Diversification of the Sugar and Palm Oil Industries: Indonesia

Survey of Energy and Product Investment Options

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1.0 EXECUTIVE SUMMARY

1.1 Introduction

This report presents the results of a preliminary study of the technical, economic and commercial feasibility of improving the utilization of biomass byproducts from the sugar and palm oil industries of Indonesia. The primary purpose of this study is to explore possibilities for new development and investment in these industries and for joint ventures between Indonesian organizations and foreign investors.

Promising opportunities for new energy and related byproduct ventures have been discovered in this preliminary study. The BEST team recommends that site-specific studies to investigate these opportunities in more detail be conducted in the near future. The nature of the follow-up studies is discussed at the end of the Executive Summary.

The supply of byproducts from the sugar and palm oil industries and their possible uses are briefly summarized in the next sections.

1.2 Supply of Byproducts

Sugar Industry

Indonesia has 67 sugar plants with a total of 181,000 metric MTs (MT) per day of cane processing capacity. The average size of plants is about 3,000 MT per day. These plants process 26 million MT of cane per year, producing about 2 million MT of sugar and 1 million MT of molasses. Bagasse represents about 32 percent of the cane processed, or 8.3 million MT per annum at about 50 percent moisture content.

Molasses is another import byproduct of the sugar industry. It is widely used as animal feed supplement, and as a substrate for fermentation processes producing alcohols, vitamins, monosodium glutamate (MSG), and other products. Indonesia exports about one third of its molasses production at favorable international prices of around US$ 60 per MT, although the trend of percentage exported is decreasing. Since molasses is a more highly valued product of the sugar industry, rather than a waste product it is not a major subject of this study.

Over 90 percent of the bagasse now being produced in Indonesia is used in the sugar mills as fuel to produce steam and electricity. For this reason, most of the mills are self-sufficient in energy production. However, since bagasse has been virtually a free energy resource with few other uses, these mills have had no incentive to use the energy in bagasse more efficiently. Consequently, the mills use low pressure boilers and single cycle turbogenerators that require around 80,000 BTU per kWh of energy produced. The energy efficiency of the larger mills can be substantially increased, with substantial savings of bagasse for surplus electrical production and other possible uses.

As much as 30 percent of the total biomass in cane fields before harvest is in leaves and cane tops. Small holders, mainly on Java, use this material for animal feed, while large estates generally leave it on the ground at harvest. This material could provide a substantial additional source of biomass from the cane industry. However, there are significant costs of gathering, transporting and storing these byproducts (BEST Report, 1989).

Palm Oil Industry

Indonesia has 500,000 ha of mature palm oil estates and 333,000 ha of immature estates. The estates and associated mills produce 1.6 million MT of palm oil and nearly 345,000 MT of palm kernel meal used for animal feed. The average palm oil mill processes about 30 MT of fruit bunches per hour. The largest plants have capacities up to about 60 MT per hour. At the largest plant size, a palm estate of about 10,000 ha is required. The fiber of the palm fruit and shells of the palm nuts are used as fuel to provide steam and electricity for the mills, which are mainly self-sufficient in energy production. Palm oil production is seasonal with the differential between the peak production and the trough at roughly a factor of two.

The major biomass byproduct from the palm oil industry is empty fruit bunches (EFBs), the fibrous residue remaining after the palm fruits are separated in the mills. Indonesia now produces about 5 million MT of EFBs (at 60 percent moisture). Currently, EFBs are often incinerated at the plant site, which causes some air pollution. By 1992, this pollution will need to be curbed in compliance with new environmental regulations. The only beneficial current use of EFBs is the fertilizer value of the ashes. At a few places, the EFBs are chopped up and spread on estate grounds without incineration.

Other potentially important palm industry biomass products are in the estate grounds themselves. First, the fronds from the palm trees are trimmed annually, to reduce infestation by rodents. This produces about 10 MT/ha. of palm fronds (at 50 percent moisture) per year. These fronds could be used as fuel for power production, especially in the offseason when EFBs are not available. Second, grasses grow between the palm trees in the estates. These grasses could be utilized as animal feeds--either by grazing livestock in the estates under carefully controlled conditions, or by harvesting and processing the grasses for markets. Last, the wastewater from palm mills contains solids that could be used as animal feeds or as a substrate for fermentation processes. However, little is known about the value these solids in either use.

In terms of possible uses for these sugar and palm wastes, the BEST Project roughly ranks biomass in terms of a hierarchy of values, called "The Five `Fs'": Food; Feed (for animals); Fiber; Fuel; and Fertilizer. The situation with respect to each of these products is described briefly as follows:

Food

The major food use of byproducts is the use of molasses and, possibly, condensates from the waste water

of palm plants as a substrate for fermentation processes to produce ethanol, alcohols, monosodium glutamate (MSG), vitamins, and other possible products. Ethanol is being produced by a public sector plant, and MSG by a Japanese-operated private sector plant, near Surabaya. There probably are other plants, of which the BEST team is not aware, elsewhere in Indonesia which use molasses as a feedstock. The proprietary nature of many of these processes and products precludes their coverage in this report.

Feed

Molasses is widely used for animal feed. Bagasse is too low in nutrient value for this purpose. However, pilot plants in Brazil are reported which hydrolize bagasse to produce more digestible feed. There are also four or five plants in Indonesia that use fresh leaves stripped from the sugar cane in the fields to produce animal feed that is exported to Japan. Two of the plants visited by the BEST team, each produce around 40 MT (air dry) of baled cane leafs per day. It is reported that there is an optimal level of leaf stripping that improves the yield of the cane, but too much stripping decreases yield. It is unknown what that optimum level is or whether stripping is done accordingly.

The palm industry produces meal from the palm nuts that is a valuable animal feed. It is possible that EFBs, with a residual oil content of about 10 percent could be used as feed for ruminate animals. The team has not been able to find any reports on this possibility. The condensate from palm waste water, mentioned above, is another possible source of animal feed. The moisture content of this material, however, is likely to be too high to be an economical source of feed. Also, as noted before, the grasses in the palm estates can be utilized as animal feed.

Fiber

Several plants in Indonesia are pulping bagasse for newsprint. The newest and largest plant, P.T. Tyiwi near Surabaya is privately owned and the BEST team was not permitted to see it or to interview its personnel. There is a public sector plant, P.K. Leces near Propolinggo, which the Team did not visit. The Team could not find cases where EFBs are used for paper pulp. The Indonesian Planters Association for Research and Development has had samples of EFBs analyzed for paper pulp quality and the results are reported as favorable. It appears that paper pulp is potentially one of the most important uses of bagasse and, possibly, EFBs in the future. However, the technology and economics of this use are not yet clear.

Bagasse is being used in Thailand and Pakistan to make an extruded fiberboard that is used to make furniture as well as construction materials. These are generally small, low-cost plants, and this potential use should be investigated further.

Another possible use that is based on fibrous byproducts is also an "F"--namely, furfural. Furfural is a chemical that is extracted from such biomass materials as maize cobs and bagasse. It is used as a solvent in certain chemical processes, and as a plasticizer. The world market for furfural is very limited, at only about 50,000 MT pa; while the potential supply of maize cobs and bagasse is virtually limitless. One U.S. company is said to have about 80 percent of the total world market for furfural. Since furfural production is largely a proprietary technology, the BEST team has not been able to obtain reliable technical information on it. The feasibility of this technology in Indonesia appears to depend on the interest of foreign companies in serving the domestic market. In any case, since furfural production consumes only about seven percent of the total biomass processed, it would not compete with such end uses as energy. Furfural production thus could be included as a part of the process stream of these other uses.

Fuel

By far the most important potential use of bagasse and EFBs under present technology and economic conditions is as a fuel for production of heat and power. The findings of this study for each of these byproducts is the subject of Section 1.4 below.

Fertilizer

Neither bagasse nor EFBs is of much value as fertilizer. The exception, as noted before, is that EFBS are typically incinerated, and the ash is applied to fields to provide potassium and potash. It should also be noted that applying excessive biomass back to the soil can cause substantial loss of soil nitrogen and methane pollution of the atmosphere through processes of decomposition.

1.4 Energy Use of Byproducts

The rapidly growing economy of Indonesia is encountering severe energy constraints. Indonesia currently has an installed capacity of 11 gigawatts (GW; one billion watts), 7 in the state-run PLN system and 4 GW at private industrial estates and plants. It plans to add 16 GW over the next 10 years, mostly from coal and natural gas. Even so, there could be a short fall of 3 GW, or 20percent, by 1995, mainly in Java and Sumatra. In addition, a good deal of the expansion outside Java still will require diesel generator sets and the projected electricity shortages will induce plant owners to continue using diesel engines to generate power for their factories. Biomass energy can make a modest but important contribution to resolving this problem -- especially in more remote, rural area, where diesel use is predominant. For example, if only 20percent of the surplus bagasse produced in Indonesia were used for generation of surplus electricity, about 50 additional megawatts (MW, one million watts) would be available using current technology and more than 200 MW with high efficiency technology. If all the EFBs were converted to electricity, an additional 100 MW would be available. Together, these two biomass energy sources could provide an additional 150-300 MW, sufficient to fill 5-10 percent of the projected shortage of 3 GW. Behind the national figures lie some locally significant effects of biomass-based electricity systems. Potential electricity generation from sugar mills in Lampung province, Sumatera could exceed 100 MW, about twice the existing diesel capacity of the province. Generation of power from such mills would not only replace existing diesel use but also would provide ample reserves for new industries.

The rest of this summary outlines the findings of the study on the feasibility of a biomass energy program in Indonesia.

Energy from the Sugar Industry

The sugar industry of Indonesia operates at very low energy efficiencies because bagasse is virtually a free energy resource -- and, indeed, the best way to dispose of it is through burning it in low efficiency boilers. This point is illustrated in the large, 10,000 MT per \pageday, private-sector plant of Gunung Madu, in Lampung. The plant was designed to burn all the bagasse, but four years ago the plant started to produce surplus bagasse at a rate of 800 MT/day. This surplus created a mountain of bagasse that now totals more than four millions MTs and has become a serious problem for the plant managers.

Of course, excess bagasse production would become a major source of revenue if it could be converted to electricity and sold. In Hawaii, electrical production from sugar mills provides about half of the baseload electricity on the island of Hawaii and has become a major source of profit for the mills.

While energy efficiency typically can be improved by about 20 percent through simple improvements in sugar processing in the plant, the greatest gains in energy efficiency are obtained from conversion of low pressure boilers and power plants, operating at 10-20 bar pressures, to medium (40 bar) and high pressure (above 60 bar) co-generation systems. Through such improvements, energy output per MT of cane processed can be increased as much as nine times--from 10 to 20 kWh/MT up to 90 kWh/MT (BEST, 1989; p. 5). Such large improvements, however, are generally feasible only in large plants, above 7,500 MT of cane per day. Smaller plants can make m or e modest improvements, on the order of doubling or tripling energy efficiency. In mills of 5,000-7,500 MT/d capacity, such simple conservation measures as air pre-heaters, economizers and improved juice extraction can save as much as 25percent of the current energy use. Such economies would allow a mill to export as much as 2_ 3 MW during the milling season.

