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ASSESSMENT OF BIOMASS AS AN ENERGY RESOURCE IN INDONESIA: BIOMASS TASK

ENERGY PLANNING FOR DEVELOPMENT PROJECT

FOR ENERGY/DEVELOPMENT INTERNATIONAL

MARCH, 1981

OLYMPIC ASSOCIATES CO.
SEATTLE, WASHINGTON

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BY

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Rolf T. Skrinde

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EXECUTIVE SUMMARY

1.0 Introduction

In May 1980 the first phase of the Energy Planning for Development project was initiated, with the Biomass Assessment task carried out in November. Biomass has historically been the primary energy source in Indonesia, and acceleration of its development and use is of great significance in order to avoid economic and social problems as the limited supplies of kerosene being substituted for biomass become exhausted or continue to escalate in price.

The significance of emphasizing biomass as an energy source is that because of the climate, rainfall, and fertile conditions of the soil in Indonesia there are great opportunities to grow vast amounts of this resource which can be converted into energy. Programs of accelerated growth of biomass and conversion to energy should be implemented now while there are funds available from the sale of fossil fuels, and in preparation for future years when available fossil fuels will be diminishing in quantity while population growth and increasing use of energy continues.

Biomass is one of the major renewable energy sources which can be harnessed for future use. An accelerated biomass program should provide the greatest amount of energy in the near term at least cost. It also is a program which can be carried out simultaneously throughout the entire country in small-sized projects which will benefit not only the people individually but also the national government if the government can reduce or eliminate the present cost of subsidizing

kerosene use. Biomass energy should therefore be given the highest priority in early implementation programs in order to develop energy self-sufficiency for Indonesia without the use of fossil fuels.

This Biomass Assessment component of the Energy Planning for Development Project is intended to assist in the development of policies and programs to enhance the use of biomass as an energy resource.

2.0 Biomass Resource Base

Section 2.0 describes the biomass resource base in Indonesia. Indonesia is blessed with abundant renewable resources of biomass. The question is whether these renewable resources can supply significantly more energy, commercial as well as non-commercial, without adverse effects on the food and fiber supply. Currently, 122 million hectares are in forest and are classified as 47 million hectares production forest, 40 million hectares protection forest, 10 million hectares conservation forest, and 25 million hectares reserved forest. Unproductive land in Indonesia amounts to 42 million hectares. Current use of woody biomass for energy has increased by 2.2 percent per year during the period 1969-1976, with consumption exceeding recorded production by some 36 million tonnes in 1976 on Java alone.

Where there is a shortage of fuelwood, such as on Java, the use of agricultural wastes and the home garden's potential for firewood are important. Data indicate that if home gardens were well managed they could contribute up to 60% of the fuel demand of a village community.

Table 2-4 provides an estimate by the Forest Products Research Institute of Bogor, of the TCE (Tonnes Coal Equivalent) of energy produced from combined firewood and agricultural waste production from 1969 to 1978. The corresponding BOE (Barrels of Oil Equivalent) can be obtained by multiplying these figures by a factor of 5.05.

Table 2-5 shows that approximately 122 million of the 190 million hectares of land in Indonesia are in forests, with the remaining used for agriculture or comprising wasteland. According to the Directorate of Reforestation and Rehabilitation, unproductive land in Indonesia in need of rehabilitation amounts to 42 million hectares, broken down as follows:

Denuded forests and second growth	23 million hectares
Denuded soils and alang alang	16 million hectares
Rainfed agricultural land	3 million hectares

Twenty million of the 42 million unproductive hectares are considered critical or seriously eroded:

Alang alang (Imperata cylindrica)	13 million hectares
Secondary growth (belukar)	4 million hectares
Rainfed cropland (tegalan)	3 million hectares

Wastelands on Java count 4 million hectares or more than 30 percent of the total land area.

Development of biomass for energy on the 42 million unproductive hectares alone would provide much of the fuelwood required to meet cooking needs on Java and the outer islands. Currently, non-wood residues are not being fully exploited for energy, and although

reliable data are lacking, such residues are extremely significant especially for densely populated areas such as Java.

3.0 Trends in Extent of Biomass Resource Base

On Java a burgeoning population uses more and more land to grow food, and in doing so leaves less and less land to grow fuelwood, the traditional cooking fuel for the rural and large parts of the urban population. The rural population can no longer supply the needed fuelwood from private properties, and in pilfering from public lands contributes to deforestation and attendant erosion. Scarce populations, abundant renewable resources, forest exploitation, and clearing for transmigration projects characterize significant portions of the outer islands, however, especially Kalimantan and Sumatra.

It is apparent that deforestation is continuing of mountain slopes previously unexploited. The expansion of new transmigration populations in portions of previously uninhabited islands is also resulting in further deforestation in those areas as forest lands are put into agricultural production. The consequence of such patterns is reflected in the reduction of production of fuelwood and agricultural wastes in heavily populated areas such as Java, as shown in Table 2-4.

4.0 Current Utilization of Biomass

Section 4.0 describes the current utilization of biomass. It is seen that, on an equivalent basis, firewood and waste still contribute about 50% of the energy of the country, although the use of gas and oil is increasing dramatically. The fossil fuel resource is rapidly declining, however, while firewood and wastes are renewable resources.

It therefore cannot be over-emphasized that all possible efforts must be made to reverse the trend and expand the renewable firewood and waste resource base in order to conserve and become increasingly independent of fossil fuels.

5.0 Potential for Future Use

There are several programs underway to increase biomass resources in Java and other densely populated islands. These include dissemination of seeds and seedlings of fast growing trees, experimental plots of fast growing trees, and research on soil characteristics relating to increased biomass production. It is envisioned that extensive fuelwood plantations could be developed on the so-called wastelands of Java, comprising some four million hectares. The yields of these impoverished soils could be improved by the planting of leguminous trees, and an annual yield of only 10 tonnes per hectare would be more than the present fuelwood consumption on Java. A significant portion of the fuelwood demand on Java by the years 1990 and 2000 could be provided, especially if the remaining 16 million hectares of marginal land were put into production.

It is also possible to convert biomass on other islands with surpluses to higher forms of energy for transport to Java and other areas of biomass deficiencies. This potential is described in detail in Section 5.0.

6.0 Barriers to Use

The barriers to increased biomass use are described in Section 6.0.

These include availability of land, potential for nutrient depletion, unknown effects of introducing new tree species into the agricultural sector, high cost of converting biomass to more concentrated energy forms, and difficulty of transport in order to balance areas with biomass surpluses with areas of deficiencies.

7.0 Current Policies and Projects

Repelita III, the third five-year plan (1980-1984) emphasizes several major points relating to energy. One is to enhance conservation of kerosene and other oil resources by substituting other energy sources such as biomass, and another is implementation of programs to use renewable energy sources such as biomass.

The government of Indonesia is therefore implementing a large number of important biomass projects, which are described in Section 7.0. Although the effort currently being made is great, further acceleration is necessary in order to provide sufficient biomass for energy in the future and reverse the trend of deforestation and attendant erosion problems.

8.0 Recommended Steps in Development of Biomass Resources

A comprehensive program of recommendations to develop additional renewable biomass energy sources is provided in Section 8.0. Some of these recommendations are:

1. Fast growing trees and development of an integrated wood energy village concept for transmigration areas: Several new tree species are recommended for evaluation, and the Terms of

Reference for a demonstration wood energy village is provided in Appendix C.

2. Charcoal Production and Use: Increased use of charcoal from ravaged forests or woodlots and increases in the efficiency of charcoal production can play a positive role in avoiding the dual problems of deforestation and increased kerosene use. Development and demonstration programs are recommended on: the charcoal marketing and distribution system particularly the concept of charcoal centers, improved cooking devices, and charcoal production from agricultural wastes.

3. Utilization of Wood Residues: Very large amounts of logging and sawmill wastes (many million cubic meters annually) are available for more effective use - particularly by the wood products industry itself. Studies are required of possibilities of satisfying internal needs and the possibility of charcoal production.

4. Advanced Conversion Technology: Additional improvements in pyrolysis technology should be supported and the commercialization of this technology should be accelerated through low interest loans or other means. Research and development on low calorific gas generators using agricultural wastes, advanced wood and wood residue gasifiers should continue to be supported.

ASSESSMENT OF BIOMASS AS AN ENERGY RESOURCE IN INDONESIA

1.0 INTRODUCTION

Biomass has traditionally been the primary energy source in Indonesia, but as population densities have increased on various islands, especially Java, biomass materials have often become insufficient to meet the demand. The result has been deforestation of not only those areas where food production is necessary to support the population, but also some mountainous areas which are unsuitable for growing of crops. These steeply sloping areas which have become denuded of forests are often subjected to severe erosion problems.

The rapid development of oil and gas in the past decade has provided a degree of energy relief, since kerosene can be used as a cooking fuel as well as for lighting purposes. The government is assisting the people to meet high energy costs by subsidizing the cost of kerosene. However, this subsidy, estimated to amount to 360 million U.S. dollars in 1979 alone, is cutting drastically into export earnings. Since 80% of Indonesia's population live in rural areas, many of which are taking advantage of the subsidy to convert to kerosene-based cooking, it will become an increasingly serious national problem of demand for this fossil fuel unless the biomass resource base is developed and used more efficiently.

