STATUS AND POTENTIAL OF CO - GENERATION IN THAI RICE MILLS

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ABSTRACT

Co-generation in rice mills is unique in that it can utilize waste i.e. rice husk as energy sources. Despite the importance of the co-generation, there is very limited information about the subject and there is a statistical inconsistency in the existing studies in many respects. This paper is an attempt to provide information relating to the industry on such issues as: the energy consumption pattern at the industry-level, the energy distribution and energy-use characteristics at the plant-level, the availability of energy resources, and the prospect for increased co-generation. It finds that existing co-generation in the rice milling industry is limited, but there are ample potentials for development, estimatedly 80 to 90 GWh per year if improvement on steam-generating efficiency is made by the rice mills concerned. Apart from the general practices of providing financial and technical assistance to firms, it is essential that in this particular area of co-generation, the government should enact a law to allow private generation of power for sale; otherwise the co-generation potential would be foregone. It is also important that more studies should be conducted to generate information for assisting the system choice by the Thai rice mills.

INTRODUCTION

Co-generation denotes the simultaneous production of electricity or mechanical energy and useful thermal energy, and is also referred to as "Combined Heat and Power" generation. It is an established practice in many manufacturing industries, especially steam-raising industries. It does not significantly alter the energy consumption, either heat or power, of the industrial site where it is employed. Nevertheless, it can substantially reduce energy costs, especially in the case of using waste fuels as primary energy sources. When widely applied, it can have significant contributions to make at the national level. The most significant is primary fuel saving. The amount of premium fuel such as fuel oil to co-generate steam and electricity is less than the amount of premium fuel required by industrial firms to produce steam and the utility to generate electricity separately. The use of expensive premium fuels can be even further reduced in the case of waste-fuel utilization. In addition, at the national level, an extensive application of CHP may also obviate some marginal power stations, hence reducing or deferring

capital expenditures for construction of electric utility power plants; also increased co-generation could in principle reduce the dependence on imported energy.

Despite the importance of CHP to the national energy economy, the potential for industrial CHP development in Thailand is not clearly known. Indeed, little is yet known about the status of co-generation in industry in Thailand. This paper seeks to explore this issue by initially focussing on rice milling. At least in the context of Thailand, agro-industry is unique in that the CHP application can be combined with economic exploitation of agricultural by-product, i.e. rice husk, as energy source.

ENERGY CONSUMPTION PATTERN

Although it is commonly accepted that rice husk is the major energy source in the rice-milling industry, there is a great variation in the estimates, made by various agencies, of rice husk consumption, both in absolute terms and in relation to the consumption of other energy resources. The problem of statistical inconsistency arises mainly from the insufficiency of data base in the earlier years. The latest available information from National Energy Administration (NEA), 1984, shows that about half of the energy demand of the industry is met by rice husk, one third by diesel oil, and one tenth by fuel oil. The share of purchased electricity is less than two per cent.

This information seems to suggest either that there is little demand for electricity in this industry or that self-generation of electricity is already widely practiced; hence the extent for further co-generation for serving the industry itself may be limited. Furthermore, given that rice husk is a waste fuel, the use of diesel oil and fuel oil raises questions about the availability of rice husk; hence the extent of further utilizing rice husk as the energy source for co-generation may be limited.

AVAILABILITY OF RICE HUSK

Estimating the availability of rice husk requires knowing the ratio of rice husk per paddy rice. Rice husk production, based on the information from Agricultural Statistics Center (1980) is about 26% by weight of the paddy milled, regardless of the size of rice mills.