The study's preliminary economic analysis of electricity production by the sugar industry indicates that highly favorable returns on the order of 20-40 percent per annum can be obtained by designing large, new sugar mills for electrical production, or by including such capabilities in expansions of existing mills. These returns are possible because the additional cost of improving new power plants is rather low. On the other hand, it probably is not economically feasible to convert existing plants to high energy efficiency systems until the existing equipment needs to be replaced. However, given the more modest measures noted above, the total generation cost from existing mills can be quite low, normally below the current baseload costs in the PLN system.

The study team learned that one 10,000 MT per day public sector plant, P. J. Kembalkrep, is being planned in the Mojokerto area for operation in 1994, and four similarly sized plants are being planned by the private sector in Lampung. Each of these plants could generate about 30 MW of electricity, using high pressure equipment, exporting 20 MW. These plants are logical candidates for the first efforts in bagasse-based electrical production. Investigations of similar opportunities in Thailand showed returns on investment in the 30-40percent range, even where the mills sell some bagasse to fiberboard factories.

Energy from the Palm Oil Industry

Since EFBs are now being incinerated, it is easy to produce electrical energy from palm plants by simply installing additional power capacity to utilize this resource for energy production. However, the EFBs would have to be chopped and dried to around 50percent moisture, which would entail some cost. Also, even if all of the EFBs were used for electrical generation, a 40 MT per hour plant would produce only about one MW of electricity. Because most palm oil plants are in remote areas, there may not be a market even for this amount of electricity. Thus the potential for using EFBs as a power source depends mainly on the market for electricity--either by local users, or through transmission lines.

A possible solution to this problem is to build a power plant near existing transmission lines that would be fed EFBs from several surrounding plants. Such an opportunity exists in the Medan area, as discussed in the text, where several palm plants in the neighborhood of PTP's Adolina mill could support a power plant of over 3-5 MW.

An important added advantage of power production from EFBs is that the improved combustion technology would substantially reduce the air pollution caused by open incineration.

Energy Policies

One of the greatest sources of uncertainty in the energy field of Indonesia is that of government policies for generation and sale of electricity by the private sector and other organizations in relation to PLN, the governmental electrical agency. PLN has announced its willingness to purchase electricity from other producers but the terms and conditions are not yet clear. Obviously, until PLN's intentions are made more concrete, little progress can be made in electrical production from biomass resources, or any other sources, other than by PLN itself.

1.5 Recommendations

The BEST team recommends that site specific studies be made of the technical, economic and commercial feasibility of designing new, large and medium sugar cane mills to high energy efficiency standards with electricity export. Further, the team recommends site-specific feasibility studies for factories which are planning overall expansion or replacement of their power facilities. Specifically such studies should be undertaken for factories in the Lampung and Mojokerto areas. In addition to the focus on new or expanding mills, the team recommends that a follow-up team look at several existing mills and investigate ways of making such mills net electricity exporters.

A good way to begin these studies would be to have a workshop in Hawaii to visit power exporting sugar mills and to review alternate plant technologies and economics. Indonesian participants in such a workshop should include representatives of public and private sector sugar companies and PLN. After this workshop, detailed studies could be made of the planned new public and private sugar mills.

It is possible that these new mills could establish the basis for biomass-based growth centers in which industries producing such products as animal feeds, vitamins, MSG, alcohols, fiberboard and other products would be located on the grounds of the sugar mills. The sugar mills would provide these industries with reliable and economical energy supplies.

The team also recommends that the feasibility of using palm industry EFBs for electrical generation in areas close to villages, industries and transmission lines be further examined. This study should concentrate on the feasibility of establishing a central power plant in the Medan area that would use EFBs from several neighboring palm oil plants. Such plants could become the basis of biomass-based growth centers, as in the case of sugar mills.

Last, the study recommends that Perkebunan actively solicit investments by the private sector in furfural, vitamins, fiberboard, alcohols and other products noted above. The BEST project could be able to assist Perkebunan in this task by assisting in making contacts with private sector firms. Continued support for research in the sugar and palm industries and their byproducts is essential to full utilization of these valuable resources.

2.0 DIVERSIFICATION OF SUGAR AND PALM OIL: INDONESIA

There is an increasing awareness of the importance of resource conservation in Indonesia. Although oil products still represent a major component of exports, they are rapidly decreasing. Between 1986 and 1989, the proportion of exports contributed by oil decreased from 51 to 39 percent. With increasing domestic demand for oil products, the quantity of oil available for export is expected to decrease to a relatively low level and by 2010 the nation could become a net oil importer.

The government of Indonesia has adopted an effective investment plan and an export strategy for promoting non-oil exports to offset the expected changes in the composition of exports. Consistent with these new directions is the search for alternate sources of energy. One often overlooked area is the more efficient utilization of waste products from the production of primary products in agriculture.

Sugarcane and oil palm are two agricultural commodities in Indonesia with growing volumes of waste products. There are 67 sugar factories processing over 26 million metric MTs (MT) of sugarcane annually. These plants produce 2 million metric MTs of sugar and 1 million MT of molasses. Bagasse represents about 32 percent of the cane processed, or 8.3 million MT per annum at about 50 percent moisture content. With the exception of some of the larger sugar factories, the industry uses nearly all of the bagasse for its own its energy requirements. With the introduction of existing higher efficiency technology, energy production could be made more efficient for production of surplus power or making possible the release of larger quantities of bagasse for other products while becoming an energy self-sufficient industry.

Increased sugarcane production is planned to meet growing domestic demand for sugar. Similarly, new factories are planned, particularly off Java where electricity grids are not well developed. These medium-to-large scale factories offer important opportunities to become efficient producers of energy as well as sugar.

Growing very rapidly in size, the palm oil industry represents another opportunity for improved utilization of its waste products. Indonesia has over 500,000 hectares (ha) of mature palm oil estates with an additional 333,000 ha of immature estates. The estates and associated mills produce nearly 1.6 million metric tons of palm oil and nearly 345,000 metric MT of palm kernel. The 83 palm oil mills use the fiber of the palm fruit and shells of the palm kernel as fuel to provide steam and electricity for the mills. In terms of steam and electricity, cogeneration is a growing practice; however, there has not been much emphasis on energy efficiency and self-sufficiency. As with the sugar industry, the scope for increased energy production appears to be large.

Other palm oil wastes include stripped fruit bunches, which are typically field disposed or incinerated with no heat recovery, several streams of palm oil mill effluent or sludge, and the palm oil tree fronds. Several new products are under consideration which could utilize these waste products.

The overall objective of this study is to provide a preliminary industry assessment to determine the basic plausibility of sugar or palm oil energy projects in Indonesia. The study is divided into three parts. The first part provides background information on the sugar and palm oil industries and the various products which could be produced from the waste products from these industries. The second part discusses the use of sugar and palm oil waste products for energy production, including economic and financial analysis. The third part of the report presents the conclusions and recommendations based on the findings of the study.

3.0 SETTING OF THE SUGAR AND PALM OIL INDUSTRIES

3.1 Sugar Background and Policies

Sugar has long been identified as one of several basic agricultural commodities in Indonesia and, along with cane production, has thus been the subject of various types of governmental policies and controls. The main goal of these policies has been to regain the sugar self sufficiency, which Indonesia enjoyed prior to independence. The results have been mixed; Indonesia presently produces about 90 percent of its total consumption. Under sugar self sufficiency policy, furthermore, most of the emphasis has been on producing more sugar without much consideration for the most efficient use of byproducts from sugar production.

One of the critical aspects of sugarcane production in Indonesia has been the increasing pressure on land utilization on Java. Cane cultivation is in increasingly severe competition with food crops, in particular rice. This trend represents an attempt to maintain Indonesia's current status of rice self sufficiency.

Undeveloped areas outside of Java are still available, and it is generally agreed that further expansion of sugarcane production will take place off Java. This approach has been incorporated into Indonesia's overall strategy for agricultural development of the outer islands. However, the capacity to utilize land areas off Java is limited by various constraints, and special considerations of the existing limitations on capital, manpower and technology must be taken into account. Under these conditions, private enterprise is being requested to take a more active role in developing the sugar industry on the outer islands of Indonesia.

Other policies and programs aimed at increasing sugar production in Indonesia include the implementation of the Tebu Rakyat Intensifikasi, or small sugarcane farmers intensification program, rehabilitation of sugar factories on Java, erection of new sugar factories on the outer islands, strengthening of the government estate enterprises as well as the marketing and pricing operations of BULOG (The State Commodity Agency).

Sugar Industry Statistics

Review of recent production statistics indicates a relatively constant level of sugar production. While the area under sugarcane has increased somewhat, the rate of production per hectare has decreased due to a diminishing level of sugar extraction from the sugar cane (Table 1). Given constantly increasing population and an increasing level of per capita consumption of sugar, the potential for achieving self sufficiency in sugar production in Indonesia would not appear to be positive in the next few years.

The projected balance sheet for sugar in Indonesia during 1989 to 1993 indicates maintaining of sugar imports representing about 15 percent of total projected consumption needs (see Table 2). The apparent sharp increase in imports for 1990 indicates a change in government policy with respect to stock maintenance, moving from a stock position of between 800,000 to 900,000 MT to a goal of 1,500,000 MT of sugar.

Area and Sugar Production, 1985-1989

Year	(ha)	(MT)	(%)	(MT/ha)	(MT)	(MT)
1985	277,709	76.3	8.14	6.21	21,194,963	1,725,386
1986	316,033	79.5	8.05	6.40	25,127,096	2,022,387
1987	337,531	77.0	8.20	6.32	26,000,751	2,132,036
1988	329,467	76.6	7.60	5.82	25,234,864	1,917,422
1989	340,035	78.8	7.64	6.02	26,811,513	2,047,375
Source : Indonesian Sugar Council (Dewan Gula						

At the present time, there are 67 sugar factories in Indonesia with crushing capacities ranging from 1,000 to 10,000 metric tons of cane per day (TCD). The total crushing capacity of sugar factories in Indonesia is 181,000 TCD, with 134,000 TCD or 74 percent on Java and 47,000 TCD on the outer islands. The sugar cane harvest in 1989 was nearly 27 million MT, and sugar production was over 2 million MT.

The milling season in Indonesia is from January to October on Sumatera, and April to December on Java, Kalimantan and Sulawesi. The duration of the milling season ranges from 80 to 200 days. Most of the factories in Indonesia are using the double sulphitation process to produce white crystal sugar, except for 10 sugar factories which are using the double carbonation process.

One of the important byproducts of the sugar industry is molasses. Total molasses production in Indonesia is presently over 1.1 million MT. (See Table 3). In the past, a high proportion of the molasses production has been exported. But with increasing domestic demand for this product, exports are expected to be negligible within five years.