The Government of Indonesia's (GOI) response to the problem of meeting the country's energy demands while maximizing petroleum export earnings is found in Repelita III, the third five-year plan (1980-1984). The

plan emphasizes three points relating to energy: 1) accelerated exploration of conventional fossil fuel sources; 2) enhanced conservation of kerosene and other oil resources by substituting other energy sources; and 3) intensified research, development and use of renewable sources such as biomass.

The report which follows is an assessment of biomass as an energy resource in Indonesia. Of course, many highly qualified engineers and scientists in Indonesia and from abroad have made related assessments, and in this case the data available are used to provide the biomass component of the Energy Planning for Development Project. The results are intended to assist in the development of policies and programs to enhance the use of biomass as an energy resource.

Included in the biomass assessment reported herein is an estimate of the extent of the resource base and trends which would affect the biomass resources available for energy. The extent to which biomass is currently used for energy purposes is then quantified. Estimates are then made of the technical potential for economical use of wood and crop residues as an energy resource in the future, as well as the major barriers that must be overcome if the various biomass resources are to be used at their maximum potential.

Current policies and projects relating to biomass energy research, demonstration, pilot plants, and operational plants are described. Section 8 consists of recommended programs in the development of increased fulfillment of energy needs through the use of biomass. Finally, an evaluation is made of the significance of the conclusions

drawn on the biomass assessment, the benefits which could be derived, and further general recommendations with respect to Energy Planning for Development.

2.0 BIOMASS RESOURCE BASE

Indonesia is blessed with abundant renewable resources; it is the extremely high population density on Java and Madura that threatens to overwhelm the resources of these two islands.

2.1 Fuelwood

Long before using other material as fuel, the Indonesian community has used firewood and agricultural waste products. These materials are used as fuel mainly in the village community, where because of the low income level, firewood and agricultural waste products play an important role for cooking purposes. Villagers obtain much of their firewood and agricultural waste products from their own home garden (pekarangan). When this supply becomes exhausted they look for firewood on public lands such as Government forests.

The home garden's potential for firewood is important. Many studies have been made of fuelwood production and consumption. Hardjodarsono (1978) stated that a coconut tree, for instance, can give a fuel supply from the leaf's mid rib as large as 48 kg/year; from the coconut-fiber and shell the estimated production is 0.5678 m^3/year. The trees at the home garden produce an average yield of 1,622 m^3/family/year. According to a survey of the LPHH (Research Institute for Forest Products) in 1971 the average need of firewood for one family is 2,510 m^3/year in East Java. Based on these data, if all home gardens were well managed, they could contribute 60% of the fuel demanded by the village community.

Table 2-1 describes production and consumption of fuelwood in 1976 on Java and the outer islands. On Java, consumption exceeded recorded production by some 36 million tonnes in 1976. The discrepancy is made up of fuelwood production in home gardens, farm plot boundaries, community lands, and pilfering from public lands, in what proportions is not known.

TABLE 2-1.

FUELWOOD PRODUCTION AND CONSUMPTION IN FORESTS IN 1976* (TONNES)

	Java	Outer Islands	Total
Production	1,251,046	21,303,819	22,554,865
Consumption	37,126,680	23,107,751	60,234,431

(after Hardjodarsono, 1978)

*Production is measured and recorded as thinnings from managed forests, logging, and forest industry residues, as well as wood from estates and agricultural enterprises (e.g., rubber trees) which is used as fuelwood. It does not include total biomass production by photosynthesis in Indonesia.

Consumption is based on a conservative estimate of per capita consumption. A number of studies are being made on present and future fuelwood consumption.

2.2 Agricultural Residues

The amount of agricultural products produced in 1978 has been estimated (Statistical Pocketbook of Indonesia 1978/1979) to be as shown in Table 2-2.

TABLE 2-2.

AGRICULTURAL PRODUCTION IN 1978

Wet Land Paddy		
Total Area		7,653,046 ha
Production	Total	24,265,578 tonnes
	Java and Madura	15,205,652 tonnes
	Other Islands	9,059,926 tonnes
Dry Paddy		
Total Area		1,240,334 ha
Production	Total	1,614,460 tonnes
	Java and Madura	436,446 tonnes
	Other Islands	1,177,014 tonnes
Maize		
Total Area		3,027,849 ha
Production	Total	3,885,389 tonnes
	Java and Madura	2,818,637 tonnes
	Other Islands	1,036,752 tonnes
Cassava		
Total Area		1,382,854 ha
Production	Total	12,960,655 tonnes
	Java and Madura	9,470,679 tonnes
	Other Islands	3,489,976 tonnes
Sweet Potatoes		
Total Area		292,550 ha
Production	Total	2,234,559 tonnes
	Java and Madura	1,007,077 tonnes
	Other Islands	1,227,482 tonnes

TABLE 2-2. (CONT'D)

AGRICULTURAL PRODUCTION IN 1978

Peanuts		
Total Area		514,077 ha
Production	Total	439,221 tonnes
	Java and Madura	322,029 tonnes
	Other Islands	117,152 tonnes
Soybeans		
Total Area		741,252 ha
Production	Total	570,861 tonnes
	Java and Madura	450,466 tonnes
	Other Islands	120,395 tonnes

(Statistical Pocketbook of Indonesia 1978/1979, 1979)

The agricultural wastes produced in 1977 are estimated to be as shown in Table 2-3.

TABLE 2-3.

CROP RESIDUES IN 1977

	1000's of Tonnes
Dried Stalk Paddy	933.89
Rice Hulls	337.32
Maize	62.83
Sweet Potatoes	246.04
Cassava	1,201.56
Soybeans	30.60
Peanut (unshelled)	34.06
Coconut (unshelled)	1,434.11
Fruits	363.01
Vegetables	151.55
Bagasse	3,137.18
Total	7,932.18

(Statistical Pocketbook of Indonesia 1977/1978)

A compilation of combined firewood and agricultural waste production in Java and outside Java for the years 1969-1978 has been prepared by the Forest Product Research Institute as follows and shown in Table 2-4.

TABLE 2-4.

FIREWOOD AND AGRICULTURAL WASTE PRODUCTION IN JAVA AND OUTSIDE JAVA, 1969-1978 (TCE)[1]

Year	Java	Outside Java	Total
1969	21,455,562	26,054,774	47,510,336
1970	22,457,946	28,493,981	50,951,927
1971	22,592,511	30,398,157	52,990,668
1972	22,013,257	30,341,687	52,354,944
1973	24,070,068	35,986,539	60,056,607
1974	24,441,829	36,136,553	60,578,382
1975	23,759,481	29,969,299	53,728,780
1976	22,492,734	32,491,492	53,984,226
1977	21,518,186	32,105,386	53,623,572
1978	20,543,639	32,718,759	53,262,398

[1]TCE = Tonnes Coal Equivalent

Note: 1 TCE = 5.05 BOE

Source: Research Institute of Forest Products, Bogor

2.3 Forestry and Forest Product Residues

Forests are an important source of biomass as shown in Table 2-5.

TABLE 2-5.

FOREST AREA IN INDONESIA

Island	Land Area (1,000,000 ha)	Forest Area (1,000,000 ha)	Ratio to Total Land (Percent)
Java & Madura	13.2	2.9	21.8
Sumatera	47.4	28.4	60.0
Kalimantan	53.9	41.5	76.9
Sulawesi	18.9	9.9	42.4
Nusa Tenggara & Bali	7.4	2.0	27.7
Maluku & Irian Jaya	49.7	37.5	75.5
Total	190.5	122.2	64.2

(Source: Directorate General of Forestry, 1975)

Of the 190 million hectares of land in Indonesia, about 24 million hectares or 13 percent can safely be used for agricultural purposes. An additional 26 percent or 51 million hectares can be used for agriculture provided appropriate conservation measures be taken. Some 60 percent or 115 million hectares should be in forest.

Currently, less than half of the total forest area is classified as production forest as is shown in Table 2-6.

TABLE 2-6.

CLASSIFICATION AND AREA OF FORESTS

Classification	Area (1,000,000 ha)	Percent of Total Forest Area
Production Forest	40	32.8
Protection Forest	47	28.5
Conservation Forest	10	8.2
Reserved Forest	25	20.5
Total	122	100

(Source: Directorate General of Forestry, 1975)

On the islands of Java and Madura, 1,845,000 ha (64 percent of total forest area) are classified as production forest out of a total forest area of 2,900,000 ha and total land area of 13,200,000 ha, which represents only 14 percent of the total land area on the two islands. Most of this production forest is man made and consists of teak (*Tectona grondis*), pine (*Pinus merkusii*) and several other species.

