a substantial energy feedstock [2]. Thailand is an agricultural to agro-industrial country and possesses huge amounts of resources in biomass including agricultural wastes that can be used as feedstock for renewable energy (RE) purposes. Thailand has a high potential of using energy from biomass. The total agricultural residues in Thailand were around 61 million tons in 1997, which is equivalent to 426 x 109 MJ of energy [3]. In this situation, country with the abundant and variety of biomass and agricultural wastes such as Thailand should have the great challenge and opportunity for this supply to anaerobic digestion for biogas production accordingly by the strategy of government. Biogas has a rising demand and a promising potential in the production in country. Thus, this paper had been reviewed and surveyed the status and potential of biogas production from biomass and agricultural wastes, the existing biogas technology and biogas utilization, driving forces, and future aspects.

2. Review and survey

The study was reviewed the literature from the articles, national and international journals, academic thesis and dissertations, printed documents, online documents, and data from primary information such as questionnaire, field survey and interview from involving researchers, Biogas technology producers and users. The review and data analysis for the status and potential of biogas production from agricultural and agro-industrial wastes in Thailand was as follows.

2.1 Biogas production in Thailand: Feedstock, status and potential

The energy situation in Thailand heavily dependent on fossil fuels which account for 80% of the total energy supply. In accordance with the government policy of promotion of alternative energy following the continuous rise of oil price, Ministry of Energy has a strategy aiming at increasing the use of alternative energy from 6.4% (2008) to 20.3% (2022). In order to ensure energy security and economic competitiveness as well as to minimize environmental impacts, Thailand is making attempts to promote and support the utilization of alternative energy. Thailand has abundance of biomass and agricultural wastes as shown in Figure 1 for bio- based share in renewable energy [4]. Bio-based RE such as agricultural residues, crops, biogas from biomass and wastes, MSW and biofuels has shared in a large portion of RE more than 90% of potential RE in Thailand.

Biogas is one of the potential sources for RE in Thailand. Anaerobic digestion or biogas technology is one of the most popular technologies using biomass especially from agricultural and agro-industrial wastes for RE production and abatement of environmental pollution. In this situation, country with the abundant and variety of biomass and agricultural wastes such as Thailand should have the great challenge and opportunity for this supply to anaerobic digestion for biogas production accordingly by the strategy of government. Four key components in biogas production are feedstock, microorganisms, environmental control for anaerobic digestion and reactor configuration or biogas technology. Nowadays, three major sources of biogas feedstock for biogas production in Thailand are from agro-industrial waste,

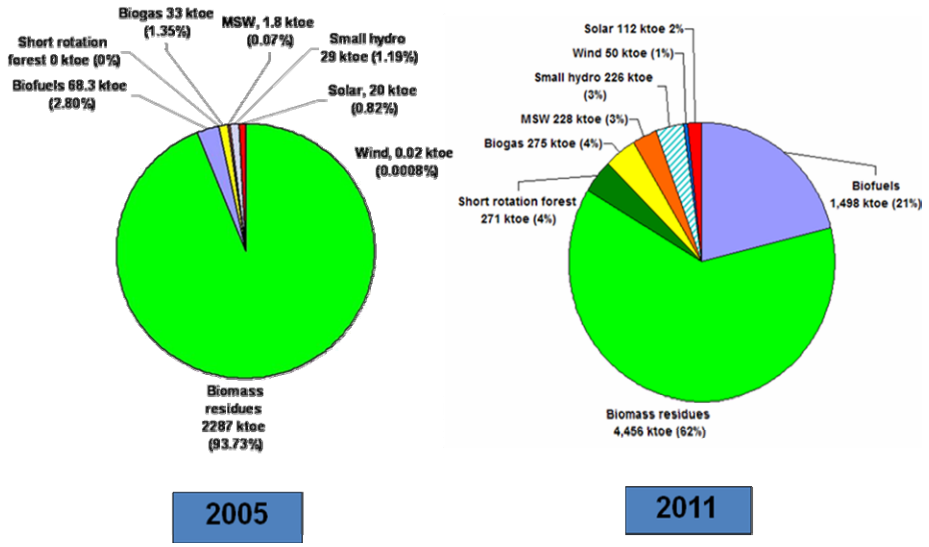

Figure 1. Energy from bio-based share in renewable energy in Thailand [4].

farm waste and municipal solid waste (MSW) which was studied and surveyed for biogas assessment. Agricultural crops will be the future feedstock. The status of biogas feedstock was evaluated by various sectors; animal manure sector in pig and cow were 1.3 and 9.2 million tons/year, respectively; agro-industrial wastewater from factories of cassava starch, crude palm oil, ethanol, canned tuna, canned pineapple, sugar and slaughterhouse were 34.4, 2.5, 5.9, 18.8, 4.8, 7.9 and 2.1 million m^3/year, respectively including 3.9 million tons of cassava pulp; municipal solid waste was 15.3 million tons/year [5]. The potential of biogas production from major sources of animal manure, agro-industrial wastes, and organic fraction municipal solid waste was annually produced 1060, 1005, and 870 million m^3, respectively. Potential of biogas production from various sources of feedstock was shown in Figure 2. The potential ratio for biogas production from 8 main sources was shared by 34% agro-industrial wastes, 36% animal manure, and 30% municipal solid waste. Major agro-industrial wastes, animal farm waste and municipal solid waste were major sources of biogas feedstock in use by biogas technology as shown Figure 3. Current existing utilization of biogas in farm, agro-industrial wastes, and municipal solid waste 17%, 36%, and 4% of potential of biogas production from feedstock, respectively [5-6].