Balance Sheet, 1989-1993

Item	1989	1990	1991	1992	1993
1. Production	2,047,238	2,215,360	2,283,300	2,342,640	2,373,600
2. Import	282,922	636,040	240,289	281,893	355,914
3. Beg. Stock	848,168	898,328	1,378,528	1,436,069	1,495,912
4. Total Avail.	3,178,328	3,749,728	3,902,117	4,060,602	4,225,426
5. Consumption	2,280,000	2,371,200	2,466,048	2,564,690	2,667,278
6. Ending stock	898,328	1,378,528	1,436,069	1,495,912	1,558,148
Population	177.8	181.4	185.0	188.7	192.5
Consumption PC (Kg)	12.82	13.07	13.33	13.59	13.86

Assumption: Consumption Growth = 4.25 % per year

Another important joint product or waste product from sugar production is cane bagasse. With bagas se totalling approximately 32 percent of total sugar cane production, over 8 million MT of bagasse are currently being produced in Indonesians cane mills. About 90 percent of this bagasse production is being used as fuel for the sugar factory boilers. Some of the remaining bagasse is used as pulp in paper production. The rest is presently going unused for any purpose.

Table 3. Production and Use of Molasses, 1985-1989 (MT)

Year	Production	Export	Industrial Use	Other
1985	869,995	577,022	224,009	68,964
1986	918,992	714,712	268,988	64,708
1987	1,105,560	624,780	324,187	156,593
1988	1,029,206	540,211	483,211	784
1989	1,148,862	385,070	623,196	140,596

Source : Indonesian Sugar Council & Beverage and other food products

The distribution and marketing of sugar has been controlled by BULOG (Logistics Board) since 1982. This government body has the mandate to maintain adequate supplies of sugar at prices which are considered reasonable and stable. The sugar price policy in Indonesia has attempted to maintain a competitive balance between sugar and other commodities, particularly rice. The production-side incentives of sugar price regulation are implemented by setting ex-factory prices for sugar through annual governmental decrees (see Table 4). Retail prices for plantation white sugar are controlled by the government as well.

Table 4. Government Regulated Sugar Prices in Indonesia, 1981-1990
_____}
Minister of Finance Decree \tab \tab Factory\tab \tab Price ex-
_____\tab Production \tab \tab Factory
Date\tab \tab Number\tab \tab \tab Price\tab \tab \tab (Wholesale)
_____
Rp. per quintal -
1-4-1981 \tab \tab SR.43/MK.011/81 \tab 35,000 \tab \tab 42,930
2-7-1993 \tab Kep.447/KMK.011/83 \tab 35,000 \tab \tab 40,600
1-5-1984 \tab 346/KMK.011/84 \tab 40,000 \tab \tab 50,447
28-3-1985 \tab 294/KMK.011/84 \tab 42,500 \tab \tab 52,903
26-5-1987 \tab 342/KMK.011/87 \tab 46,750 \tab \tab 57,965
27-5-1988 \tab 571/KMK.013/88 \tab 51,425 \tab \tab 64,061
31-7-1989 \tab 837/KMK.013/89 \tab 60,000 \tab \tab 74,300
1-4-1990 \tab 391/KMK.013/90 \tab 65,000 \tab \tab -------
_____
* }{\fs20 Price reflects factory production price plus regulated charges for packaging and various taxes.}

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Another active partner in providing institutional support for the development of sugar production is the Indonesian Sugar Council formed by government decree in 1982. The Sugar Council includes representation by all the major directorates and government bodies related to agricultural production and agricultural industries. In addition to the bureaus providing direct support for program planning, monitoring, and control, Council maintains linkages to the Indonesian Sugar Research Institute which provides the technical support for sugarcane production and sugar processing. [The organizational structure of the Indonesian Sugar Council is shown in Annex 1.]

Given the goal of sugar self sufficiency along with population and income related demand increases, the government has established policies to expand sugar production over the next few years. This includes setting price incentives to maintain the level of farmer and sugar factory incomes and, as noted, encouraging the development by the private sector of new sugar factories on the outer islands.

The estimated current cost for establishing a sugarcane estate and sugar factory with a capacity of 4,000 TCD is about Rp 140 billion. Although available feasibility studies would not indicate high returns to the investment, private investors have shown continued interest in the possibilities of developing sugar plantations and factories on the outer islands. An important obstacle holding up the development of new plantations is the general lack of infrastructure in the areas available for expansion of sugarcane production. In this respect, government assistance is expected to be forthcoming.

Other measures being requested by private producers include:

- The opportunity for direct sales of 50 percent of the sugar production on Sumatera and 75 percent of sugar production from factories in eastern Indonesia.
- Permission to sell 30 percent of their production at FOB price to BULOG whenever the world market price is higher than domestic prices.
- Present plans for expansion of sugar factories would provide an increase of 32,000 TCD, for an increase of nearly 20 percent in factory capacity. A list of the currently projected investments in sugar factories on the outer islands is given in Annex 2.

3.3 Palm Oil Industry Background

Palm was first introduced to Indonesia in 1864 and decedents of these original plantings can still be seen in the botanical garden in Bogor. Palm oil originally developed in the northern part of Sumatera and then expanded to other regions of the country. The plant was quite successful in achieving high yields and slowly became an important crop for domestic use as well as for export markets. With the drive to expand non-oil exports, palm oil has been one of the principal agricultural commodities promoted. Over the twenty year period ending in 1988, palm oil production increased by over 350 percent. Today, palm oil represents the second most important agricultural export from Indonesia, exceeded only by rubber.

The area under palm oil is expected to continue to show rapid expansion. During 1989, over 110,000 ha was planted for a 13 percent increase in the total palm oil area. By 1993, the area under palm oil is expected to reach 1,200,000 ha. This rapid growth has taken place in all enterprise categories, but the growth has been especially strong in the locally owned private estate category. Palm oil has been designated by the government as the primary crop for developing the private sector during the current five year plan (Repelita V).

The overall development of palm oil estates has been facilitated by the Ministry of Agriculture. The government unit for state owned corporations (Badan Usaha Milik Negara) has been in charge of coordination of government estate development. Other estate development, especially small holders, has been coordinated through the Directorate for Estate Crops in the Ministry of Agriculture.

Most of the government palm oil plantations (PTP's) up to 1980 were located in North Sumatera. In the last decade ten of the other 25 provinces including the eastern-most province of Irian Jaya have been rapidly developing new estates.

Oil Land Areas by Type of Enterprise, 1988.
\par \pard \qj\ri-432\box\brsp20\brdrdb
\tx288\tx1008\tx1728\tx2448\tx3168\tx3888\tx4608\tx5328\tx6048\tx6768\tx7488 {\uldb
_____}
\par \tab Enterprise\tab \tab Mature area\tab \tab Immature area\tab Total area
\par _____
Government estates\tab 288,095\tab \tab 69,902\tab \tab 357,997
\par \tab Private estates:
\par \tab Joint venture\tab \tab 56,564\tab \tab 12,564\tab \tab 69,162
\par \tab Locally owned\tab 77,382\tab \tab 129,688\tab \tab 207,070
\par \tab Small holders\tab \tab 21,816\tab \tab 36,473\tab \tab 58,289
\par \tab Nucleus small holders 58,632\tab \tab 84,193\tab \tab 142,825
\par _____
\tx288\tx1008\tx1728\tx2448\tx3168\tx3888\tx4608\tx5328\tx6048\tx6768\tx7488 \tab Total area \tab \tab
502,489\tab \tab 332,854\tab \tab 835,343

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Palm oil is harvested as fresh fruit bunches (FFB) throughout the year. The normally expected range of production varies between 20 to 25 MT of FFBs per hectare, depending on genetic characteristics and cultivation practices. The FFBs are brought by trucks or other transport to the palm oil mills.

Palm oil mills process the FFB's to extract the crude palm oil (CPO). The byproducts of this process include the palm kernel, empty fruit bunches (EFBs), and the fiber from the exterior fruit. The palm kernel is then crushed to produce palm kernel oil (PKO) with empty shells being a byproduct of this process. Palm oil and palm kernel oil are the main economic products along with palm kernel meal. The EFBs, fiber, and shells are regarded as waste products.

The rate of oil extraction from palm oil averages between 21 and 23 percent, while the palm kernel extraction ratio averages between 4.5 and 5.5 percent. Extraction efficiency can be increased by improved processing systems and better management practices.

Indonesia's palm oil development is expanding somewhat more rapidly than total world growth in palm oil production (see Table 6). Over the four year period, 1984 to 1988, palm oil production increased by 39 percent in Indonesia compared to a 26 percent increase for the world as a whole. During this same period, Indonesia's market share of the total world supply increased by nearly two percentage points.

Table 6.\tab Indonesia Palm Oil and Palm Kernel Production Compared to World Total\tab 1984 to 1988 (MT 000s)
\par \pard \qj\ri-432\box\brsp20\brdrdb
\tx288\tx1008\tx1728\tx2448\tx3168\tx3888\tx4608\tx5328\tx6048\tx6768\tx7488 {\uldb
_____ }
\par \tab Year\tab \tab {\ul World production} \tab {\ul Indonesia}
\par
\par \tab \tab \tab Palm oil \tab Palm kernel \tab Palm oil\tab \tab Palm kernel\tab
_____

1984\tab \tab 6,942\tab \tab 2,415\tab \tab 1,121.1 (16.2%){\up6 *} \tab 293.3 (12.1%)
1985\tab \tab 7,587\tab \tab 2,628\tab \tab 1,297.9 (17.1%)\tab 259.8 (9.9%)
\par \tab 1986\tab \tab 8,279\tab \tab 2,783\tab \tab 1,357.4 (16.4%) \tab 274.9 (9.9%)
\par \tab 1987\tab \tab 8,733\tab \tab 2,840\tab \tab 1,406.0 (16.1%) \tab 311.0 (11.0%)
\par \tab 1988\tab \tab 8,774\tab \tab 2,957\tab \tab 1,562.3 (17.8%) \tab 345.0 (11.7%)
_____
* }{\fs20 Figures in parentheses indicate Indonesia production as a proportion of world production.

(formatting for above table, lost in translation)

Prices of CPO for domestic use are regulated by the government through the Ministry of Trade. The objective of these regulated prices is to insulate domestic producers from international prices which tend to vary significantly over brief periods of time. This policy has given stability to domestic products produced from CPO, particularly cooking oil.

There are several important reasons why the international palm oil prices exhibit a high level of variation. Table 7 shows the recent history and variability of prices for the various palm oil products for the export market. Price instability has two main causes. On the supply side, changes in rainfall in producing countries may cause yield and production variations from one year to another. On the demand side, changing trade policies in consuming nations along with production variations in substitute crops (e.g., soybean oil) can lead to significant changes in quantities of palm oil needed from one year to another.

Table 7.\tab Average export prices of palm oil products from government estates
\par (- US Dollars -)
\par {\uldb _____
\par }\pard \ri-432\box\brsp20\brdrdb
\tx288\tx1008\tx1728\tx2448\tx3168\tx3888\tx4608\tx5328\tx6048\tx6768\tx7488 \tab Commodity\tab \tab \tab 1987\tab \tab \tab 1988 \tab \tab \tab 1989
\par \tab _____
\par \pard \qj\ri-432\box\brsp20\brdrdb
\tx288\tx1008\tx1728\tx2448\tx3168\tx3888\tx4608\tx5328\tx6048\tx6768\tx7488 \tab Crude palm oil \tab \tab 0.2821 \tab \tab 0.3792 \tab \tab 0.3009
\par \tab Palm kernel oil\tab \tab 0.3767 \tab \tab 0.4747 \tab \tab 0.3832
\par \tab Palm kernel pellet\tab \tab 0.0548 \tab \tab 0.0765 \tab \tab 0.0788
\par \tab RBD palm oil \tab \tab 0.2835 \tab \tab - \tab \tab 0.3062
\par \tab RBD palm stearin\tab \tab 0.2805 \tab \tab 0.3827 \tab \tab 0.2687

\par \tab Crude palm stearine - \tab \tab 0.3795 \tab \tab _

(formatting for above table, lost in translation)

The price for CPO received ex-factory is a composite of the controlled domestic price and the varying international price. With about 60 percent of current production being exported, there is still great price variation caused by changes in the international prices. With increasing levels of demand for cooking oil in the domestic market, the relative proportion of exports is expected to decrease. This will have a stabilizing effect on domestic prices for CPO (See Table 8).