This figure is compatible with the figures from experiments, e.g. 22.5% to 25.2% as obtained by the Thailand Institute of Scientific and Technological Research and the Industrial Inspection Department of the Ministry of Industry. As the total paddy rice production in Thailand is about 15 million tons per year and the amount of available rice husk is assumed to be 25% of the paddy rice, it can be therefore estimated that there are about 3.75 million tons of rice husk produced per year. The amount of rice husk used and left unused in rice mills can then be estimated as follows:

Assumptions made from data of typical Thai rice mills:

Boiler thermal efficiency	=	40%
Steam engine thermal efficiency	=	15%
Conveyor mechanical efficiency	=	70%
Heat content of husk	=	13.81 MJ/kg
Energy used in milling 1 ton of paddy	=	64.45 MJ

Hence;

Energy input requirement	=	$\frac{64.45}{0.4 \times 0.15 \times 0.7}$	MJ/ton
	=	1535	MJ/ton
Husk burnt	=	$\frac{1535}{13.81}$	kg/ton
	=	111	kg/ton
Husk left = 250 – 111	=	139	kg/ton
Husk left/Husk produced	=	139/250	= 0.556

Given that not all rice mills use rice husk for their energy requirements, the total amount of rice husk left unused by rice mills should be more than 55.6% of the total amount of rice husk produced, or more than 2.09 million tons per year.

ENERGY – USE CHARACTERISTICS

Traditional non-energy uses of rice husk include uses as animal feed and fertilizer. At present, no accurate estimation of such uses is available; but the amount is believed to be very little. Use of rice husk in other industries is also limited, and is restricted to rural factories located near rice mills, largely because of the low heat content of husk and the storage and transport costs involved.

In the rice milling industry, the use of rice husk as energy source is however limited to large-scale rice mills using steam engines. According to a sampling survey by NEA, 1980, as well as the Agricultural Statistics Centre of the Ministry of Agriculture, only rice mills which have capacity above 20 tons per day, use rice husk as their main energy sources and they account for 20% of about 500 rice mills in the country. A preliminary analysis by the Asian Development Bank, 1984³, estimates that there are about 86 rice mills where on-site electricity generation from rice husk is viable. These mills range from 170 tons/day up to the second largest rice mills in Thailand; the largest mills already generate their own electricity using rice husk. Use of rice husk for electricity generation in smaller rice mills is unlikely to be economically viable, even though some of the mills at present burn rice husk to generate mechanical power for process uses.

Another recent study by Boonyiem & Associates, 1986⁴, exploring the subject in more details also arrived at a similar finding. One of its conclusions is that there are

less than 100 rice mills with production capacity from 100 tons per day up that have potentials for husk-based electricity generation after improving their energy usage. Therefore, the analysis to be presented below will focus only on large-scale rice mills.

There are two types of large-scale rice mills in Thailand i.e. rice mills for parboiled rice and for white rice. Their energy-use characteristics are different, as can be described below.

Rice mills for parboiled rice

In this type of rice mills, rice husk is used as fuel for the boiler to produce steam for various process-heat energy requirements as well as for driving the milling machine. Steam is first utilized to heat water up to about 70°-80° C for soaking paddy to increase the moisture content of the paddy. The soaked paddy is then steamed to obtain the fusion of starch granules of the paddy so as to reduce cracks in the paddy grain. The steamed paddy grain is further heated by steam in the drying process to reduce its moisture to the level that it becomes suitable for milling. In the milling process, a steam engine is usually employed to provide the motive power required. However, some rice mills may also use electrical energy for parts of this process or for the entire process.

As for electrical energy, this type of rice mills consumes 50-500 kW, depending on the source of energy that drives the milling machine and on the production capacity.

In relation to the milling of white rice, parboiled rice milling consumes a large amount of energy for the milling process as well as for the parboiling process. In general, the rice husk which is the by-product of the milling process in this type of mill is inadequate to meet the energy demand of the mill. Additional amount of husk may have to be purchased; or else some energy demand may have to be fulfilled by electrical energy.

Rice mills for white rice

This type of mill utilizes steam only for the steam engine to drive the milling machine. Therefore, it consumes much less energy than the parboiled rice mill. Usually, there will be about 20-25% of the by-product husk leftover. If electrical energy is also employed to drive the milling machine, the amount of husk leftover could reach 30-35% of the amount obtained from the milling. Since there is usually an excessive amount of husk, the remaining husk is either sold at a low price to parboiled rice mills and brick-yards, or burnt and dumped in the case where there is no nearby rural industry using husk.