According to DITSI (Directorate of Reforestation and Land Rehabilitation) there are 42 million hectares of unproductive land in Indonesia in need of rehabilitation, and of these, 20 million hectares are considered critical or seriously eroded. The breakdown of these critical land areas is as follows:

13 million hectares alang-alang (Imperata cylindrica)
4 million hectares secondary growth (beluka)
3 million hectares rainfed agricultural land (tegalan)

20 million hectares

Four million hectares of waste land are on Java and constitute more than 30 percent of the total land area. (Source: Forestry for Industrial and Rural Development in Indonesia, Forestry Faculty IPB, Bogor, 1979.)

Predictions are that the situation is rapidly getting worse, especially on Java.

In comparing Table 2-1 with Table 2-5 it is seen that much of the potential for obtaining firewood from forests in Indonesia is presently not utilized. For example, the 122.2 million ha of forest area shown in Table 2-5 produces annually at least 10 tonnes of biomass per ha by normal photosynthetic growth, which amounts to 1222 million tonnes annually. This is more than 50 times the amount which is used for fuelwood, shown in Table 2-1. On a conservative basis of two BOE equivalent to one tonne of wood, the energy potentially available annually from forests in Indonesia is 2444 million BOE, far more than the present oil production of the country.

3.0 TRENDS IN EXTENT OF BIOMASS RESOURCE BASE

3.1 Deforestation

Although estimates of potential biomass resource available in the form of normal unharvested growth suggest vast energy supplies in the form of biomass, deforestation is already an acute problem in Indonesia. On Java, a burgeoning population uses more and more land to grow food and in doing so leaves less and less land to grow fuelwood, a traditional cooking fuel for the rural and large parts of the urban population.

The rural population can no longer supply the needed fuelwood from its own property, and in pilfering from public lands contributes to deforestation and attendant erosion, serious problems in their own right. Scarce populations, abundant renewable resources, forest exploitation, and clearing for transmigration projects characterize significant portions of the outer islands, however, especially Kalimantan and Sumatra.

In this situation, it is apparent that deforestation is continuing to spread on Java into additional areas such as fertile river banks and mountain slopes previously unexploited. The expansion of new transmigration populations in portions of previously uninhabited islands is also resulting in further deforestation in those areas as forest lands are put into agricultural production. The consequence of such patterns is reflected in the reduction of production of fuelwood and agricultural waste products, such as shown in Table 2-4 above. Combined with an annual increase in fuelwood consumption similar to that reported by the Ministry of Agriculture during the period of 1969-1976 of 2.2 percent per year, the trends suggest the need for increasing the role of alternative energy production strategies.

3.2 Agricultural Crops Which Produce Residues

One opportunity to increase biomass availability for regions (such as Java) with large discrepancies between production and consumption is to export surplus agricultural and woody residues from the transmigration areas to the supply short regions. In this context, it is expected that traditionally grown crops such as sweet potatoes and cassava and residues such as straw, hulls, leaves, inflorescences, etc., harvested in new areas may supply useful residues for energy purposes. While these crops do not hold much promise for direct export to fuel deficient areas such as Java, their conversion to other fuel products such as charcoal or densified pellets may enhance the viability of export of such residues.

A second opportunity to increase the amount of agricultural crops or residues available for energy consumption involves the production of alternative fuel feedstocks from biomass such as *Euphorbia* sp. and other petroleum plants, or from Lalang or *Imperata*, a small genus of closely allied grasses of the family *Gramineae*. Such feedstocks have the potential to increase production of biomass energy, although their use at present is only minimal.

4.0 CURRENT UTILIZATION OF BIOMASS

Included in this chapter is a summary of current patterns of biomass utilization in Indonesia, emphasizing technologies, and current consumption patterns which relate to the use of biomass for energy. Consumption of fuel wood and agricultural waste is examined. Official and unofficial policies and/or programs instituted by the government to promote biomass energy are included wherever appropriate.

Firewood is the most widely accepted and used biomass resource in Indonesia at the present time, with its main use being for household and industrial purposes. Uses in the household, especially in rural areas is almost exclusively for cooking. In smaller industries, firewood is used as a fuel in the food processing (soya bean cake factories, bakeries) industries, while non-food industries such as batik manufacturing, tobacco manufacturing, tea plantations, leather factories, and brick and tile manufacturing also resort to firewood for energy. In the transport sector, only old locomotives of the railroads still burn firewood as a fuel.

The use of agricultural waste for energy purposes has been more limited than that of firewood. Several reasons are offered for this, including technical, economic and social constraints such as diseconomies in collection and pre-processing of waste materials, present use and adaptation as fertilizer for crops, and reluctance to adopt new methods of handling waste products (for further discussion of constraints to

use of biomass resources for energy, see Section 6.0). Table 4-1 illustrates best available data on total consumption of fuelwood and agricultural wastes in Indonesia, according to geographical region and economic sector (i.e., household, industry and transportation). Because of population density differences, the fuelwood conditions of Java and the other islands are considered separately.

Excellent summaries of biomass production, consumption and relationships to other energy sources utilized in Indonesia have been pr .pared by Arismunandar (1979), Kadir (1979) and Kadir and Arismunandar (1980). Excerpts from these papers are presented below.

Table 4-2 gives figures on production and consumption of firewood and agricultural waste from 1967 up to 1976.

The above table shows that, on the whole, a surplus consists of production over consumption of firewood and agricultural waste. This surplus, however, stems from outside Java. On Java itself, consumption is gradually growing faster than production, and since 1976 consumption has overtaken production on Java.

Table 4-3 compares the consumption of firewood and agricultural waste to that of oil in Indonesia, expressed in million tonnes coal equivalent.

It is seen in Table 4-3 that growth trends of both firewood and waste and those of oil were about the same in the years 1967 up to 1971. Starting from 1972 oil consumption grew at a much faster rate, in 1976 reaching a consumption more than twice of that in 1967, while

Table 4-1

Consumption of fuelwood and agricultural waste

(In Million Tonnes)

YEAR	J A V A				OUTSIDE JAVA			GRAND TOTAL	
	House-hold	Indus-try	Trans-port	Total	House-hold	Indus-try	Total	Total	Growth (%)
1967	16,03	5.55	0,11	21,69	11,83	0 89	12,72	34.41	-
1968	17,15	5.14	0,07	22,36	12,77	0,90	13.67	36.03	4.7
1969	18,36	6,32	0,10	24,78	13.79	0.99	14.78	39.56	9.8
1970	19,66	6,15	0.09	25,90	14.90	0.94	15.84	41.74	5.5
1971	20,91	6.79	0,07	27,77	15,97	0,98	16.94	44.71	7.1
1972	22,05	7,86	0,03	29,94	16,91	0,99	17,90	47.84	7.0
1973	23,66	6,92	0,01	30,59	18,26	1,03	19,29	49.88	4.3
1974	25.27	8,54	0,02	33,83	19,71	1,02	20.73	54,56	9.4
1975	27,04	8,04	0,07	35,15	21,26	1,06	22,32	57.47	5.3
1976	29,54	7,53	0.06	37,13	23,11	1,07	24,18	61.31	6,7

Source : Ir. H.M.S. Hardjodarsono M.Sc. : Firewood and Agricultural Waste and its Prospects in Indonesia (1978)

Table 4-2

Production and consumption of firewood and agricultural waste

(In Million Tonnes)

YEAR	JAVA			OUTSIDE JAVA			TOTAL		
	Production	Consumption	Surplus	Production	Consumption	Surplus	Production	Consumption	Surplus
1967	32.43	21.69	10.74	35.01	12.72	22.29	67.44	34.41	33.03
1968	35.62	22.36	13.26	41.27	13.67	27.60	76.89	36.03	40.86
1969	35.01	24.78	10.23	35.03	14.78	20.25	70.38	39.56	30.82
1970	36.64	25.90	10.74	44.03	15.84	28.19	80.67	41.74	38.93
1971	36.86	27.77	9.09	47.96	16.94	31.02	84.81	44.71	40.10
1972	35.58	29.94	5.64	47.44	17.90	29.54	83.03	47.84	35.19
1973	39.27	30.59	8.68	51.61	19.29	32.32	96.89	49.88	47.01
1974	39.88	33.83	6.05	54.72	20.73	33.99	94.59	54.56	50.03
1975	38.77	35.15	3.62	50.88	22.32	28.56	89.70	57.47	32.23
1976	36.70	37.13	0.43	51.87	24.18	27.69	88.57	61.31	27.26

Table 4-3

Consumption of firewood and agricultural waste, and oil

(In Million Tonnes Coal Equivalent or TCE)

YEAR	FIREWOOD + WASTE		OIL		TOTAL		RATIO
	10^6 TCE (A)	%	10^6 TCE (B)	%	10^6 TCE (C)	%	A : C %
1967	11.47	100	7.38	100	18.85	100	60.8
1968	12.01	104.7	7.72	104.6	19.73	104.6	60.9
1969	13.19	114.9	8.07	109.3	21.26	112.8	62.0
1970	13.91	121.2	8.66	117.3	22.57	119.7	61.6
1971	14.90	129.9	9.55	129.4	24.45	129.7	60.9
1972	15.95	139.1	10.96	148.5	26.91	142.7	59.3
1973	16.63	144.9	12.78	173.2	29.41	156.0	56.5
1974	18.19	158.6	14.56	197.3	32.75	173.7	55.5
1975	19.16	167.0	16.37	221.8	35.53	188.5	53.9
1976	20.44	178.2	18.42	249.5	38.86	206.2	52.6

Source: (For Oil) : TKT.BBM.E Department for Mines

Note: The above Table indicates that firewood and waste consumption increased at percentage rates greater than the percent increase in population from 1967 to 1976. This is probably not the case, since kerosene has been used increasingly as a cooking fuel substitute, and illustrates the need for more detailed data on firewood and waste consumption.

firewood and waste grew only about 78% in the same span of years.