Table 8.\tab Palm Oil, Palm Kernel and Palm Kernel Oil Utilization (MT)
\par {\uldb _____}
\par \pard \ri-360\sl288\box\brsp20\brdrdb
\tx288\tx720\tx1728\tx2448\tx3168\tx3888\tx4608\tx5328\tx6048\tx6768\tx7488 \tab \tab Year\tab
Domestic consumption\tab \tab \tab Export
_____\tab \tab _____
\par \tab \tab \tab Palm oil Palm Kernel\tab \tab Palm oil\tab {\ul Palm Kernel}
Nuts\tab \tab Oil
_____
\tx288\tx720\tx1728\tx2448\tx3168\tx3888\tx4608\tx4950\tx6048\tx6480\tx7488 \tab \tab 1984\tab 993,200
\tab 230,100\tab \tab 127,900\tab \tab 9,160\tab \tab 0
\par \tab \tab 1985\tab 779,900\tab 237,300\tab \tab 518,000\tab \tab 22,500 \tab 0
\par \tab \tab 1986\tab 852,903\tab 0\tab \tab \tab 504,497\tab \tab 3,937\tab \tab 42
\par \tab \tab 1987\tab 935,120\tab 0\tab \tab \tab 470,880\tab \tab 0 \tab \tab 83,302
\par \pard \ri-360\sl288\box\brsp20\brdrdb
\tx360\tx720\tx1728\tx2448\tx3168\tx3888\tx4608\tx4950\tx6048\tx6480\tx7488 \tab \tab 1988\tab 901,210
\tab 0\tab \tab \tab 661,097 \tab \tab 0 \tab 121,724

(formatting for above table, lost in translation)

Palm oil mills use solid fuel to produce the steam used to process the FFB's. The solid fuel is a mixture of fiber and shell, the ratio of which is influenced by the type of boiler used. The most commonly used boiler type is the low pressure water tube boiler. If the mill and boiler operate 20 hours per day, the solid fuel from the fiber and shell is sufficient for the boiler consumption needed for processing the FFBs. However, if the mill is operated for less than 20 hours a day, the factory will usually experience an insufficient supply of fuel to keep the boiler operating. Thus, energy needs are often supplemented with oil, generator sets or publicly supplied electricity sources.

While the fiber and shells are currently being used entirely as a fuel for the boilers, the other main waste product, EFBs are usually burned in incinerators at the palm oil mills. Another means of disposing of this waste is to return the EFBs to the estate fields as a source for organic matter. The more generally used practice of burning the EFBs creates an air pollution problem from the formation of CO and NO??gases. This practice will likely be decreased as environmental regulations come into effect although the ashes which are rich in K?O can be used as fertilizer.

By 1993 the palm oil crop in Indonesia will produce 3 million MT of dry empty bunches, the majority of which will be produced in the provinces of North Sumatera and Riau. Because of the large volume being produced, it is important to find an attractive economic use for the EFBs.

In order to insure sufficient supplies of solid fuel for boiler consumption, it has been proposed that the palm oil factory could also use the EFBs as a supplementary fuel. But the use of EFBs as a fuel requires adjustments to be made in the boiler burner along with other changes such as the use of a monomuncher, which would be used to cut and compress the EFBs. Early studies on the use of EFBs as an additional solid fuel for boiler consumption indicated the net energy gains from burning the EFBs would not be very high after deducting the energy used to prepare the EFBs.

4. NON-ENERGY USES FOR SUGAR AND PALM OIL WASTES

4.1 Current Waste Utilization

Sugar and molasses, palm oil and palm kernel oil have been important economic products for Indonesia. However, byproducts produced from sugarcane and palm industry waste products would appear to have the potential for significantly increasing the overall returns from the processing of these two raw materials as well as having positive environmental effects.

There is an expanding quantity of waste products resulting from the processing of sugarcane and oil palm which are, to varying degrees, going unused or could be used more efficiently. As shown in Table 9, about 30 million MT of raw material are available for producing byproducts from the waste products. In addition, at least part of the approximately one million MT of molasses currently produced with sugar could be used as a substrate for producing a wide variety of other economically important byproducts.

Table 9.\tab Utilization of Sugarcane and Palm Oil Waste Products
\par {\uldb _____}
\par \pard \ri-432\box\brsp20\brdrdb
\tx288\tx1008\tx1728\tx2448\tx3168\tx3888\tx4608\tx5328\tx6048\tx6768\tx7488 \tab Waste product\tab
\tab \tab Used\tab \tab Unused\tab Total
\par \pard \qc\ri-432\box\brsp20\brdrdb
_____
\par - MT millions -
Sugar:
\par \tab \tab Bagasse\tab \tab \tab 7.2 \tab \tab 0.8\tab \tab 8.0
\par \tab Cane tops \tab \tab \tab 0.1* \tab 3.4* \tab 3.5
\par \pard \ri-432\box\brsp20\brdrdb
\tx288\tx1008\tx1728\tx2448\tx3168\tx3888\tx4608\tx5328\tx6048\tx6768\tx7488 \tab Cane leaves\tab
\tab \tab 4.0{\up6 *} \tab 4.0{\up6 *} \tab 8.0
Sub-total \tab \tab \tab 11.3 \tab 8.2 \tab 19.5
\par \tab Palm oil:
\par \tab Empty fruit bunches\tab \tab 0\tab \tab 3.0\tab \tab 3.0
\par \tab Fiber\tab \tab \tab \tab 1.3\tab \tab 0\tab \tab 1.3
Shells\tab \tab \tab \tab 0.2{\up6 *} \tab 0.2{\up6 *} \tab 0.4
Palm tree fronds\tab \tab 0 \tab 6.0 \tab 6.0
\par \tab Sub-total\tab \tab \tab 1.5\tab \tab 9.2 \tab 10.7
\par \tab \tab Total\tab \tab \tab \tab 12.8\tab \tab 17.4 \tab 30.2
\par \pard \qj\ri-432\box\brsp20\brdrdb
\tx288\tx1008\tx1728\tx2448\tx3168\tx3888\tx4608\tx5328\tx6048\tx6768\tx7488 {\fs20\up6 *}{\fs20 = Estimated}

(formatting for above table, lost in translation)

Sugar processing presently produces 8 million MT of bagasse and 11.5 million MT of cane tops and leaves. At the present time, about 90 percent of the bagasse is being used as fuel in the sugar mills itself. However, there is considerable scope for increasing the efficiency of this energy production which would free up a sizable proportion of the bagasse for other uses or for energy production.

An indeterminate quantity of the cane tops and leaves are now being used for animal feed. Generally, the cane tops and leaves being produced on Java are fed to cattle, while most of the production off Java is going to waste. The 3.5 million palm tree fronds produced each year represents another raw material source which could be used for some economically important byproduct.

Oil palm processing is already using most of the fiber and shells for energy production. Again, this process could be made more efficient to allow the use of these waste products for other purposes. In addition, most of the EFBs are being incinerated. While the ash as noted before, is sometimes used as a source of potash fertilizer, this may be an inefficient use of this raw material.

Given this background, there appears to be considerable scope for more efficient utilization of the waste products from the sugar and palm oil estates and factories in Indonesia. The following is a review of some of the products which have been or could be produced from these waste products.

Pulp

Paper pulp production from bagasse is an established commercial practice in a number of locations, with early attempts dating back to the nineteenth century. However, it was not until the early 1900's that pulp production from bagasse became an economically viable enterprise

With an expanding population and increases in incomes, the demand for paper in Indonesia is increasing rapidly. For example, during 1981 to 1986 the total consumption of paper increased by 34 percent see Annex 5. During the same period, of importation of pulp for the paper industry increased from 86,000 to 255,000 MT. As the major raw material, there is an increasing need for supplies of pulp.

At the present time, there are two paper factories on Java (one each in the public and private sectors) which are using bagasse as a source of pulp used to produce paper. Although it was not possible to obtain more information on their operations, they are both operating with apparent commercial success.

Although bagasse pulp may not be of sufficient quality for some papers, there appears to be ample scope to use excess supplies of bagasse as a raw material in paper production. The yield of pulp from bagasse is some 49 to 50 percent. Thus, approximately 500,000 MT of pulp would have been required to substitute for the imported pulp in 1986. It is noteworthy that this quantity is approximately equal to the bagasse in excess of needs for boiler fuel in the sugar mills. With increased boiler efficiency, additional quantities bagasse could be made available for pulp production.

Ruminant animals such as dairy and beef cattle require two types of feeds, namely roughage (high fiber - low protein) and concentrates (high protein and low fiber). Both types of feeds are in high demand in Indonesia, but roughage is in particular demand on Java, where the availability of grazing land is extremely limited. The production of cattle feeds represents another important potential use for the waste products of the sugar and palm oil mills.

4.5 Animal Feeds

Cane tops are already used as fodder for cattle on Java. As a normal practice, family members of the cane cutters collect the tops during the harvest season using it as fodder for their own cattle. During the off season, the dry cane leaves can also be collected without any harm to the growing plant. However, this practice is usually discouraged because of the problems of preventing the collection of green leaves which has a detrimental effect on cane growth.

In addition to this informal collection on Java, a factory is operating in North Sumatera to process cane tops and leaves. With an installed capacity of 150 MT of input per day, this Japanese joint venture factory is presently processing an average of 100 MT of cane tops and leaves from a nearby sugarcane plantation. The basic product is a compressed bale of cut tops and leaves dried to a moisture level of about 15 percent. (See Annex 6 for a list of the processing steps.) These bales are shipped to Japan and used as cattle forage.

With the harvest season lasting five-seven months, this implies the need to strip leaves and tops from growing sugarcane in order to have year round supplies. Though it is apparently not harmful to the plant growth to strip away the dry leaves, this is hard to control. A conservative estimate of the quantity of cane

tops and leaves available for producing cattle feed would be about 200,000 MT (Table 9). This assumes all of the cane tops and leaves on Java are already used, and would imply that the opportunities for commercial production of cattle feed are off Java.

4.6 Particle Board

One of the important uses for excess bagasse is in structural materials. The team was unable to find any plants in Indonesia producing particle board or high density fiber board from bagasse. However, there are at least five plants in Thailand and several in Pakistan that use bagasse for these materials. The fiber board produced in the Thailand plants is a high density material which is high quality and durable, suitable for furniture and shelving.