For the mills which exclusively employ steam engines to drive the milling machines, electrical energy will be used only for lighting purpose with a consumption of about 5-15 kW. Several of these mills generate this electrical energy by connecting generators to the transmission shafts of the milling machine. For the rice mills which utilize steam engines but supplement with electric motors for some processes, the electricity consumption is about 15-30 kW. In the case where no steam engine but electric motor is used, the electricity consumption can be as high as 110-300 kW.

The energy-use characteristics of the two types of rice mills described above suggest that

(i) Because the parboiled rice mills consume high energy and have inadequate supply of rice husk, the possibility of on-site electricity generation will depend, among other things, on the improvement to the steam generator to reduce husk consumption per unit of steam generated.

(ii) Regarding the rice mills for white rice, only the mills that have high electric power demand should be considered in the assessment of the potentials for on-site electricity generation. Rice mills that need small supply of electric energy such as in lighting, i.e. less than $15 \text{ kW} \times 6500$ working hours or about 100,000 kWh/year, can generate electricity by connecting generators to the transmission shafts of the milling machines, and are hence neglected from the analysis.

POTENTIAL OF HUSK SAVING BY BOILER IMPROVEMENT

In the case of the rice mills for parboiled rice, improvement to the existing boilers, which usually have as low efficiency as 40%, will significantly reduce the amount of husk consumption. This will not only result in self-sufficiency of husk supply but also enable co-generation of electricity.

Assuming that the boiler thermal efficiency is raised to 60%, the saving in husk consumption would equal 33.3%. If improvement is also made to the steam engine and conveyor, the saving is much higher. According to a few available plant-level surveys by Westall and Adams, 1984⁵, this amount of husk saved is also sufficient to meet the requirement for electricity generation.

The husk requirement for electricity generation to meet the mill's own electricity demand is less than half of the amount of husk saved through boiler improvement. Hence, there is a possibility of co-generation for external electricity consumers in the parboiled rice mills.

In the case of the rice mills for white rice, about 20-35% of the rice husk produced is usually left unused. If boiler improvement similar to the above case of parboiled rice mills is made, the amount of husk left would increase to 50-68%. However, since this type of rice mill already has excessive amount of husk which usually is burnt into ash or dumped, there may be little incentive to improve energy efficiency under the present utility regulations. Nevertheless, in the mills which consume a large amount of electrical energy, i.e. more than 100,000 kWh per year, there may be a possibility of self-generation of electricity using the available rice husk. According to the information from the Thai Rice Mill Association, the number of rice mills in Thailand that have paddy input capacity of 100 tons per day or higher is 155. Of these 155 rice mills, 129 mills having a total combined capacity of about 1.8 million tons per year are for white rice. The remaining 26 mills produce parboiled rice; their total annual capacity is about 0.7 million tons of paddy. Based on this information, the overall availability of rice husk after implementing boiler improvement in these large-scale rice mills can be estimated as follows:

Rice mills for parboiled rice:

Total capacity = 0.7 million tons of paddy per year
Husk produced about 25% = 175,000 tons per year
Husk left about 30% husk produced = 52,500 tons per year

Rice mills for white rice:

Total capacity = 1.8 million tons of paddy per year
Husk produced about 25% = 450,000 tons per year
Husk left about 60% husk produced = 270,000 tons per year

This total amount of about 322,500 tons of husk left per year, which is about 15% of the earlier estimate in Section 3, presents a more realistic estimate of the overall availability of rice husk which can potentially be utilized for electricity generation. Yet, this figure is still highly overestimated because it is unlikely that this whole amount will be used for electricity generation in rice mills. There is no information to allow eliminating the amount deposited in the rice mills that have low electricity demand. Nevertheless, this figure can be used to test the reliability of the estimates made by other studies, i.e. they must be less than the amount of electricity which can be generated from 322,500 tons of rice husk per year.

POTENTIAL OF ELECTRICITY GENERATION

At present, there are only two studies attempting to estimate the electricity generation potentials in rice mills in Thailand. The first, conducted by the Asian Development Bank, 1984,³ indicates that about 82.59 GWh/year of electrical energy is possible. However, this study provides no information as to how the figure was derived. Another study was contracted out by the NEA to Boonyiem & Associates, 1986, (4) to survey the electricity generation potentials of 30 rice mills which have 100 tons/day or higher capacity, and from that to estimate the overall potentials in the rice milling industry in Thailand. It concludes that the number of mills suitable to produce electricity for self-consumption is small because most of the mills at present do not use much electricity. However, if there is a policy measure to allow them to sell electricity, then there will be more mills that can economically utilize their leftover rice husk to produce electricity.