It may be interesting also to draw a total picture of consumption of all kinds of primary energy, which shows the role which firewood and waste plays in this total energy budget. Table 4-4 shows the consumption of firewood and waste, oil, gas, coal and waterpower for the years 1967 to 1976, expressed in million tonnes of coal equivalent.

From Figure 4-4 it is observed that the two main ingredients of the energy budget are firewood and oil: firewood as a strong first in the Sixties, and oil as a second, together making up for more than 95% of total consumption, and the balance being made up by gas, coal and hydropower.

In the Seventies relative weights changed. Although in absolute terms still growing, percentage-wise consumption of firewood declined. On the other hand, consumption of oil grew, both in absolute amounts as well as in percentage, arriving in 1976 as a very close second in total energy use, and most probably overtaking wood and agricultural waste within a short time.

In the absence of sufficient quantities of firewood materials for household cooking, it has been necessary to resort to the use of increasing amounts of kerosene for both cooking and lighting purposes. Table 4-5 shows a recent compilation of household energy uses from which it is seen that kerosene use is increasing by approximately 10% per year, while charcoal, which is a common fuel source in many countries, is not being developed in Indonesia.

Table 4 - 4

Consumption of Primary Energy

(In Million Tonnes Coal Equivalent)

YEAR	FIREWOOD*		OIL		GAS**		COAL		HYDRO		TOTAL	
	10^6TCE	%	10^6TCE	%	10^6TCE	%	10^6TCE	%	10^6TCE	%	10^6TCE	%
1967	11.47	57.9	7.38	37.3	0.66	3.3	0.17	0.9	0.11	0.6	19.79	100
1968	12.01	56.8	7.72	36.5	1.13	5.3	0.15	0.7	0.14	0.7	21.15	100
1969	13.19	58.4	8.07	35.7	1.02	4.5	0.17	0.8	0.15	0.6	22.60	100
1970	13.91	58.5	8.66	36.4	0.88	3.7	0.16	0.8	0.15	0.6	23.76	100
1971	14.90	57.3	9.55	36.7	1.19	4.6	0.19	0.7	0.18	0.7	26.01	100
1972	15.95	57.0	10.96	39.2	0.72	2.6	0.19	0.7	0.16	0.5	27.98	100
1973	16.63	55.5	12.78	42.7	0.23	0.8	0.13	0.4	0.19	0.6	29.96	100
1974	18.19	53.5	14.56	42.8	0.90	2.6	0.15	0.4	0.23	0.7	34.03	100
1975	19.16	50.9	16.37	43.5	1.69	4.5	0.19	0.5	0.24	0.6	37.65	100
1976	20.44	49.4	18.42	44.5	2.02	4.8	0.27	0.6	0.22	0.5	41.37	100

*) Including Agricultural Waste

**) Natural Gas and Liquified Petroleum Gas

Source: (For Oil and Gas) ; TKT,BBME, Department for Mines

Table 4 - 5

QUANTITY OF ENERGY USED BY HOUSEHOLDS IN INDONESIA *

X 1000 TCE

YEAR	ENERGY TYPE			
	OIL (KEROSENE)	LPG	CHARCOAL	FIREWOOD & AGRICULTURAL WASTE
1974	3 171	22	34	17 349
1975	3 636	33	42	19 038
1976	3 948	38	44	21 221
1977	4 390	41	52	23 158
1978	4 786	30	38	25 310
1979	5 269	32	34	27 315

*) BPPT/Bechtel program of energy modeling: report under preparation (1980)

In order to provide assistance to the people with low income levels who must resort to the use of kerosene, the Indonesian government has subsidized its cost. This has resulted in benefits to the poor people, but since 1969 the increase in kerosene use has become so great that substantial amounts must now be imported to meet the demand. It has been seen in the many surveys made that dependence on kerosene increases with proximity to cities and heavily populated areas, and that 80% of household consumption is for cooking, with 20% for lighting purposes.

The amount of kerosene used for household purposes in the period 1969-1978 is shown in Table 4-6.

Table 4 - 6

CONSUMPTION OF KEROSENE BY THE HOUSEHOLDS *

1969 - 1978 (kilo litre)

Year	Sale of kerosene	Consumption of kerosene by the households	Consumption of kerosene for cooking only
1969	2.700.067	2.160.053	1.728.042
1970	2.732.195	2.185.756	1.748.604
1971	2.817.548	2.254.038	1.803.230
1972	3.306.580	2.645.264	2.116.211
1973	3.681.977	2.945.581	2.356.464
1974	4.258.050	3.406.440	2.725.152
1975	4.882.663	3.906.130	3.124.904
1976	5.302.722	4.242.177	3.393.741
1977	5.895.330	4.716.264	3.773.011
1978	6.426.000	5.140.800	4.112.640

* Source: Directorate General of Oil and Natural Gas (1978)
Progress Report "Utilization of Firewood and Agricutlural Waste in Indonesia", Satyawati Hadi, et al, LPHH (April 1979).

5.0 POTENTIAL FOR FUTURE USE

In order to assess the potential for future use of biomass as an energy resource, it is necessary to consider the geographic and demographic characteristics of Indonesia. Each island is an entity unto itself, and movement of biomass fuels between islands would include transportation to dockside, loading onto boats, ship transport to the island of destination, offloading of the boats, and transportation to distribution networks on the receiving island. This multi-handling process results in very high transportation costs between islands, and firewood which has not been processed to charcoal or other concentrated energy forms does not have sufficient energy per unit weight or per unit volume to justify the transportation costs.

In further consideration of geography and demography, Java has an extremely high population; densities on most of the other islands are comparatively low. Some 70% of the population of Indonesia lives on Java alone. Therefore, while firewood and agricultural wastes are used for household cooking purposes throughout Indonesia, it is only on Java and on a few other heavily populated islands that there has become a scarcity of biomass resources for energy purposes. On Java there are essentially no old forests of trees remaining for fuelwood use, and the population must resort increasingly to that which grows annually, along with agricultural residue and house garden materials which are combustible. High value wood products such as lumber are imported to Java.

A major purpose then in assessing the potential for future use of biomass as an energy source is to determine the feasibility of developing a larger biomass base for Java and to prevent the deforestation conditions of Java from occuring on the other islands. It may also be possible to convert biomass on islands with surpluses to higher forms of energy for shipment to Java and other areas of biomass deficiencies.

5.1 Programs to Increase Biomass Production

There are several programs underway to increase biomass resources on Java and other densely populated islands. These include dissemination of seeds of fast growing trees, experimental plots of fast growing trees, and research on soil characteristics relating to increased biomass production. On the island of Java nearly every square meter of land is utilized intensively for agricultural purposes, and therefore there is a competition between biomass for energy vs. biomass for food. Fast growing trees would economically produce more biomass on less land, and therefore have the potential of meeting energy needs while allowing food crop production to continue. There are also about 20 million ha of marginal land not well suited to agriculture, where fast growing trees would provide the potential of meeting much of the islands' firewood needs. For example, it is envisioned that extensive fuelwood plantations on the so-called wastelands of Java (4 million hectares) could be developed by the year 1990. Here is where the soil improving capacity of many of the leguminous tree species would pay off handsomely. The yields of these impoverished soils would be lower than average but would

increase as time went by. At a yield of only 10 tonnes of biomass per hectare per year the 4 million hectares would yield 40 million tonnes annually more than the total present fuelwood consumption on Java. At a conservative value of two BOE per tonne, assuming minimal transport costs between the production and consumption sector, this biomass would supply a significant portion of the fuelwood demand on Java by the year 1990. If the remaining 16 million hectares of marginal land in Indonesia were put into production of fuelwood by the year 2000, the yield of the entire 20 million hectares at 10 tonnes per hectire could be 200 million tonnes, which at two BOE per tonne would be equal in energy to 400 million BOE.

It may also be possible to convert biomass on other islands with surpluses to higher forms of energy for transport to Java and other areas of biomass deficiencies. As an example, a rule of thumb states that firewood can be transported economically only up to 80 kilometers while charcoal can be transported up to as much as 600 kilometers. Here is an opportunity to supply urban centers on Java or other densely populated islands with harvested biomass from large plantations. The biomass could be converted to charcoal in small portable metal kilns, for which economical processing techniques and technology exists. As transport costs are reduced through improvements in shipment technology, it is anticipated that such biomass supplies may become feasible within the time frame considered here, to the year 2000.