There are two major material costs for producing particle board. The first is the raw material and the second is energy, both mechanical and heat energy. All but one of the Thailand plants are located adjacent to sugar mills. In one case, the sugar mill owns the fiber board plant as well. Where the bagasse sales were handled through market exchanges, sugar mills generally received Rp 3,500 - 7,500 per MT. In a few cases, the prices range as high as Rp 8,500. With transportation of the bagasse costing the particle board manufacturers at least Rp 3,000 per MT, the apparent value of the bagasse as a raw material for these products will exceed Rp. 6,500 per MT. The upper limit on possible prices for bagasse will depend on what other materials are available. It is possible that given Indonesia's rich forest resources, bagasse can not command too high a price in this end use.

While the volumes of bagasse that might potentially be absorbed in the fiber board industry are significant, they are still relatively small in comparison with the potential output of excess b
agasse. Thus, it is reasonable to expect that a fiber board plant, located adjacent to a sugar mill could rely on that mill for its heat and power needs. These types of closed product and energy systems are viewed as having the greatest promise for the sugar industry and need to be investigated further.

Alcohol

Alcohol is a product which can be produced from a variety of the waste products of sugar and palm oil production. While molasses is the most obvious alcohol feedstock, using simple fermentation process, the market for Indonesia molasses is sufficient high to preclude its consideration for value ethanol or fuel alcohol. The market for other alcohols need further investigation in Indonesia.

Vitamins, Proteins, and Industrial Chemicals
Molasses is the most important byproduct from sugar production. It is already used to produce mono-sodium glutamate, ethanol and, acetic acid, with the remaining molasses exported to Japan, Taiwan, and South Korea. However, as a substrate for fermentation processes, several other chemicals can also be produced such as ethyl acetate, butyl acetate, acetonnese, and buthano (2-ethyl hexanol). Since Indonesia is in the process of industrialization with an increasing demand for industrial chemicals, it is reasonable to expect the country to consider the manufacture of these other chemicals within Indonesia, substituting for some which are presently being imported.

5.0 ENERGY USE AND POTENTIAL IN INDONESIAN SUGAR FACTORIES

Sugar mills use large amounts of energy to extract the sucrose and molasses from cane. Using current technology, it takes about five barrels of oil equivalent to obtain one metric ton of plantation white sugar. Since most mills use bagasse to provide both steam and electrical energy for the mill, this energy requirement translates to 2.6 MT of bagasse for each MT of white sugar produced.

At the present time, Indonesia's sugar mills produce about 8.3 million MT of bagasse annually. About 1.1 MT of bagasse is produced in excess of the sugar plants' normal requirements.[1] This bagasse is normally sold to paper and pulp mills or held over for starting up the boiler in the following season.

Cane processing efficiency varies widely from one mill to another. This depends largely on the type and age of equipment used, and the efficiency of processing and extraction.To understand how bagasse could be made available for uses outside the mill, it is important to review the major uses of energy in those mills

5.1 Steam and Energy Balance

The composition of whole sugar cane varies greatly from one country to another and can be affected by such variables as rainfall, fertilizer, harvest techniques, and cane cultivar, among others. The composition of cane in Indonesia is roughly as follows:

Item	Percent of Whole Cane
Sucrose	10-17
Water	65-75
Reduction sugar	0.5-1.5
Inorganic matter	0.5-15
Organic acids	0.15
Other substances	0.5-1.5.
Fiber	11-19

In the sugar factory, the cane is milled and pressed so that the cane juice is separated from cane, leaving the fibrous residue bagasse. The juice is further processed (clarified) while the bagasse is conveyed to the boiler for fuel. The water content of the bagasse passing through the last mill is high, usually from 46-50 percent. The bagasse contains some sugar and other materials, in addition to fiber as follows:

Water	46-50%
Fiber content	48-51.0%
Brix (including pol or soluble sugar 1-3%)	4.5%

For example, a sugar mill which processes 4,000 metric tons of cane per day (TCD) where the cane has a 30 percent bagasse content will produce .3 percent x 4,000 MT or 1,200 MT bagasse per day. Thus the total production of bagasse is equivalent to 2,300 barrels of oil in energy terms. Of this total energy production from bagasse, about 95 percent goes to the turbogenerators or to the mechanical drive turbines. Only about five percent goes to the evaporators via a pressure reducing valve. Saving energy in the mill then becomes a question of improving combustion efficiency and making better use of the energy that is exhausted through existing turbogenerators.

[1] About 15% of this total is produced at one mill, the Gunung Madu mill In Lampung province which produces more than 150,000 MT/yr of surplus bagasse.

5.2 Areas for Reducing Energy Use in Sugar Mills

In spite of the tremendous heating and grinding demands of the milling process, several mills studied by Winrock teams have been able to reduce energy use substantially. These reductions have in turn led to availability of significant volumes of excess bagasse for other uses, including generation of electric power in the mill itself.

Without making significant modifications to the mills or to the processing of the cane, there are often several areas in which energy use can be reduced. Some of these modifications involve modest investments. The possible modifications include the following:

- Installing pre-evaporators to conserve steam;
- Using continuous vacuum for low grade sugar extraction;
- Flue gas drying of excess bagasse to increase combustion efficiency;
- Baling of surplus bagasse to improve its storability and use beyond the grinding season;
- Installing air preheaters and economizers on the boilers; and
- Closing pressure reducing valves to force additional steam through the turbogenerators and using the evaporators as "sinks" for the steam.

Other alternatives generally involve the use of higher temperatures and pressures in the boiler and turbogenerator units. The volumes of energy that can be produced from such investments are outlined in the following section.

Typical reductions in bagasse use may range from 10-20 percent, permitting the sugar mills to export power or sell the bagasse to paper and pulp mills. The mill studied in Section 3.B Option One shows how up to 1 MW can be exported from existing equipment simply by making better use of existing energy flows. In the simplest case, such conservation measures consist of forcing additional steam through the turbogenerators. Greater amounts of energy can be conserved by installing additional equipment including deaerating feedwater heaters which absorb turbogenerator exhaust.

5.3 Sugar Industry Generation Options and Capital Costs

This section outlines the types of investments that are necessary to export electricity from Indonesia's sugar mills. The BEST team briefly visited four sugar factories in September 1990. No direct measurement of process variables was possible on this mission. Certain process variables which are critical to estimating export capability, such as quantities of surplus bagasse, boiler flue gas excess air and temperatures, evaporator supply juice densities, and bagasse ash and moisture variability were not routinely measured or were not available from all of the mills. This is not unusual for sugar factory operations since their main concern is the efficient processing of cane and sugar, not the generation of electric energy for export.

Predicting the export electric power and energy for a sugar factory requires a detailed analysis of factory operations. Heat balances must be conducted to determine export levels with sufficient precision to substantiate investment decisions. The predictions contained herein were made without benefit of such detailed analyses.

There are, however, a series of typical export electric energy options available to most sugar factories of the types and sizes in Indonesia. These are described below.

5.3.1 Processing Changes For Electricity Export

Sugar factories in Indonesia are designed to produce that amount of steam and electric energy needed from bagasse fuel to operate the factory. During off seasons, electric energy is purchased from PLN or is generated using diesel engines at various levels to support off season maintenance activities. The capacities of the interconnections for the factories are generally limited to 1,000 - 3,000 kW.

Several of the factories reported burning fuel oil to support operations. However, with appropriate energy management steps, sufficient surplus bagasse can be stored for start up of the boilers each season and for steam production during brief periods where the process is interrupted.

Most Indonesian sugar factories are essentially "balanced" or even slightly in surplus with regard to bagasse.[2] That is, they produce more bagasse than is consumed for boiler fuel. The amount of surplus bagasse is generally estimated by observation of the quantity of bagasse stored in huge open air piles. Too little surplus bagasse raises the threat of burning oil to support the process. Too much bagasse can create a major disposal problem.

In general, cane sugar factories control surplus bagasse by the design and operation of their energy producing and consuming devices in the factory. There are a number of ways surplus bagasse can be controlled by modifying one or more of the following variables:

1. Boiler heat recovery systems;
2. Process evaporators;
3. Dilution of cane juices;
4. Venting of process steam; and
5. Steam cycle design.

Where bagasse is treated as a valuable resource, either for fuel or for byproduct usage, all of the above areas offer potential for increasing the quantity of surplus bagasse. Conversely, where bagasse creates a disposal problem, these same areas permit a considerable degree of operational control over surplus bagasse quantities. Control of these parameters can vary the quantity of surplus bagasse from zero to 30 percent or more of total bagasse produced.

The Indonesia sugar factories studied do not have condensing turbogenerators and therefore lack the ability to generate significant quantities of surplus electric power as a means to control surplus bagasse quantities. Further, the process equipment is designed for high production rates with minimal interruptions at relatively low initial cost.

The various options presented herein require relatively minor changes in the mill's process equipment or operation. Options 1 and 2 use existing factory equipment while the third option, which entails installing a new boiler and turbogenerator, requires substantial changes in the setup of the mill but not in its operation. The generation options which the team identified for Indonesia are listed below. Costs are summarized in Table 13.

5.3.2 Generation/Export Option 1

There are no process equipment changes required in this system. The factories which go forward with this option should have adequate steam and power generation capabilities to produce an export of 1,000 kW periodically or continuously, and to do so without resorting to burning fuel oil. The changes in operation that are required to obtain the 1 MW of export electricity are relatively simple.

It is necessary to "force" the existing evaporators to absorb the additional 10 - 20 MT/hour of turbogenerator exhaust steam during periods of export. Alternatively, exhaust steam or first evaporator vapors may be vented, or vacuum pans switched from vapors to exhaust steam, depending on the size and condition of the evaporator system. Since this option is considered to be used only during processing and generally to assist in meeting peak demands, this option is suggested solely for near term implementation. This option does, however, represent a low cost means to assist in controlling surplus bagasse, provides some additional revenues, and provides a small amount of peaking capacity to PLN.

[2]This excludes the Gunung Madu Mill which produces 800 MT/d of surplus bagasse.

As a part of an industrial complex, the energy from this option can replace diesel generation. at the sugar factory. This option could be accomplished in the nearest term since it requires only the installation of electrical protective devices, which would require approximately six months. Investment costs are shown in Table 13. The costs and performance figures are not based on any particular mills in Indonesia but are considered to be applicable to mills in the 4000-6000 TCD crushing capacity range.

5.3.3 Generation/Export Option 2

This option requires that live and exhaust steam systems and the respective condensate system for one boiler and one turbogenerator be isolated from the rest of the factory piping in order to permit isolated operation during the off season. An air condenser is included which could be used both while processing as well as during the off season. This option would have no negative impact on processing capabilities. It would, however, offer a greater means to control surplus bagasse than Option 1.

Expanding the capacity of the air condenser from 1,000 kW (10-20 MT/Hr) to 5,000 kW (50-100 MT/Hr) would not be prohibitively expensive (see Table 3.1). Alternately, the process evaporators may be used to absorb the additional condensing load for export during the off season if provisions can be made for off season maintenance.

There are a variety of ways to provide additional condensing capability other than using the existing evaporators or an air condenser. The use of the existing cooling ponds or some degree of spray pond or cooling tower for cooling using a surface condenser can be considered.

Some factories do not use deaerating feedwater heaters. Installation of a deaerating feedwater heater not only increases condensing capability but improves boiler and steam cycle performance and efficiency.

