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# A STUDY ON THE POTENTIAL OF CORN COB ENGINE-GENERATOR FOR ELECTRICITY GENERATION IN THAILAND

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**Abstract:** This paper describes the potential of using corn cob as a primary energy source for electricity generation in Thailand. Due to increase in energy demands, fuel cost, and environmental issues, the reliance of fossil fuel has to be reduced. One of the alternatives is to utilize agricultural residues. This paper provides an overview of the availability of corn cob in Thailand and a description of a small-scaled biomass gasifier engine-generator. Based on literature research and estimation, over 1 GWh/year could be produced from this technique. This will provide substantial savings on fuel cost and reduction on environmental impacts. In addition to the generation of electricity, this also provides a safe means to dispose the waste residues. This is an initial phase of an ongoing project to be undertaken in Phitsanulok, Thailand.

**Keywords:** biomass, generation, corn cob, gasifier

## 1. Introduction

The use of renewable and sustainable energy resources will play a major role in many aspects of electricity generation. In particular, due to environment issues and ever increasing energy demands, the world is forced to look for alternative energy sources. Also, it is anticipated that shortage of hydrocarbon fuel will be inevitable. In terms of population growth, it has been estimated that by the year 2060, the world population will be in excess of 12 billions. Currently, over 80% of the crude oil reserves are under the control of only eight countries. Therefore, a number of strategies, such as special tariff and subsidy agreements, have been established in many countries in order to stimulate the research and utilisation of alternative energy sources.

Biomass, which roughly accounts for 10 to 15% of the world energy consumption, is currently in use. It is one of the most important energy sources as it is renewable and sustainable. In some developing countries, biomass provides over 33% of their energy consumption.

Typical examples of biomass are agriculture residues and forestry products. Additionally, the biomass materials can also come from plantation which were grown in order to meet large demands [1-3]. Biomass utilisation is crucial in reducing the emissions of carbon dioxide, which causes more than half of the green house gases. In nature, carbon dioxide is used in the photosynthesis process. Therefore, zero net carbon dioxide emission can be obtained when biomass is incorporated in a sustainable manner. Nevertheless, production of biomass is normally dispersed over large regions due to the nature of planting. In other words, availability of biomass is limited to localised areas. Due to its low bulk density, this leads to high transportation, handling and storage costs in order to run and operate large central power/heat plants. A strategy used to alleviate such problems is to deploy small-scale utilisation or decentralised power/heat plants. This can also assuage the material shortage issue, which is one of the major problems for large-scale biomass power/heat plants.

Several ways can be used with biomass to obtain its energy. The different methods are associated with the products being used. The materials can be burnt directly or converted into several types of fuels. One of the biomass conversion processes is gasification. This is simply defined as the partial-oxidation process to convert a biomass into a gaseous energy carrier, called "producer gas". With regards to transportation and handling, producer gas is considerably easier to utilize in comparison with raw biomass. Besides, utilization of the gas is cleaner than that of the raw biomass as the contaminants are removed during the gasification process. Based on the above reasons, the potential of small-scale electricity generation is considered in this paper. Since Thailand is a major producer of agricultural products, a large amount of agricultural residues are available. One of the main residues is corn cob. Hence, the use of corn cob

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as a source of renewable energy for electricity generation is discussed in the following sections.

**2. Corn cob in Thailand**

It is widely accepted that the availability of biomass resources strongly depends on geographical regions. This is in particular that in situations when different types of agricultural residues are produced at different locations. In many developing countries, agricultural residues are either burnt off or left in the fields after harvesting. This is a waste of the huge amount of potential energy resources. Over the world, the total estimated amount of biomass generated was over three billion tonnes. For Southeast Asian countries, agricultural residues can supply up to 40% of the energy consumption if they were fully utilised [4]. On the contrary, the level of agricultural residues utilisation in some areas is considerably low. This is due to a severe lacking of the necessary technologies and conditions such as taxes and high cost of equipment have made the use of biomass unjustifiable [5].

Maize is one of the most important crops in Thailand. During the period 1991 to 2000, more than 3.3 Mt per year of maize was produced. In the year 2000, there was about 4.4 Mt of maize grown in the country [6]. It is obvious that harvesting of such amount of crop has led to a large quantity of maize residues.