5.2 Direct Combustion

Direct combustion of biomass already provides the bulk of household

energy needs in rural areas. On a limited scale, biomass is also being used to provide energy in certain industries. For example, palm oil mills utilize a large portion of the waste (fiber and fruit shell) to produce steam and electric power for in-plant use. Also, most of the existing plywood mills use their own wood waste to produce steam for drying the lumber and finished products. Almost all the small-scale brick and roof tile manufacturing operations use wood and other agricultural wastes to fire their kilns.

The opportunities for expanding the current use of biomass in the industrial sector, particularly the forest products industries, and the introduction of biomass as a fuel for electricity generation in remote and isolated areas of Indonesia are promising. The forest products industry is rapidly growing and is expected to continue expanding throughout the next 20 years. Plywood and pulp and paper operations are expanding most rapidly. Almost all the existing saw mills and plywood mills use diesel generators for supply of plant power requirements. This is particularly true of plants which are located on the islands of Sumatra and Kalimantan. The wastes available from the saw and plywood mills can be used to generate the energy requirements of these mills.

For example, an average size saw mill processes approximately 50,000 m^3 of logs per year. About 30 to 40 percent of this quantity is generally considered to be waste material. The average power requirement of such a mill is 500 kW; the waste material, burned in wood-fired boilers, could produce energy in excess of the mill needs. In the plywood

mills, wood-fired cogeneration (simultaneous production of electricity and steam) would be an ideal application of emerging biomass energy technology. Assuming an aggressive effort to promote the use of such technologies, it is anticipated that the forest products industry could become energy self-sufficient within the time frame of the next 10 to 15 years.

As shown in Section 2.3, the forest area in production consists of 40 million ha. The normal practice of forest harvesting to provide logs, lumber, plywood, and other forest products results in approximately 50 percent of the tree and root system to be used as product material and the remainder is left in the forest as waste. In processing of logs to produce lumber and plywood another 35 percent is waste material, and therefore the energy potential from the production forest area is about 67 percent of forest biomass being grown for harvesting.

Since Ellis (1978) reports forest biomass production of up to 18.4 oven dry tonnes per ha per year, using a figure of 10 tonnes per year is a conservative estimate of forest growth through normal photosynthetic activity. Therefore, if 40 million ha of production forest were to produce 10 tonnes per ha, the forest production would be 400 million tonnes per year, 67 percent of which would be waste which could be converted to energy. This would, at a conversion factor of two BOE per tonne, amount to 540 million BOE per year.

Electricity generation by small wood-fired electric power plants should be considered for the islands of Sumatra, Kalimantan and other forest-rich islands. These islands not only have the resource, but

also provide ideal sites for demonstrating the technical and economic feasibility of small scale (0.5-10 MW) wood-fired power plants. However, as the island of Java is scheduled to have a large coal-fired central electric power plant generating station by 1983, it will be almost impossible for any wood-based electric plant to be cost competitive on this island in the time frame considered here.

At the present time, about half of the electricity generation on the islands of Sumatra, Kalimantan, and Sulawesi is done by the PLN (state-owned utility). PLN currently has about 584 MW of oil-fired installed capacity on these three islands, with the majority of the plants diesel engine/generators with an output capacity of about 1 MW or less. Since most of the forest resources are present on these islands and the islands serve as preferred regions for translocation of some of Java's large population, the use of wood and forest products residues for local electrical consumption appears to be a viable option. These plants would operate with capacities from 500kW to 10 MW generating capacity, depending on location and size of the local market. Successful implementation of these plants would be dependent upon cooperation between PLN, the Department of Forestry and the forest products industry, and would parallel the growth of transmigration populations in those regions.

For household energy use, technological advances in the fields of silviculture, charcoal production and charcoal stove design will make increased use of natural growth of biomass and charcoal a technically and economically feasible method to meet energy needs

of the householder in the next 10-15 years as other options and alternatives are investigated on Java and the other densely populated islands. Curiously enough, however, rather than concentrate on programs of reforestation with fast growing trees and more efficient charcoal production and usage, emphasis has been placed on increased kerosene usage, now becoming a burden to the government, as discussed earlier. Within the next decade, it is absolutely essential that the decline in household energy use supplied by biomass be reversed, and a strong government effort must be undertaken to promote the use of fast-growing trees, charcoal use and efficient stove design.

5.3 Gasification

Gasification is the thermal decomposition of solid carbonaceous fuels (i.e., coal, wood, agricultural waste) in the presence of limited (less than stiochiometric amount) supply of air to produce low-BTU combustible gases. Since air-blown biomass gasification technology for producing low-calorific value gas is commercially available in the near term, this technology should find ready application in different Indonesian energy-consuming sectors. The low-BTU value gas produced from air-blown gasifiers can be used to operate internal combustion engines, or fire boilers, drying kilns, etc.

In the forest products industry, the large amounts of wood waste, estimated above to amount to as much as 270 million tonnes per year, can be converted to supply in-plant energy needs of these mills, using atmospheric pressure air-blown gasifiers. Gasification recovers between 45-90 percent of the energy value of the feedstock material, depending upon the biomass resource, thus yielding between 240 and 490 million BOE.

The suitability of this technology as a preferred alternative to direct combustion of the wood waste in the forest products industry, however, largely depends on the relative economics, ease of operation and compatibility with the existing energy supply system. If a new mill is being constructed, a direct combustion system would probably have an economic advantage over gasification systems. However, in the case of existing mills, the gasification option offers better flexibility and compatibility with the existing energy generation system of the mill. For example, the gasification system provides the opportunity of retrofitting existing diesel generators, either mobile or stationary. In such a manner, both mill energy and mobile field equipment energy usage can be supplied by biomass. The simple design, quick start-up and minimum operation and maintenance of small gasification systems would enable rapid and complete conversion of existing facilities and operations to biomass energy, and enable future plants to utilize biomass as well.

The gasification option could also be considered for retrofitting existing small (less than 10 MW) PLN oil-fired electricity-generating plants in Sumatra and Kalimantan. Again, the relative economics of direct combustion vs. gasification systems tends to suggest that existing facilities could best be retrofitted with gasification systems, while new facilities could best be served by direct combustion technology. Such a scenario implies conversion of existing facilities and development of new generating plants on the outer islands to use the available biomass resource such that most present and future energy demands in these sectors are met with biomass through the next 20 years.

Gasification technology is also suitable for supplying energy for different agriculture and/or related operations. For example, agricultural waste (crop residues) can be used to produce a low calorific value gas which, in turn, could power a retrofitted diesel generator to drive either an irrigation pump or rice mill. In Indonesia, rice husks and rice straw are the most commonly available agricultural residue. The higher ash content (silica) of the husks creates some operational difficulties for gas generators, but these modifications can be overcome by design modifications. Assuming a strong government effort to promote the use of such technology then, it is anticipated that gasification systems for the agricultural sector could play a significant role in meeting the energy needs for irrigation or food processing during the next 20 years, provided that alternative uses of the feedstock are not a problem. Other barriers to the use of such technology in the agricultural sector are discussed in Section 6.0.

In the long term, advanced gasification technologies (eg., high pressure gasification, fluid-bed gasification, oxygen-blown gasification and catalytic gasification) may play an important role in supplying different chemicals and fuels from biomass. For example, methanol is one of the chemical fuels which could be produced via this biomass gasification (oxygen-blown) and subsequent catalytic synthesis route. Since methanol is one of the liquid fuels which is being given high priority as a substitute fuel in the transportation sector, such technologies should become viable options for increased biomass energy usage, although the potential for widespread use in Indonesia is most likely limited to beyond the next decade.

5.4 Pyrolysis

Pyrolysis is the thermal decomposition of solid carbonaceous fuels in the absence of air, which produces combustible gases, oils (tars), and solid char residue. Since pyrolysis of biomass results in a number of products, local markets must be assured for not only one but three separate products if the technology is to be economically feasible. The oils produced in pyrolysis are the most easily shipped, and their production amounts to approximately 0.5-1.0 BOE per tonne of biomass pyrolyzed.

It has been found that pyrolysis of rice husks gives powdered char, which contains more than 40 percent ash (silica). Also, the product gases, except for direct burning, cannot be directly (without extensive cleaning) used in internal combustion engines. In this sense, pyrolysis does not convert biomass directly to usable energy products, but it produces three different products that can be further processed or refined for intended application. As a result, a small-scale (1 tonne/day) pyrolysis plant may not be able to process and market the energy products (particularly oil and char) effectively. Moreover, since the quantity and the quality of different pyrolysis* products are extremely dependent upon the operating conditions, a close control of these operating conditions is essential for obtaining a proper yield of consistent quality energy products.