The specific equipment provided to increase export from 1,000 kW to the 5,000 kW capacity of the proposed interconnect would depend on each particular factory's equipment arrangement as well as the actual quantities of surplus bagasse presently available. The cost estimates used in Table 13 used the Gunung Madu Mill in Lampung, South Sumatera, as a model. This option would permit export during both the processing season as well as the off season up to 3,500 kW.

5.3.4Generation/Export Option 3

A new 10,000 kW stand-alone plant, using only bagasse for fuel, is the basis for this option. Surplus bagasse is increased by additional flue gas heat recovery devices on each existing boiler coupled with additional control devices to measure and control excess air to a minimum. In factories where no deaerating feedwater heater exists, one would be added to serve all existing boilers. During the off season, the surplus bagasse remaining is used to maintain export of electric energy.

Three factories studied by the BEST Project in Thailand had flue gas temperatures ranging from a low of 190°C (374°F) to a high of 250°C (482°F). A target exit gas temperature of 177°C (350°F) can be reasonably obtained with an engineered mix of economizers and air heaters. Excess air reportedly ranged from 30 percent to 70 percent, based on measurements of carbon dioxide. A target average excess air of 50 percent is reasonable provided boilers are equipped with air flow measurement and feedback control as well as reliable flue gas analyzers. In-situ oxygen analyzers are recommended for flue gas analysis as they are simpler to maintain than CO_2 analyzers and more sensitive in the low excess air ranges.

One potential candidate for such investments is the P.G. Gempalkrep mill in East Java. The mill is soon to be rebuilt and enlarged to 10,000 TCD crushing capacity. The 10 MW figure was chosen at this site as this seems to be the practical limit for PLN's substations to absorb electricity at 22 kV without resorting to export directly into the high voltage transmission system. For local transmission, the mill would likely need to use the PLN system to wheel the power. Thus the investment costs are unlikely to vary with the ultimate customer. No change to sugar process equipment is required although some minor modifications in equipment and management practices may yield additional surplus bagasse.

Exporting up to 5,000 kW appears to be the practical limit if the power is to be absorbed into existing utility 22 kV distribution lines. Larger amounts might disturb the system. The Gunung Madu mill in Lampung, South Sumatera, was used as a model for this investment option.

5.4 Capital Costs

Table 13 indicates the current installed costs for each option and the anticipated time required to design, procure, and install each option. These figures are adapted from calculations that were made for similar mills in Thailand, adjusted for the specifics of the Indonesian situations.

For Option 3, the high pressure unit that is to be installed for electricity export is compared to a similarly sized unit which would be used for the mill and perhaps for export of energy as at the Gunung Madu mill. It should be emphasized that these figures are provisional and do not reflect the specifics of mills in Indonesia. Such specifics can be uncovered during the second phase study.

Table 13 Here

(formatting for above table, lost in translation)

The figures for tie lines and interconnection to the PLN system are based on studies of such interconnections in Costa Rica and Thailand, among other countries studied. Even where the sugar mill may not tie into the PLN system, there will be substantial investment costs, of about the same magnitude to transmit and distribute electricity within the industrial complex.

A range of export capabilities is given for Options 2 and 3 (see Table 14). For Option 3, the lower level represents the capacity to export during the factory off season with no usage of existing factory power or condensing equipment.[9] The higher level represents the tie line capacity and also indicates a level which might be achieved during processing by utilizing the existing power and condensing equipment.

It should be noted that the additional costs for exporting power are significantly lower in new plants than are the full installation costs of the high pressure boiler and extracting-condensing TG set.

In the case of Option 3, the total costs of a high pressure boiler and an extracting-condensing turbogenerator total $8.96 million while the entire unit would cost $20.6 million. However, the low pressure system, which the mill requires regardless of electricity exports, costs $11.6 million.

5.4 Range of Export Capabilities for Various Options

As has been stated previously, each factory is unique. Processing rate, total tons of cane processed, cane quality and equipment arrangements dramatically affect the amount of bagasse energy available for producing electric energy for export. For purposes of this investigation a range of export is given for general guidance only. This range represents the capabilities of plants which process less than 1,000,000 tons per year of cane up to plants which process 2,000,000 tons of cane. Exact predictions of export capabilities can only be achieved following an in-depth investigation of individual factory equipment, operations, and heat balances.

Table 14 summarizes those probable ranges of export power and energy for each option, utilizing existing supplies of bagasse. From Table 11, it can be concluded that burning of oil in existing boilers (Options 1 and 2) is prohibitive except under extreme emergencies. Additionally, the export of electric energy from bagasse during the off season is probably not practical (except for facilitating bagasse disposal) in those factories with high heat rates. These are factories where the boiler steam pressures are 15 kg/cm^2 or less.

[9] In other words, the plant can operate as a stand-alone facility.

Table 14: Ranges of Export Options for Power and Energy

(formatting for above table, lost in translation)

Note: NPHR=Net Plant Heat Rate, BTU/kWhHeat rates, electricity export, and fuel consumption are given for the high pressure Option 3 plant only.

The generation options outlined in Section 5 must be examined in terms of their investment, generation and operating costs in order to evaluate the attractiveness of investments. These are analyzed for each option in this section, followed by an analysis of purchase power price issues. Returns on investment are analyzed in Section 7, Financial Analysis.

For the government or industrial users, the ultimate buyers of the electricity, there are two major economic issues. These are the level and structure of the purchase prices, and the stability and management of the distribution grid in the areas where power will be exported to the system. Where the electricity will be exported offsite, say to a nearby industrial estate, PLN will be concerned if it is asked to wheel power through its system to the estate.[10]

In the text that follows, the first subsection deals with the generation side issues. The next subsection is concerned with purchase price issues and the result ant returns on investment for the cogenerators.

6.1 Generation Costs

In Table 10 (see Section 3.B.2), detailed cost estimates were given for the three major generation options. Using those cost estimates, the teams economists were able to estimate the likely generation costs under a variety of investment and plant utilization scenarios. There are three major elements of generating cost:

1. Investment in boilers and turbogenerators;
2. Rate of utilization of the plant; and
3. Fuel costs, which consist of the purchase price of the fuel as well as the \tab net heat rate (fuel consumption per kWh) of the power plant.

Interest rates may have an important impact on generation costs for some of the more sizable options which involve new plant and equipment. In addition, the simple availability of feedstocks may prove an important issue when it comes to whether an investor will go forward.[11] In this study, the team has assumed that the required volumes of fuel will be available at a price that is sufficient to ensure their supply.[12]

6.2 Option 1

This investment is designed to export electricity only during the milling season. It is low efficiency (60,000-80,000 BTU per kWh) and will consume all of a mill's surplus bagasse during the milling season.

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[10]If a mill must wheel power through PLN lines, then PLN must be assured of the quality and continuity of the power supply from the generator. In addition, PLN will ask for compensation when it is asked to supply electricity to the estate in the event of a forced outage at the sugar mill

[11]This issue may be locally important if a sugar mill is relatively isolated or if there are a number of competitors for the sugar mill's bagasse. These might include fiberboard or pulp mills.

[12]Another project, supported by USAID, has investigated the feasibility of gathering the cane trash and leaves to use as fuel for power generation. The project concluded that the costs of delivering cane trash to a sugar mill were competitive with coal and less expensive than heavy fuel oil.

A typical plant configuration, designed to export 1MW during the milling season, has the investment and operating costs that are shown in Table 12.

The total investment, Rp 270 M ($145 k), is just a fraction of the cost of new generating capacity. However, the low investment cost is tempered by two considerations. First, the fuel consumption is high. Second, the plant has a low utilization rate, certainly less than 50 percent, compared with the 60 percent or more that PLN's large new facilities show. A small investment amortized over a small output can still be expensive relative to PLN's facilities.[13]

In general plant factors below 10-15 percent turn out to be uncompetitive relative to PLN's costs. However, if the plant is well used, more than 20 percent of the total year, its net capital costs turn out to be quite low (see the 25 percent utilization case). Table 5.1 shows the capital costs of generation for Option1. The Best, Medium, and Worst cases refer to the net capital costs and fuel cost/fuel consumption variables. Thus, low utilization of the plant corresponds with the worst case and therefore high costs. Conversely, high utilization corresponds with low capital costs and is the best case.

The Table shows that at low utilization rates (15 percent), the net capital cost of a 1 MW plant opting for immediate export will have capital charges of about Rp 34 per kWh. When combined with the low thermal efficiency of the boiler and turbogenerators in such a mill, the overall costs of generation could go as high as Rp 78 per kWh (see Table 3.3). At the operating efficiencies typical of such mills and with bagasse valued at Rp 7,500/MT, the cost of fuel comes to roughly Rp 30 per kWh. With low investment in the mill's generation system, the costs of interconnection dominate the total investment charge.

6.3 Option 2

This generation choice requires that the mill make a greater investment in its internal generation system. In addition, there will be some modifications of plant operations to accommodate the greater net export of power, up to 4 MW. In comparison to the first option, both the mechanical and electrical investments appear to be far greater. However, the investment is expected to be amortized over a greater operating year. In an optimistic case, such a plant could operate as frequently as existing thermal power stations, 65 percent. In the worst case, it is assumed that the plant could export only half the time during its milling season, hence the 25 percent figure. The required investments for this option were shown in Table 10.

Table 12: Option 1: Investment Costs and Operational Parameters

(formatting for above table, lost in translation)

Note: The base case assumptions include a 10 percent interest rate. No use of cane tops or trash is assumed and the heat rate for the boiler is assumed to range from 27,500-40,000 btu/kWh during the grinding season and ~80,000 btu/kWh in the off season.

Option 2 has greater plant utilization rates than does Option 1. Correspondingly, the unit generation costs (per kWh) should generally be lower than is the case for Option 1. The range of capital charges and fuels costs is shown in Table 13. The median value of the capital costs, Rp 26 per kWh is about ten percent less than the median capital cost in the first option.

If the plant is utilized at a 65 percent rate, the net capital charges will be as low as Rp 20 per kWh. With higher efficiency overall, Option 2 shows fuel costs of just Rp 18 per kWh when bagasse is Rp 7,500/MT ($4/MT). Total generation costs, shown at the bottom of Table 13 range from just about Rp 29 per kWh to Rp 80 per kWh. The median value is Rp 44 per kWh. The second Option is less costly for each of the cases examined due to the relatively high fixed cost of electrical interconnection in the first Option.

[13]This figure refers to the proportion of the total hours in a year that the plant is operating. Thus a 25% utilization rate means that the plant operates 2190 hours (i.e., 0.25 x 8760)

Table 13: Option 2 Investment Costs and Operational Parameters}

(formatting for above table, lost in translation)

Note: The base case assumptions include a 10 percent interest rate. No use of cane tops or trash is assumed and the heat rate for the boiler is assumed to range from 27,500-40,000 btu/kWh during the grinding season and \dn6~80,000 btu/kWh in the off season.