One kind of maize residues is *corn cob* which are left after the milling process. The residues are estimated based on maize generation and residue-to-product ratios (RPR). For corn cob, the value of RPR is 0.273 [7-8]. This figure is utilised for subsequent calculations in this paper. The quantities of corn cob produced from 1991 to 2000 are shown in Figure 1. As can be seen from the graph, approximately one Mt/y of the residue were available. Also, the value of such residue generated in 2000 was 16% more than that in 1991. There was a slight reduction of crop yield in 1993 and 1997, however the values still exceeded 900 kton/year.

The annual energy available from corn cob was calculated and shown in Figure 2. The lower heating value of 16.28 MJ/kg for corn cob, which was used in the calculations. The figure was reported in reference [7]. According to Figure 2, the energy was estimated on the basis of the lower heating value based on the amount of corn cob. Above 14 TJ of energy was produced yearly. Thus, by using with appropriate technologies such as biomass gasifier engine-generator, the existing energy can be converted into usable, valuable and convenient form of energy.

**3. Biomass Gasifier Engine-generator System**

One of the energy conversion technologies which is suitable for small-scale electricity generation is *"Gasifier Engine-Generator"*. As depicted in Figure 3, the system mainly comprises of four main parts. They are: gasifier, gas cleaning system, engine, and generator. For the first part, it seems that downdraft gasifiers account for the lowest cost per unit of primary energy saving [9]. Also, the construction of the gasifier is simple and robust. The gaseous fuel generated, called producer gas, is considerably clean, particularly on tars contamination aspect. It is therefore recommended for use with engine generators. A number of the systems generated clean producer gas by using settling tanks, bag filters, cyclones or scrubbers were stated. An example of those is the 10 kWe for community electricity in Indonesia [10]. Besides, using producer gas with engines with and without a modification was also reported in some papers [11-13].

The two basic types of equipments for on-site power generation are synchronous and induction generators. The first type is normally utilised for standby purpose. It is also used to provide independent electricity generation away from the main utility grid. The latter type is suitable for use in parallel with the mains supply since they require reactive power for their operation. The necessary VAR can be supplied from the utility grid in the case of grid-connected system. Also, induction generators are suitable for load shaving during the load peak period or for based load displacement.

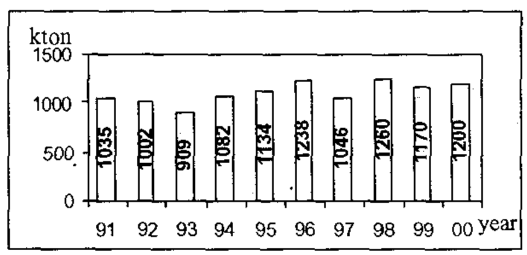

Figure 1. The annual quantity of corn cob in Thailand

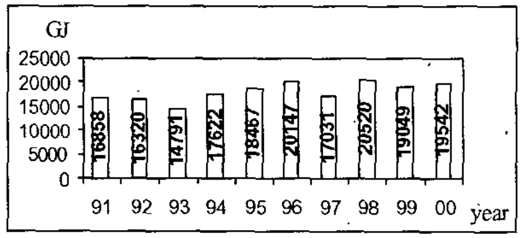

Figure 2. The energy form corn cob available in Thailand

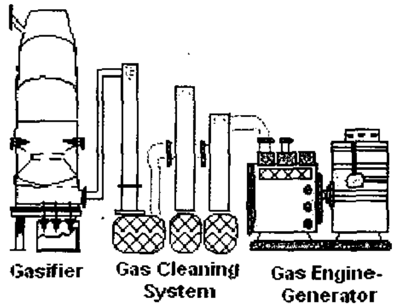


Figure 3. Small-scaled gasifier engine-generator system

Nevertheless, induction generators can also be utilised as an isolated power source. Connection of capacitors across the generator terminals is a method for self-excitation induction generators (SEIG) [14]. No moving contacts, small in size and weight, as well as reduction in the cost of unit and maintenance are some examples of its advantages. Moreover, for self-excited induction generators, the separate dc source for excitation is not required. Brushless rotor construction, good over-speed capability, and self-protection against severe overload as well as short circuit protection are also the advantages of self-excited induction generators, and in particular, squirrel-cage induction generators [15-16].