Because of this inherent requirement of a pyrolysis process, it would be very difficult to obtain a consistent quality energy product from a simple inexpensive small pyrolysis unit. If all the required controls

*The term pyrolysis refers to low-temperature pyrolysis process

are used to improve the performance of a small pyrolysis plant, it would no longer be an inexpensive system. Therefore, it seems that the ability of the pyrolysis process to extract a range of more valuable hydrocarbons from biomass may only be exploited at a large-scale (at least 100 tonnes/day of bone dry biomass) operation. Small-scale biomass conversion systems should be primarily restricted to combustion and air-blown gasification technologies.

A review of the biomass resource availability in Indonesia would indicate that only wood and wood residue could sustain the operation of large-scale pyrolysis plants. Once again, because of the wood fuel transportation cost limitations, these plants would have to be located near the wood resources; this would require the plants to be located on the islands of Sumatra and/or Kalimantan. The economic feasibility of large wood-based pyrolysis plants would very much depend on the marketability of pyrolytic oil and char. Based on the results of studies conducted in the U.S.A., it could be safely assumed that the pyrolytic oil, after necessary equipment modifications, could be used in industrial residual fuel oil-fired installations. On the basis of 270 million tonnes of wood waste estimated previously, the potential of pyrolytic oils would be between 135-270 million BOE per year.

The product char could be used for household (particularly rural) energy needs. Another emerging application for the product char is its use in existing residual oil-fired industrial and utility boilers as a char/oil mixture. The feasibility of this application, however, depends on the successful adoption of coal/oil mixture combustion technology for the char/oil mixture combustion. It should be recognized

that char, depending on its volatile content, has different combustion properties than most of the coals.

As such, it appears that the technical potential for pyrolysis in the years 1990 and 2000 would be limited to the islands of Sumatra, Kalimantan or other forested islands where a combination of local markets for each by-product and ready availability of woody biomass could support development of the technology. In one scenario, both the pyrolytic oil and char would be used to fire local industrial oil-fired generating plants and supply household cooking fuel, while the product gas could be used to supply the pyrolysis unit with heat and in-plant power to run the equipment. Under such a scenario, it is anticipated that large-scale pyrolysis units would become cost competitive with alternative fuels only after large local markets could be developed and process refinements completed, which most likely limits its potential use to the long-term when the local population and industrial base expands. Even then, the total of all by-product streams would probably not be sufficient to meet all the energy needs of the local markets, and additional measures would be necessary to meet demand.

5.5 Alcohol Fermentation

The technology of alcohol fermentation is well known throughout the world, although recent process and design alterations have resulted in several refinements in the technology. Fermentation technology has been given high priority for development within the country, and already the technology is being adapted by the government to the

peculiarities of Indonesia. As such, it is anticipated that within the next 20 years, if the government's plans and programs are fruitful, some 20 million kiloliters or over 50 percent of the transportation sector's energy demand will be met by production of power alcohol from sugar and starch crops such as molasses, cassava, sweet potatoes, Sago palm, etc.

Not mentioned in government plans but potentially as valuable to productive capacity as sugar or starch crops, cellulosic biomass (agricultural residues such as corn stover, bagasse, and other cellulosic materials such as wood, municipal solid wastes, etc.) may prove to be a preferred feedstock in the event that the food vs. fuel question cannot be resolved. This is especially important in that many of the alcohol production facilities will likely be located in remote regions to stimulate relocation of large numbers of the population to these unsettled regions. Should production of sugar or starch crops in these areas not reach expected production levels, abundant lignocellulosic and cellulosic biomass could become the preferred feedstock, although additional refinements in processing technology would be required. Such technology is currently in the process of refinement in the U.S.A. and other developed countries and thus would likely not be available for use in Indonesia for the next several years unless a concentrated effort were begun soon.

At present, government projects designed to stimulate development of alcohol fermentation technology should ultimately lead to widespread use of power alcohol as a direct substitute for gasoline or diesel in the transportation sector. However, widespread use will probably

not occur until subsidies on gasoline and diesel are removed, or direct subsidies are given to use of power alcohol since the present price of power alcohol is about twice that of gasoline. Despite such government intervention into the price structure of liquid fuels used by the transportation sector, it is likely that by 1990 production of power alcohol will be able to supplant a significant portion of the gasoline and diesel fuel demand, and by the year 2000, as stated above, supply more than 50 percent of that sector's energy demand.

5.6 Methane Fermentation

The production of fuel gas (biogas) from digestion of organic wastes to methane and carbon dioxide is widely practiced throughout the world, and has been utilized to some extent in Indonesia as well. However, due to several technical, economic and social barriers to use of the technology (see discussion in 6.6), it is anticipated that methane fermentation will play only a very limited role in supplying energy to the industrial/commercial and residential sectors. Major feedstocks for methane fermentation now and into the future are rather limited to animal excreta and water hyacinth for householder or villager use, and other similar feedstocks for commercial/industrial use. The availability, quantity and quality of these feedstocks are not expected to change drastically in the foreseeable future, resulting in only limited production by 1990 and 2000. Economically, the value of the gas produced could very well be cost competitive to projected costs of oil on the world market at that time, although it is likely that widespread and dispersed utilization of the technology would be hampered by the inability of the individual or collective users

to pay the capital cost of such facilities and maintain units in proper fashion.

5.7 Summary of Potential for Future Use

As seen in Section 2.3, there are approximately 122.2 million ha of forest lands in Indonesia. At a photosynthetic growth rate of 10 tonnes annually per ha, 1220 million tonnes of biomass are estimated to be produced per year, which is equivalent to at least 2440 million BOE per year. This is equivalent to about four times the present oil production of Indonesia, but of course much of this biomass is in protected and conservation forests or otherwise unavailable in densely populated areas where it is needed.

In Section 5.1 it is seen that on Java alone the four million ha of so-called wasteland could produce 40 million tonnes of biomass by the year 1990, equivalent to at least 80 million BOE, and if the remaining 16 million ha of wasteland in Indonesia could be forested by the year 2000, the fuelwood production from forests could be 20 million hectares at 10 tonnes per hectare, or 200 million tonnes, equivalent to at least 400 million BOE. Much of this energy could be used directly without conversion to charcoal, but even if charcoal were to be developed and used extensively on Java, the loss in charcoal conversion of 50 percent would still result in 200 million BOE for household use on Java. Agricultural residues on Java will not increase significantly, since the agricultural productivity is presently at nearly its maximum level, and therefore the potential from agricultural wastes would be another 8 million tonnes (Section 2.2), or, at a rate of two BOE per tonne, approximately 16 million BOE.

In Section 5.2 it is seen that forestry in production primarily outside Java produces waste products which have a value of at least 540 million BOE.

It can be concluded that biomass production for energy use has tremendous potential both on Java and on the outer islands. The total amount available from both forests and farms is considerably more than four times the equivalent amount of oil presently being pumped, and the only barriers to use of this vast renewable resource are those of conversion to products which are more easily transported as solid fuels or more easily used in existing equipment in the form of liquid and gaseous fuels.

6.0 BARRIERS TO USE

Planning of programs to increase the use of biomass materials for energy must take into account those barriers which are associated with accelerated development of these forms of renewable energy. Included in this section are some of the more significant barriers to increased biomass production and conversion to energy sources.

6.1 Increased Biomass Production

There are three major barriers to increased biomass production. These are availability of land, potential for nutrient depletion, and the unknown effects of introducing new tree species which are more suitable for fuelwood into the agricultural sector. With respect to the availability of land, there is intensive utilization of nearly every square meter of productive land for rice and other food crops on Java and in other densely populated areas. There thus could become significant competition between food crops and energy biomass "crops" if there were few sources of energy other than biomass. There are areas of Java and outside Java which are not suitable for intensive food production, however, and these could produce greater amounts of biomass if managed carefully and planted with fast growing trees.

The use of greater amounts of biomass for energy purposes without returning the residues to the soil could result eventually in a decrease in soil fertility. The high fertility and productivity of Indonesian soil has been recognized throughout the world, and it is important to maintain this fertility and even enhance it

in order to assure a productive and prosperous agricultural society in the future. Depletion of soil fertility would not be a significant barrier if the biomass residue were returned to the soil or if fertilizing nutrients were added to compensate for those used in biomass production.

A final important consideration is the unknown effects of introducing fast growing trees into the pattern of agricultural practices. For example, foliage or canopy of many of the present trees grown in "house gardens" and as hedgerows is not dense, and sufficient sunlight filters through to allow the production of food crops such as taro under the trees. It is not known what the effects will be when food crops are grown under Calliandra, Leucaena and other such fast growing trees. If the trees were to cause sufficient shade so as to reduce food crop production, the beneficial effects of increased energy supply could be offset by their effects on food production.

6.2 Direct Combustion

The major barrier to direct combustion of biomass materials for energy sources is transportation costs, since as unprocessed materials they are bulky and are not a concentrated energy form in terms of calorific values per unit weight or volume. It has been stated generally by energy specialists interviewed that 75 to 150 km is the maximum distance that fuelwood can be transported economically in Indonesia. Another barrier which is largely overcome with the ingenuity of householders and research at government centers is stove design. Poorly designed stoces provide only about 10%

transfer of heat energy, while some designs developed by inventors in Indonesia used with specific biomass materials have achieved as high as 20 to 35% efficiency of heat transfer.