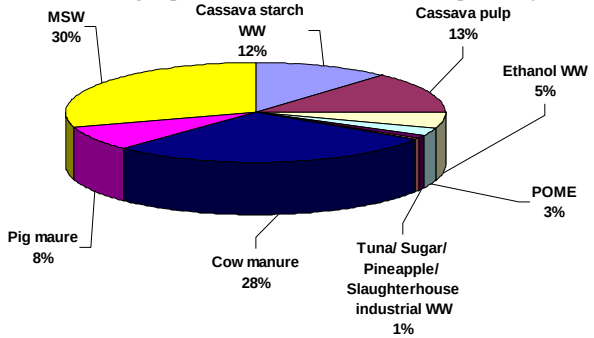

Figure 2. Potential ratio of biogas production from main sources.

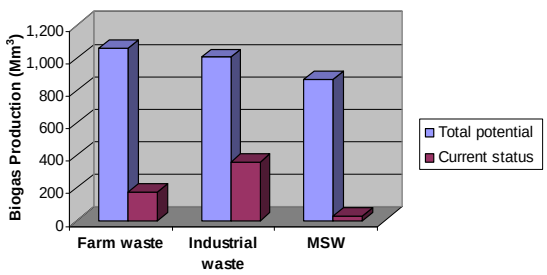

Figure 3. Potential of biogas production and existing in use of biogas.

Biogas Technology applied in Thailand was investigated in three main sectors. For animal manure, fixed dome and upflow anaerobic sludge blanket (UASB) was applied for small scale and medium to large scale, respectively, and some used anaerobic covered lagoon (ACL). Agro-industrial wastewater was used UASB, anaerobic fixed film (AFF), completely stirred tank reactor (CSTR), anaerobic baffle reactor (ABR), ACL, and anaerobic hybrid reactor. Municipal solid waste was applied anaerobic digester such as landfill and CSTR. The trend of constructed biogas technology in Thailand during 1984 until now has progressive increasing. Figure 4 shows number of constructed biogas technology in Thailand during 1984 to 2006. Success biogas technology has been applied in pig farm, cassava starch industry, crude palm oil industry, etc. Normally, the utilization of biogas in Thailand is used in form of thermal energy (heat) and electricity. The existing utilization of biogas was 224 ktoe for thermal energy and 46 MW for electricity [1,5-6].

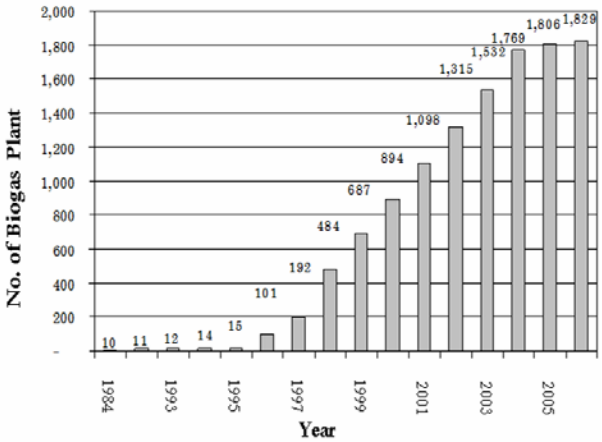

Figure 4. Constructed biogas plants in Thailand during 1984-2006.

2.3 Fifteen years plan of biogas energy

Ministry of Energy has a strategy aiming at increasing the use of alternative energy from 6.4% in year 2008 to 15.6, 19.1 and 20.3% in year 2011, 2016 and 2022, respectively. Biogas is one of energy in concerning from waste due to this technology by anaerobic digestion can gain triple benefits in abatement of organic pollutants for environmental conservation, resources conservation, and generation of high quality of renewable fuel. Thai government has enhanced a policy of using biogas energy to be national agenda. Biogas is set as one of RE source in Thailand's alternative energy strategic plan which was used for

electricity and heat energy 46 MW and 224 toe in year 2008, respectively. The target plan for biogas production has been aimed to produce 60, 90 and 120 MW for electricity and 470, 540 and 600 ktoe for heat energy in year 2011, 2016, and 2022, respectively [1].

2.4 Driving Forces and future perspectives for biogas technology in Thailand

Incentive and promotion measures for biogas projects in Thailand has been implemented to support and promote the increasing biogas technology by several means such as government subsidization, soft loan, tax incentive, BOI, ESCO fund, CDM, adder cost, etc. However, biogas technology has been required to develop in the future as following:

- Process control, modeling and optimization by improving biogas yield, increase OLR, reactor configuration
- Further application to others f edstock such as solid residual, energy crop, xenobiotic substances
- Pre and post treatment for digestibility improvement and nutrient recovery
- Biogas clean up by improving removal efficiency of impurity (hydrogen sulfide)
- Further application in utilization by upgrading to high value /rich methane gas in using for fuel cell, vehicle, CNG, etc.

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