For SEIG, the terminal voltage decreases with the load connected across the generator terminals. Using a suitable regulator scheme can diminish this problem. It is apparent that there are three main voltage-regulating schemes. They are: switched capacitor, variable inductor and saturated core reactor [17]. A simple control scheme without any real time requirement, which results in overall cost reduction, was also stated. For such a scheme, the reference current is tracked by the controller current. Controlling the excitation current supplied from the controller can be utilised to regulate the generator voltage [18].

In remote and rural areas, single-phase power supply is usually required. The use of three-phase induction generator in generating the single-phase supply has also been reported. For systems above 3 kW, it appears that the use of three-phase induction machines is preferred in terms of cost and machine size aspects. In addition, based on same physical size, the efficiency of three-phase induction generators is higher than that of the single-phase machines. Nonetheless, this may lead to situations of unbalanced loads, and results in increasing losses [15,19].

**4. From Corn cob to Electricity**

Electricity generation from corn cob has a high potential for Thailand. From literature reviews, the overall efficiency of biomass gasifier engine-generator system normally ranges between 11 and 24%. Although the efficiencies of gasifiers and generator are rather high at a typical value of over 75% [11,13], the engine efficiency is somewhat low due to the properties of producer gas. This results in a low overall efficiency.

Based on the range of efficiencies of equipments, electricity generated from corn cob in Thailand was calculated by using the data in year 2000 as shown in Figure 4. From the graph, with the overall efficiency of 20%, over one GWh of electricity can be generated.

A method to compare the power output from diesel engine and producer gas engine was proposed. There are three main factors affecting the efficiency and power output of the engines: the energy density factor resulted from the ifference in the energy density of the fuels; the factor due to change in the mole factor between the reactant and production; finally, the temperature effect on pressure due to the change in peak temperature in the engine cylinder [20]. For the producer density energy gas of 2.0-2.5 MJ/$m^3$, the values of derating power of engines were calculated. In year 2000, at 70, 80 and 90% of gasifier efficiency, the saving amounts of diesel fuel, with the heating value of 36.4 MJ/L, were computed and shown in Figure 5. For the density energy of 2.2, approximately 2'8 to 280 thousand litres of diesel could have been saved by corn cob electricity generation with 70 to 90% gasifier efficiency respectively.

For the purpose of evaluating the proposal and to gain further experience of this technology, a small-scaled biomass gasifier engine-generator system is proposed to be established at Naraesuan University, Thailand. Naresuan University is located at Phitsanulok, 337 km north of Bangkok. The population in the region is 865,598 with majority of the communities rely on agriculture. Some of the main products are banana, rice, maize and sugar cane. Upon the success of the pilot study, the proposed system will be duplicated and sent to regional centres in order to meet electricity demands of the local communities.

**5. Conclusion**

The potential of using corn cob as a biomass energy source for electricity generation has been discussed in this paper. An overview of the availability of corn cob in Thailand and a description of a small-scaled biomass gasifier engine-generator are presented. It is estimated that over 1 GWh/year could be produced. Apart from the benefits of electricity generation and savings on fuel cost, this also provides a means to dispose the waste residues and reduces the environmental impacts. The project will be proposed to be established in Phitsanulok, Thailand.

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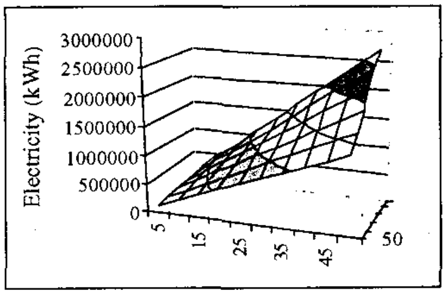


Figure 4. Electricity generated from corn cob [X: engine-generator efficiency (%), Y: gasifier efficiency (%)]

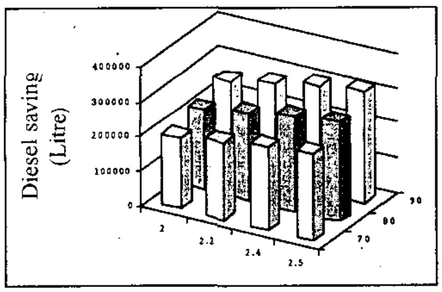


Figure 5. The amount of diesel saved by corn cob electricity generation [X: producer gas energy density ($MJ/m^3$), Y: gasifier efficiency (%)]

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