In the case of dendrothermal projects in which large acreages of fast growing trees would be harvested and burned directly to provide electricity, the major barriers would be the amount of land required and the capital costs of facilities for storage, processing, and electricity generation.

6.3 Charcoal Production

One of the barriers to developing a charcoal energy system is that of social acceptance. There are two components to this barrier. The poorer people who have always burned wood and biomass materials directly may not want to switch to charcoal because it is a different material with different characteristics. For example, it takes longer to get a fire started when using charcoal. On the other hand, people with higher income levels who now use kerosene may feel that it is a step backward in their pattern of living to switch to charcoal, since charcoal is not such a clean fuel as kerosene.

Another barrier to charcoal production is lack of a marketing and distribution system, since charcoal is used to such a small degree presently. Additionally, the technology of charcoal production throughout the country would have to be improved, using modern methods presently developed in other countries. Technology from Japan is apparently being introduced on Sumatera presently, and

there is discussion of charcoal production by Japan from mangrove trees.

If larger charcoal plants are to be considered, the availability of biomass feedstock would require that they be built on Kalimantan or another island outside Java. Transportation costs to Java and other areas of high population densities would then be significant barriers. Closely related to transportation is the need for packaging and storage facilities. In the high humidity of tropical climates, these could be barriers in the sense that charcoal tends to absorb moisture, and packaging and shipping must be carried out so as to minimize the amount of moisture pick-up.

6.4 Gasification

Gasification is relatively high technology processing, and a primary barrier to commercialization of the process is lack of technology de-development, not only in Indonesia but throughout the world. That is not to say that the technology is not available, but rather that it is not yet simple and easy to use. Very little new technological development has occured since more than 30 years ago, when gasification was nearly terminated because of the availability of inexpensive gas and oil. In recent years, however, more simple designs of systems have begun to be developed.

Another barrier to gasification is the high capital cost and maintenance requirements of gasifiers. Also, for existing equipment now operated by diesel or gasoline power, there is the need for retrofitting of the engines for conversion to gas.

For operation of gasifiers to be as trouble free as possible, a low moisture content of less than 30% is desirable. Therefore, drying of the biomass material could become a barrier to its use.

6.5 Pyrolysis

In Indonesia research and development work on low temperature pyrolysis has focused primarily on developing small one tonne per day rice husk pyrolysis systems for local rice mills. The initial data obtained has resulted in process modifications, and development has been carried nearly to the point of commercialization for rice mills on Java.

One of the barriers to pyrolysis commercialization is that three products are produced, and therefore markets must be found for each. It has been found that pyrolytic oil is not a suitable substitute for kerosene, and therefore other uses for this product must be developed. Also the charcoal produced by pyrolysis in some cases is not of high quality. For example, the ash content of charcoal from rice hulls is nearly 45%, and therefore the charcoal briquettes do not burn as well as charcoal with a lower ash content. In some respects a high ash content may not be totally undesirable, however, since there is a market for the ash as scouring powder and other such uses.

As in the case of barriers to charcoal use mentioned in Section 6.3, there is again the need for social acceptability of the charcoal, along with its marketing and distribution as well as the problem of moisture absorption. These can be handled if a charcoal energy

system becomes developed, but if charcoal energy in general is not accepted by the public, then the specific problems of marketing the charcoal produced from pyrolysis could be more severe.

The capital cost and maintenance of pyrolysis plants are other major factors which are barriers to commercialization. As long as diesel and gasoline are low in cost, high technology processes such as gasification and pyrolysis will not be readily commercialized. If the subsidies on these fuels were removed and additional further price increases were to occur, however, there would be a noticeable shift to these technologies.

6.6 Ethanol

Ethanol production for use as a fuel and for export is being seriously considered for certain areas of Indonesia which have low population density and where there is need to provide additional jobs and income. Ethanol facilities are thus targeted initially for transmigration areas. There are certain barriers to extensive alcohol production which are briefly summarized below.

Alcohol production is, like gasification and pyrolysis, another high technology processing system. The technological development has been carried out primarily in Europe and the U.S.A., and application on a large scale will require modifications in accordance with the conditions of Indonesia. For example, typical yeast strains used throughout the world cannot tolerate temperatures much above 32°C, while the climate plus heat of reaction for fermentation in Indonesia

results in a fermentation temperature of more than 35° . The same temperature characteristics are important in design modifications to distillation apparatus and heat exchangers so as to obtain the greatest efficiencies possible.

Another barrier to ethanol production on a large scale is the capital cost of processing plants and the economics of competing with subsidized fossil fuels in sale of the alcohol as a fuel. Maintenance and storage problems using this high technology must also be dealt with.

Disposal of fermentation residue, whether to livestock as feed or to land as fertilizer, must also be taken into account in alcohol fermentation. Additionally, the problem of water pollution from ethanol plants must be addressed.

6.6 Methane Fermentation

As discussed earlier, methane production from organic wastes and residues is perceived to have somewhat limited potential as a major energy source in Indonesia, primarily because of several technical, economic and social barriers. First, technical constraints are evident in that animal manure type feedstocks are often dispersed in the fields where the animals graze, and are not readily available near homes where biogas plants would be located. This is different from China, where biogas plants provide significant energy to millions of homes because several pigs and other animals are always present in the yards adjacent to these homes. Biogas plants in Indonesia therefore are limited primarily to cattle farms, chicken farms, and ponds containing water hyacinths. Each such facility could produce useful biogas, but the

total number of families served could be counted in the thousands, as compared to the tens of millions of families in the country.

The conditions required for biogas use are a barrier to large scale implementation, in that methane, unlike propane and butane, cannot be economically compressed to a liquid for ease of transport. It therefore is almost always piped from the fermenter to its place of use, and is generally not readily adapted to mobile equipment such as tractors and automobiles. Although compressed biogas and large gas bags have been used under wartime conditions for mobile equipment powered by biogas in the past, liquid fuels such as ethanol or methanol are generally considered to be much more suitable.

Social acceptance of biogas plants could be a barrier to widespread use, since in many cases the feedstock is animal and human waste in countries like China, and biogas thereby produced is considered by some to be unsuitable for use in the home as a cooking fuel. Additionally, in areas where animal dung has traditionally been dried and burned as fuel, the introduction of biogas plants would have to be accompanied by considerable social readjustment.

Other barriers to use of methane fermentation are capital costs, maintenance and disposal of spent residues. These are similar in nature to ethanol plants, except that biogas facilities are somewhat more simple to construct and operate.

Since biogas is highly flammable and can cause explosions, the matter of safety is a potential barrier to its use. This can be overcome readily by proper education and fermenter design.

7.0 CURRENT POLICIES AND PROJECTS

As stated in the Introduction, Repelita III, the third five-year plan (1980-1984) emphasizes several major points relating to energy. One is to enhance conservation of kerosene and other oil resources by substituting other energy sources, and another is intensified research, development, and implementation of programs to use renewable energy sources such as biomass. The Government of Indonesia (GOI) is therefore implementing projects which assess the biomass energy demands more fully, produce greater quantities of biomass, and convert the biomass more efficiently to energy use.

A number of studies are currently being undertaken on consumption patterns of fuelwood and other biomass energy sources. These studies will provide information about the amount of cooking fuel needed in the country now and in the future.

Much basic silvicultural and yield information on fuelwood species is needed. A few rather fragmented studies on fast-growing species are underway, but much more coordinated work will be necessary in order to begin to answer questions of what species to grow, where, and what production will ensue.

As stated in Section 1, the GOI is subsidizing the cost of kerosene as a substitute cooking fuel in order to provide assistance to people with low income levels who must resort to kerosene in place of firewood. Kerosene use is therefore increasing by approximately 10% per year, and since 1969 the increase in kerosene use has been so great that substantial amounts must now be imported to meet the demand.

On a limited scale, biomass is currently being used to provide energy in certain industries. For example, the palm oil mills utilize a large portion of the waste (fiber and fruit shell) to produce steam and electric power for the in-plant use. Also, most of the existing plywood mills use their own wood waste to produce steam for drying the lumber and finished products. Almost all the small-scale brick and roof tile manufacturing operations use wood and other agricultural wastes to fire their kilns.

At the present time, an Imbert gas generator and retrofitted diesel engine (25 kW output) is operating at the solar village in Picon. This gasifier diesel generator set is currently being used to pump irrigation water. A small bench-scale (about 3 kg/hr) gasifier is presently being tested for different biomass feedstock at ITB in Bandung. At the BPP Teknologi, plans are currently underway to construct a small charcoal gasifier to produce DC electricity. The capacity of this gasifier-engine generator will be about 5 kW. Also, a technical and economic feasibility study is being conducted to assess the potential of biomass-based methanol production technology in Indonesia.