6.4 Option 3

As with Options 1 and 2, the third alternative is designed to integrate with an existing sugar mill. However, a new boiler and turbogenerator system would be added to the plant. The new equipment would be sized to use available surplus bagasse that could be generated with improvements in overall operational efficiency of a mill, especially in the use of bagasse. In addition, the existing tie line would be replaced with one that would hook directly into the PLN's 22 kV system. With a new boiler and generator system, the thermal efficiency of the operation would be greatly increased. Such a mill might need perhaps half as much fuel to generate one kWh as either of the lower efficiency options. The case examined in Table 14, below, is for the additional costs that are necessary to raise the thermal efficiency of the plant and to export power. It is assumed that the plant would undertake the basic boiler and turbo-generator (TG) expenditures regardless of the power export option.

For a mill that intends to install new boilers and turbogenerators, the additional cost of investments for power export may be attractive. The marginal option shows the additional costs of investment for electricity export when a mill must purchase a new boiler and power system. The investments that are additional to a standard sugar mill boiler and turbogenerator are:

- Additional equipment for the boiler;
- Additional turbogenerator equipment and piping;\tab
- Modifications to the mill itself so that the steam for the power generation system takes priority over the steam for the milling process; and
- Tie line transformer and the tie line itself.

With median unit capital charges of Rp 20 per kWh, Option 3 generates electricity at a total cost of Rp 23-30 per kWh. Infrequent operation, combined with high fuel costs can raise the total generation cost to as much as Rp 44/kWh, well below the other two options (see Table 14, below).

Given the higher efficiency of such a unit, the fuel costs will be about Rp 12/kWh when bagasse is valued at Rp 7,500/MT. The reader should note that these costs are only for bagasse-fueled generation. The large boilers may use #6 oil or other available fuels for part of year. The average annual cost for such combined fuel generation will depend on the proportion of the fuel supply that is bagasse and that which is oil or other purchased fuels. Other fuel options may exist which enable the mill to use relatively inexpensive fuel throughout the year. In particular, recent trials with collection and use of cane trash have shown that it may be possible to collect this trash and transport it to a mill in the off-season at prices that are competitive with fuel oil. The trash, consisting primarily of tops and leaves left in the field, has been baled and transported at prices of about $25/MT (Rp 46,575) which compares favorably with fuel oil on an energy equivalent basis.

The present cost of procuring the cane trash works out to $1.45/million BTU, about half the cost of heavy fuel oil delivered to such a site. Trials will continue to determine optimal collection, baling, and transporting modes for this potential fuel.

6.5 Fuel Price Issues

It was a working assumption of this project that bagasse would be available to cogenerators in whatever volumes might be required. The reasoning behind this assumption is quite direct; the high cost of transporting bagasse limits the value of that fuel to customers at any significant distance from the mill. While in country, the BEST team found that some bagasse was being purchased by pulp and paper mills for prices as high as Rp 20,000/MT. More typically, bagasse prices at the sugar mill ranged from Rp 3,000-12,000/MT. Last year, BEST project consultants in Thailand found that a typical sugar mill selling bagasse to board or paper plants could expect to receive Rp 3,500-7,500/MT. The highest figure that the consultants encountered was Rp 8,500/MT.

The team was told that bagasse transport costs typically ranged from Rp 3,500-10,000/tonne. These costs are about the same as bagasse transport costs in Thailand.

Table 17: Option 3 Investment Costs and Operational Parameters

	Rupiah	USD
Investment		
Mechanical (includes plant modifications)	14,531 x 10^9	7,800,000
Electrical (Includes metering and switchgear)	2,049 x 10^9	1,100,000
Generating Costs (per kWh)		
Fuel @ $2/ton	5.589	0.003
Fuel @ $4/ton	11.178	0.006
Fuel @ $6/ton	16.767	0.009
Capital Charges @50% plant factor	27.014	0.015
@ 65% plant factor	19.562	0.011
@ 75% plant factor	17.699	0.010
Total Costs (per kWh)		
Best	23.288	0.013
Medium	30.74	0.017
Worst	43.781	0.024

Note: The base case assumptions include a 10 percent interest. No use of cane tops or trash is assumed and the heat rate for the boiler is assumed to be 20,000 btu/kWh at all times on either bagasse or fuel oil.

Given the relatively high transport costs of bagasse, the apparent value of the bagasse to board and pulp mills exceeds Rp 7,500/ton. At the same time, those sugar mills that are located far from board mills are unlikely to find any market for their surplus bagasse. In most cases, bagasse has a value to the mill of less than Rp 7,500/ton (wet). This figure was chosen as the baseline value for fuel when making comparisons among different generation investment options. All mills will incur some costs as they must hire crews to maintain the bagasse piles, prepare them for use and dispose of ash.

Instead of simply assuming some value for fuel, utilities often find it helpful to calculate what the fuel is worth to the power plant; in other words, what can the generator pay for fuel. This figure is an important one for resource owners when there are alternative uses for the resource, such as pulp or board manufacture. This measure of a fuel's value is called the **fuel netback value**, and is the *maximum* that a user can pay for fuel given the following data:

- The cost of the capital investment;
- The frequency with which the equipment is used - i.e., dispatch;
- The efficiency of the plant (BTU/kWh); and
- The price at which the power is purchased.

The *annual* fuel netback value is calculated as:

$$Nb_{fuel} = \text{Elec.Price per kWh} - \frac{(\text{annual capital charge} + \text{annual O\&M charge})}{(\text{kWh generated in year})}$$

In a similar way, we have calculated the netback value of fuel using present value methods as follows:

$$NB_{fuel} = \frac{\text{Present Value of Receipts - Present Value of non-fuel Costs}}{\text{Total kWh generated}}$$

Present value of receipts is the present value of sales and electricity generated from bagasse or other fuels and sold to the power company. It does not include power use internal to the mill. The latter formula is used in the tables which follow this section.

The netback value shows how much a generator can pay for fuel on a per kWh basis. Once we know the netback value of fuel on an output basis, it is an easy conversion to calculate the value of that fuel on an input basis (per MT or per 10BTU). In this report, the convention of expressing fuel netback values in Rupiahs per ton of bagasse or dollars per million BTU will be used as appropriate.

For example, take the case of plant Option 3 (See Table 14). Suppose that the purchase price for 1 kWh = Rp 75. Suppose further that the capital cost of generation, based on dispatch of 5694 hours annually (i.e., 65%) is Rp 19.6/kWh. Using the first netback formula given above, we get:

$$Nb_{fuel} = \text{Rp } 75 - \text{Rp } 19.6 = \underline{\text{Rp } 55.4}$$

In other words, the generator can pay Rp 55.4 in fuel charges to generate one kWh of electricity. Since the heat rate of the plant is 20,000 BTU/kWh, we calculate that Rp 55.4 is the value of 20,000 BTU. This figure is equivalent to a value of Rp 2,770 per million BTU ($1.49) or $8.33 (Rp 15,512) per barrel of oil equivalent, far below current market prices for fuel oil. In other words, given the prices, costs and efficiencies of the equipment, along with the frequency of use (dispatch), the plant cannot afford to pay more than Rp 30,193 per MT of bagasse at 10.9 x 10{\fs16\up6 6} BTU per MT of MT. Since this value exceeds the price that the mill might get from a board mill for its bagasse, power generation is an attractive end use for the bagasse in this case.

If dispatch goes up, then the fuel netback value will rise as well. Conversely, if dispatch goes down, then

the price that a mill can pay for fuel will fall as well. In a similar way, each of the four factors listed above directly affects the value of fuel to the plant. If dispatch, for example, rose to 75 percent or 6570 hours annually, the netback value of fuel would rise as follows, assuming the other parameters remained constant:

$$Nb_{fuel} = Rp\ 75 - Rp\ 17.7 = \underline{Rp\ 57.3}$$

With such a netback value per kWh (20,000 BTU), the value of one million BTU rises to Rp 2,865 ($1.54). This figure is equivalent to Rp 31,228/MT ($17) or $8.61/ barrel of oil equivalent (boe) (Rp 16,044).

When a netback value exceeds the cost of acquiring the fuel, then the mill can justify the investment. However, if the fuel netback value is low or negative, this usually indicates that the capital is too expensive, the power purchase price too low or the boiler too inefficient. Using a range of potential power purchase prices, the team calculated the fuel netback value for each of the model plants. Purchase prices for electricity were adjusted to the particulars of a mill's location. Thus in East Java, the PLN optional generation uses gas for baseload generation and gas turbines for peaking. In Lampung the alternative generation source is diesel, slow speed (using heavy fuel oil) for baseload, and high speed (using ADO) for peaking. These values are shown in the summary Tables which follow the rate of return discussion.

7.0 FINANCIAL ANALYSIS OF CANE POTENTIAL INVESTMENTS

7.1 Investment Analysis Approach

Using the cost information contained in the Tables above, it was possible to calculate the financial returns associated with each of the potential investments. A total of six cases were investigated for each of the mills studied. Using a real discount rate of 10 percent, the following financial calculations were made:

- Benefit cost ratio;
- Annualized benefit cost ratio;
- Internal rate of return; and
- Fuel netback value.

In addition, the netback value for bagasse in each of the cases is presented along with the financial information. The netback value that is associated with the ten percent discount rate (no inflation) cases is the one that should be compared across the different alternatives. To see how inflation of variable costs might affect the financial analysis, a separate set of calculations was made using an inflation rate of eight percent in addition to the ten percent real discount rate. These results will differ from the real-discount-rate-only approach in that they discount the capital investments more heavily, at 18 percent total, and thus will tend to show higher returns on investment.

The first three terms have become standard in economic and financial literature and are not explained here. The annualized benefit cost ratio (ABC) gives the average rate at which the returns for the proposed investment exceed or fall below the discount rate that is used in the analysis. For example, if the discount rate is 10 percent and the ABC = 12.5 percent, this means that the average annual return on the project exceeds the discount rate by 2.5 percent annually, compounded. The ABC provides an effective method of checking results across alternative investments, when other measures might yield inconsistent or misleading results.

The ABC is defined as:

ABC = (PVB/PVC)^(1/n) -1
where:
PVB = Present Value of Benefits
PVC = Present Value of Costs
n = the number of years for which cash flows are calculated

The six tables which follow provide a summary of the financial calculations that were performed for the various investment options. Each of the three cases is analyzed in nominal Rupiah (Rp).

In the tables, results are given for two different energy sales contract regimes. It was necessary to assume two types of contracts, in lieu of any specific guidance from PLN:

The first type of power sale occurs when the mill sells electricity to the grid or within an estate on a spot basis. In such cases, the generator will be paid only for the energy that is displaced at a given time of day. In each of the three examples, the peak shoulder and base energy prices vary according to the presumed fuel that is displaced. The contract has a duration of 20 years.

The second type of contract contains an energy payment, equivalent to the avoided energy cost of a baseload facility. The capacity payment is equivalent to Rp 25-35/kWh, depending on location. These contracts have a duration of 20 years.

Each of the four measures of merit noted above will have some meaning for investors or analysts. However, the two measures that are particularly important in the present context are the ABC and the fuel netback value. The full results of the financial analyses are published in Annex 8. In order to complete

these analyses, it was necessary to make assumptions about interest rates, costs (based on BEST Project's previous efforts) and other operational or financial parameters. Each of these parameters is listed in each of the tables for each case.