Based on the assumption that the price of electricity that substitutes that from the grid is 1.45 baht/kWh and the selling price of electricity acceptable to utility is 0.95 baht/kWh (4), electricity generation will be applicable and viable in about 95 rice mills. Thirteen of them are rice mills for parboiled rice; they constitute 65% of the capacity of this type of mills that have 100 tons/day capacity or more. Together they produce an estimated energy of about 17.6 GWh per year. The remaining eighty two are rice mills for white rice; they account for 66% of the capacity of this type of mills that have 100 tons/day capacity or more. They combinedly could generate about 70.7 GWh per year. In total, the electricity generation potential would be 88.3 GWh per year, representing an overall saving of about 112 million baht per year to the rice mill owners.

CONCLUSIONS AND RECOMMENDATIONS

Existing co-generation of heat and power in the rice milling industry is limited but there are ample potentials for co-generation development in the industry, estimatedly 80 to 90 GWh per year if improvement on steam-generating efficiency is made by the rice mills concerned.

Co-generation in Thai agro-industry such as rice milling, sugar milling etc. offers several merits of breaking away from the reliance on centralised utility. First, reliability of electricity for the agro-industry is ensured by the availability of the cheap fuels provided by the biomass wastes from the industry. Second, at national level, the use of expensive petroleum-based fuels can be further reduced by the waste-fuel utilization. Third, capital expenditure for the construction of electricity utility power stations can be reduced or deferred.

In order to realise the above potentials, it is essential that the government enacts an energy act to allow private generation of power for commercial sale, to mandate the electricity generating authority to purchase privately generated power and publish tariffs for the purchase of privately generated power. Measures should also be developed to technically assist potential and existing private generators, particularly in areas concerning with the management expertise in running CHP systems.

Although the capital investment needed may yield acceptable paybacks, capital availability may still be a major constraint to further co-generation development. Thus, if the government gives financial assistance to energy conservation measures, then CHP in industry should be given priority. This also includes setting up or financing technical and information services to deal specifically with CHP on an exploratory basis for a trial period to provide flexibility for policy adjustments.

Despite all the supportive efforts from the government, attempts to further develop CHP may be limited by technical factors. For example, the economics of a simple steam turbine system limit its application to high heat to power ratios. Making full use of its electricity generating capacity may lead to more heat than can be used on site. On the other hand, sizing the system to meet heat demand may result in small electricity output that the whole project becomes uneconomic. The lack of on-site flexibility in the heat to power ratios is an impediment to further CHP application, unless the purchase of CHP generated electricity by the electricity authorities at reasonable prices is realized. There is at present inadequate technical information on this issue of technical choice, particularly information which is derived from the field. Consequently, there is a need for further studies in this area.

Fig. 1 Simplified Process and Energy Flow Diagram of Typical Rice Mills for Parboiled Rice

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APPENDIX

In order to test the reliability of the estimates made by the two studies mentioned above, a simple calculation is made as follows:

Assumption :	Heating value of husk	= 13.81 MJ/kg
	Boiler efficiency	= 60%
	Steam engine thermal efficiency	= 30%
	Steam engine mechanical efficiency	= 80%
	Generator efficiency	= 80%

Calculation : Based on the above assumptions and information that the maximum amount of rice husk which can be potentially used for electricity generation is 322,500 tons per year and that the mills which have electricity generating potentials account for about 65% of the capacity of the mills covered in the analysis, the electricity generation potential in the rice milling industry is

$$\begin{aligned}
 &= 322,500 \times 1000 \times 0.65 \times 13.81 \times 0.6 \times 0.3 \times 0.8 \times 0.8 \\
 &= 333.5 \times 10^6 \text{ MJ/year} \\
 &= 92.6 \text{ GWh/year}
 \end{aligned}$$

Hence, the estimates suggested by the two studies are not overestimated.