7.2 Option 1 Results

With high fuel consumption, this option is attractive under all of the cases considered. However, it is feasible in terms of bagasse netback values only if the mill can export power for about 25 percent of the year or more. As Table 18 shows, the ABC rises above the discount rate in all cases, due to the low interest rate that a government-owned mill will pay. With inflation of the costs and revenues, the worst case shows relatively high returns. If the mill can export electricity for 40 percent of the year, about 85 percent of its own operating hours, the benefit-cost ratio rises above 3 for the capacity payment contract. More important, the ABC is well above the discount rate in both cases.

The assumptions behind this financial and economic analysis are shown in detail in Annex 8. Each example lists the key operating parameters and assumptions. For Mill Option 1, the more important assumptions include the following:

Size of the Mill	1MW
Annual Hours of Operation (worst, best)	1,314-2,066 (15-35%)
Fuel Consumption While Exporting	80,000 BTU/kWh
Bagasse Consumption	7.42 kg/kWh
Bagasse Price	Rp2,500-7,500/ton
Loan Costs	10% real, 18% nominal
Power Purchase Prices (Rp per kWh)	
Energy Sales Only	90 for peak 55 for shoulder and base
Energy and Capacity Payments	25 for capacity 55 for energy

However, even with relatively attractive returns, the high fuel consumption rates in these mills preclude the mill paying more than Rp 7,821 for fuel. For the spot sales regime, even the best case fuel netback value is just above the costs that mills will incur in moving the bagasse around the mill and feeding it to the boiler during periods when the cane processing is down.

Table 18: Results of Option 1 Financial Analysis

Case	Measure	Energy Sales Only	Energy and Capacity Payment
Worst	Benefit Cost Ratio	1.21	1.65
	ABC (%)	10.87	12.29
	Fuel Netback Value (Rp/T)	3,327.65	5,741.83
Best	Benefit Cost Ratio	2.63	3.57
	ABC	13.05	14.5
	Fuel Netback Value (Rp/T)	5,406.83	7,821.02

7.3 Option 2 Results

The improved fuel consumption and greater length export year in comparison to Option 1, up to 65 percent, make both ABCs and netbacks higher at this mill. In addition, the alternative sources of electricity in Lampung province are all quite expensive, using diesel fuel. Using nominal Rupiah, the ABCs for the mill are well above the discount rate in all cases, even when the plant factor is just 50 percent. In the other cases the ABCs range from 12.93 percent to 16.83 percent under the best conditions. Perhaps the major factor supporting higher returns for the Lampung mills is the higher avoided cost for electricity in that area. Alternatives for baseload generation consist largely of diesel units, slow speed or high speed.

Fuel netback values are far higher in this case than in Option 1, due largely to the lower fuel consumption per kWh in this plant and to the higher power purchase prices obtainable. For the long term contracts, the netback values are all above Rp 16,000/MT, far more than the bagasse will be worth for other uses, ex mill. In the spot sales cases, the netback values are in the Rp 9,400-10,600 range.

Table 19: Results of Option 2 Financial Analysis

Case	Measure	Energy Sales Only	Energy and Capacity Payment
Worst	Benefit Cost Ratio	1.68	2.58
	ABC (%)	12.40	14.39
	Fuel Netback Value (Rp/T)	9,426.39	16,420.17
Best	Benefit Cost Ratio	2.80	4.27
	ABC	14.78	16.83
	Fuel Netback Value (Rp/T)	10,654.44	17,648.23

7.4 Option 3 Results

The large scale export of electricity in a high pressure generation situation gives acceptable returns when the plant is used as a baseload unit, earning a capacity credit from the buyer. The spot sales options are generally only attractive if capacity utilization can reach 75 percent, given the initial investments that are required. In the best case, low cost generation of electricity permits the mill owners to earn ABCs of 11.50 percent and 12.92 percent, respectively for the spot and long term contracts. This mill is assumed to enjoy semi-concessional rates for borrowing at 12.5 percent interest.

The assumptions behind the financial and economic analysis are shown in detail in Annex 8. Each example lists the key operation parameters and assumptions. Some of the differences between Mills 2 and 3 include the greater efficiency and capacity of Mill 2 along with improved plant factors. With sufficient investment, the Gunung Madu mill, used as a mode for Option 2, could be converted to an Option 3 type mill. The model used in the present case is the Gempolkrep mill in East Java. Located near large thermal power plants, the avoided costs are equivalent to those for new thermal plants in the PLN Java grid.

Size of Mill MW

Annual Hours of Operation (worst, best)	4,380-6,750 (50-75%)
Fuel Consumption While Exporting	20,000 BTU/kW
Bagasse Consumption	1.92 kg/kWh
Bagasse Price	Rp2,500-7,500/ton
Loan Costs	10% real, 13% nominal
Power Purchase Prices (Rp per kWh)	
Energy Sales Only	90 for peak 55 for shoulder and base
Energy and Capacity Payments	25 for capacity, 55 for energy

The high efficiency of the Option 3 boiler and turbo-generator combination makes the fuel netback values for the case about equal to those for the Option 2 example. Given the large capital investments, the returns for the capacity payment case are quite steady. Under long term contract sales, the fuel netbacks are a minimum of Rp 10,700 and range up to Rp 16,500, under the best case conditions. For the spot sales contracts, fuel netback values are still relatively attractive, almost Rp 10,000/MT in the best case.

Table 20 Results of Option 3 Financial Analysis

Case	Measure	Energy Sales Only	Energy and Capacity Payment
Worst	Benefit Cost Ratio	0.98	1.34
	ABC (%)	9.92	11.34
	Fuel Netback Value (Rp/T)	3,702.12	10,732.2
Best	Benefit Cost Ratio	1.39	1.89
	ABC	11.50	12.92
	Fuel Netback Value (Rp/T)	9,500.47	16,530.55

5.8 Commercial Aspects of Sugar Mill Power Generation Ventures

7.5 Power Sales Contracting Issues

If PLN is the purchaser, it will want to have control over dispatch. This means that the owner of the power generating unit must allow the total number of hours of power sales to be determined by the customer (within the limits of the contractual framework). This has several implications. First, it rules out the type of casual or occasional power sales that many factories might prefer at low levels of investment and power export. Second, it places most of the financial risk onto the generator. Third, it imposes costs on the generator in terms of staffing and equipment in return for the higher prices that may accompany centralized dispatch. From the utility company's point of view control over dispatch is crucial to the job of running a reliable and cost-minimizing electric power system. Several factors influence the utility's desire to control dispatch. First, the costs of other generating units in the system owned by PLN may vary throughout the year. This is especially true in the case of hydro facilities but will also apply to some extent to generating units that consume fuel oil. This has to do with the economics of seasonal demands for various fuels and the responses of the refining system to those changes in demand. The availability, and therefore the price, of heavy fuel oil will vary from one season to another as a result of these refining changes. In most cases, the milling season coincides with the low season at PLN's hydro facilities.

Therefore, the electricity produced will be relatively more valuable to PLN that if it were replacing output from the hydro facilities. Second, the utility must be able to schedule maintenance around its least cost generation program to make sure that there is sufficient reserve power in the peak demand periods. Third, the utility will need assurance that a non-utility source will be available when it is needed regardless of the processing situation at the sugar mill itself.

For the generators, there are several financial implications of dispatch coming from the purchaser. These are:

- Uncertainty about the number of hours which will be purchased in any given month;
- Competition with the utility's own generation units, especially hydro,during periods favorable to the utility's own facilities; and
- Calls on the mill to give priority to electricity production during the sugar milling season.

Each one of these factors is reasonable and can be covered in an appropriate contract. However, one of the net results of the utility gaining control over dispatch is that the uncertainty may be borne to an additional degree by the generator. Similarly, a mill providing electricity within an industrial estate will find it necessary to adjust its operating practices in such a way that power to the other industries in the estate is maintained.

Power Purchase Price Issues

At the present time there is no final set of purchase price terms for cogenerators or independent power producers. As a result, the team's energy economist used the proposed tariff structure that is based on the opportunity costs of alternative generation sources. The proposed buyback tariffs are of two types, spot sales and long term contracts. The spot sales tariff has three parts, for peak, shoulder, and baseload supply. Each of the spot sales categories may represent a different generation mix.

In the rate of return analysis, the term used for spot sales is ten years. For the capacity contract sales, the term is 20 years. The payment to generators consists of 2 parts, a capacity charge and an energy charge.

The energy charge is made equal to PLN's expected fuel charge were the utility to provide this power. Similarly, the capacity charge is based on the alternative generation source in that area. In East Java, a baseload coal or gas plant is assumed to be the alternative investment while the alternative baseload generation source for South Sumatera is assumed to be slow speed diesel.

8.0 CONCLUSIONS AND RECOMMENDATIONS

This study reports on the results of preliminary investigations of the plausibility for initiating sugar or palm oil diversification projects in Indonesia. Though preliminary in nature, the study lays the groundwork for further study of the investment opportunities in the area of energy production as well as a review of other options for using waste products from the sugar and palm oil industries. The following conclusions and recommendations are presented to indicate steps to be taken towards a more optimal utilization of sugar and palm oil waste products.

The principal conclusions of the diversification study are:

1. A large volume of waste is produced in both the sugar and palm oil industries;

2. These wastes, totalling more than 13 million MT annually, could provide feedstock and raw materials for a variety of industries and products.

3. In the palm oil industry, the empty fruit bunches may provide locally significant fuel sources for electricity in some locations. Such generation can cut service costs and improve the reliability of power delivery.

4. Investment in a small generation station at PTP's Adoline mill appears to offer attractive financial returns, in excess of 40 percent.

5. At sugar mills, improved efficiency could provide surplus bagasse for power generation. In some locations, such mill-based power could alleviate local shortages as well as provide incentives for location of biomass-based industries.

6. Investments at several existing or planned mills could provide electricity at prices well below current PLN tariffs. Based on potential PLN savings, several of these investments offer attractive rates of return in excess of 20 percent.

The principal recommendation of the BEST Project team are as follows:

1. A follow-up study needs to be made of the technical, economic and commercial feasibility of designing new, large sugar cane mills to high energy efficiency standards with the goal of generating baseload, year-round electricity from bagasse.

2. Detailed studies should be made regarding planned expansions at both new public and private sugar mills. In addition to the focus on expanding mills, the study team recommends that the follow-up study look at several existing mills and investigate ways of making such mills net electricity exporters, both on a seasonal and a year-round basis.

3. To the extent that new product industries appear commercially feasible based on sugar industry wastes, it is possible that new power pruduction could help create biomass-based growth centers in which industries producing such products as chemical, vitamins, MSG, alcohols fiberboard and other products would be located on the grounds of the sugar mills. Power studies noted in 1 and 2 should examine power demands for these industries.

4. The team recommends that the feasibility of using EFBs for electrical generation in areas close to villages, industries and transmission lines be further examined. This study should concentrate on the feasibility of establishing a central power plant in the Medan area that would use EFBs from several neighboring palm oil plants. Such plants could also become the basis of biomass-based growth centers, as in the case of sugar mills.

5. Last, the BEST Project recommends that Perkebunan actively monitor research by the private

sector in furfural, vitamins, fiberboard, alcohols and other products noted above. Continued support for research in the sugar and palm industries and their byproducts is essential to full utilization of these valuable resources, and Perkebunan and private sugar companies should consider direct support for such research.