Research and development work on low temperature pyrolysis has primarily focused on developing small (1 tonne/day) rice husk pyrolysis systems for the local rice mills. Two one-tonne-per-day pyrolysis systems have been installed near Bandung; one of these units is installed at an existing rice mill. The main purpose of this ongoing research and development activity is to test the operation

of a small rice husk pyrolysis unit and find appropriate utilization for the pyrolysis products. The initial data obtained from the operation of the pyrolysis unit have resulted in several process modifications. These modifications are expected to improve the system performance. So far, the oil yields have been lower than the original expectations. Also, it was found that the pyrolysis oil was not a suitable substitute for domestic kerosene use.

An ambitious program is aimed at the ultimate development of new alcohol production capacity of nearly 20,000,000 Kl/yr of power alcohol by the year 2000. By contrast, current production of ethanol from biomass in Indonesia totals only approximately 30,000 Kl/yr from 9 plants, the majority being exported for beverage purposes, while production capacity in Brazil is expected to be only between 4-6 million Kl/yr in 1985. Using the Brazil program as an example, it took nearly 30 years to reach a production level of 1.5 million Kl/yr. Considering land area and population of Brazil as compared with Indonesia, an equivalent rate of development would indicate that Indonesia would produce approximately 5 million Kl by 1990 and 10 million Kl by the year 2000. An effort considerably greater than that of Brazil would therefore be necessary in order to produce 20 million Kl annually by the year 2000.

The new program, conceived to consist of as many as 4,000 5,000 Kl/yr ethanol plants, is a key component in the new transmigration program developed by the government to redistribute the country's population more evenly among the thousands of island land masses comprising the nation. These 5,000 Kl/yr alcohol plants, using locally grown

surplus agricultural crops such as sweet potatoes and cassava, and Sago palm harvested from nearby tropical marsh forestlands, will serve as the local fuel base for individual transmigration areas (4,000 families) or for export purposes. Already, the first of these plants is scheduled for construction in 1981 in a transmigration area located in South Sumatra with technical assistance from West Germany.

In the vicinity of this plant feedstock consisting of sweet potatoes will be grown by individual farmers on their individual 2 ha farms, with ¼ ha being allocated on each farm for production of the feedstock. With proper crop management, it is anticipated by Indonesian planners that the centralized ethanol plant will be able to continuously process feedstock and produce power alcohol for distribution to distant markets or use within the area, providing both employment and a fuel base for continued expansion.

In addition to the above, a new program in alcohol research is being funded by a grant in aid from Japan in the amount of $8 million. The total alcohol program of B.P.P.T. for 1981/1982 is shown in Table 7-1.

The feasibility of a wide-scale implementation of anaerobic fermentation technology as it relates to conditions in Indonesia is being investigated. Research efforts are currently underway to assess available biomass resources for use as feedstocks for anaerobic digestion units, particularly quantities and availability of water hyacinth (eichornia crassipes). This macrophyte, growing in nutrient-rich, warm, fresh water frequently obstructs drainage of farm lands,

TABLE 7-1.

B.P.P.T. ALCOHOL PROGRAM IN INDONESIA
(By B.P.P.T Teknology (Agency for Development and Application of Technology)
Fiscal Year: 1981/1982

A. PRODUCTION SIDE

1. Pilot plant (15000 liter/day)
   - By November 1982 will produce alcohol 95%.
   - Design by B.P.P.T.
   - Build by Indonesian Firm (tender)
   - Site: Tuland Bawang (Transmigration Area in Lampung
2. Agricultural Research Station for sweet potato (10 Ha)
3. Total budget for A, B, and C, U.S. $3 million (1981/1982)
4. Grant aid from Japan, U.S.$ 8 million, Biomass Research Center in Lampung. Consisting of:
   a. Alcohol plant (15000 liter/day)
   b. Research Center for:
      - Agriculture
      - Saccharification fermentation, distillation
      - Other biomass feedstock

B. SOFT WARE

National Alcohol Team (introduction of alcohol fuels in Indonesia)

a. Agriculture
b. Technology and Production
c. Economic/Marketing
d. Social Impacts

Members from: 7 Departments, and 7 University; approx. 50 people

C. DEMAND SIDE

1. Testing (June 1981)
   a. Straight alcohol:
      1 car, 1 genset 120 KW 5 cycles, 3 alcohol equipment
   b. Gasohol (10/90 and 20/80 with hydrated alcohol) 50 cars
   c. Methanol (two cars)

encroaches upon aquaculture ponds and completely encloses fresh water pools behind hydro-electric dam facilities. Estimates of water hyacinth growth and extent in Indonesia are incomplete, but preliminary estimates indicate approximately 6 million hectares of fresh water surface area in the country are covered by water hyacinth. Being rich in nutrients such as nitrogen and phosphorus, and being approximately 90% water, 10% solids (of which 80% are volatile), the water hyacinth has been reported to be a good substrate for anaerobic fermentation processes.

Other biomass materials available for use as potential feedstocks for production of biogas include, but are not limited to, animal and human wastes, and agricultural residues such as rice straw, bagasse, peanut wastes, etc.

Within the framework of various technical and economic constraints, investigations have been undertaken by various groups and institutions within the country to evaluate the feasibility of using these residues for production of biogas via methane fermentation. At the Bandung Technological Institute (ITB), several simple small-scale experimental digesters have been constructed and installed in the field at Cicurug and Lembang using animal wastes as the feedstocks. The Indonesian Petroleum Institute (LEMIGAS) is sponsoring two methane fermentation projects at Gajah Mada University, one a pilot scale fermentation tank of the Chinese design located at the research farm of the Department of Animal Husbandry and the other a bench scale study of digestion of animal wastes. LEMIGAS is also supporting anaerobic fermentation research at Cepu.

Other current anaerobic fermentation projects include the bag anaerobic digesters installed at P3T in Ciawi, operating in the mesophilic mode utilizing animal wastes; the Chinese style fixed-dome digester constructed at the Solar Village of Picon; the pilot scale digester developed by Biotrap near Bogor; and the water hyacinth digester operated in the mesophilic mode at Cilangkap. Also planned for construction and operation in the immediate future is a thermophilic anaerobic digestion system to be installed at Serpong, utilizing cattle dung as feedstock.

The nature and scope of these various on-going or completed projects are wide-ranging, including evaluation of both small (family size) and larger size (industrial/commercial scale) digestion units. Variables evaluated include: use of different feedstocks such as water hyacinth or animal wastes feedstocks; different design configurations (e.g., Chinese fixed-cover and Indian floating cover) and level of complexity; various materials of construction such as steel, ferrocement, cement and rubber-based products (e.g., butyl digestion bags at Ciawi), and both mesophilic and thermophilic digester design.

8.0 RECOMMENDED STEPS IN DEVELOPMENT OF BIOMASS RESOURCES

The development of renewable energy sources is critical to supplying the energy needs of Indonesia in the future. Biomass can and should be a major component of this energy source, and with a well planned development program, it can continue to supply major amounts of energy without creating a drain on natural forest areas or adverse effects from overharvesting of firewood in rural areas.

It is important initially for all Ministries of the Government and for the people as a whole to continue receiving the most up-to-date figures available on biomass productivity and consumption, so that they will make increased efforts to produce more biomass for energy and improve biomass conversion procedures. It will then be possible to concentrate the energy component of biomass for economical shipment from rural to urban areas. Facts such as those brought out by Arismunandar and Kadir (1979 and 1980) should be used to provide increased incentive to develop biomass programs. A summary of these facts shows that consumption of firewood and agricultural waste has risen from 34.4 million tonnes in 1967 to 44.7 million tonnes in 1971, to 61.3 million tonnes in 1976. Java, being the most densely inhabited island in Indonesia, with more than 60% of total population, and less than 7% of total land area, consumed most of this firewood; 21.7 million tonnes or 63.0% in 1967, 27.8 million tonnes or 62.1% in 1971, and 37.1 million tonnes or 60.6% in 1976.

Total energy consumption in Indonesia in those years mentioned were

19.8 million TCE (tonnes coal equivalent) in 1967, 26.0 million TCE in 1971, and 41.4 million TCE in 1976, with oil providing 7.4 million TCE in 1967 , or 37.3% of total, 9.6 million TCE in 1971, or 36.7%, and 18.4 million TCE in 1976, or 44.5% of total energy consumption. Other forms of energy, like water power, coal, and natural gas contributed but a comparatively small amount. However, they are expected to increase significantly in the future, especially coal and natural gas.

The programs recommended below to increase the production and use of biomass should result in at least a partial substitution of this form of energy for the kerosene presently used for cooking purposes. The recommended steps, in order of highest priority in the opinion of the writer, are enumerated below.

8.1 Fast Growing Trees

8.1.1 General

A major way of overcoming the fuelwood dilemma is to accelerate the development of fast growing trees throughout Indonesia and especially in Java and the NTT area. There is now a program to distribute seeds for fast growing trees, and it should be supported and accelerated. It should not be restrained while waiting for research results, but should go forward with increased distribution of seeds and seedlings representing two or three of the most promising types of fast growing trees which have been developed in other tropical countries.

At the same time, the present program of research and

development of fast growing trees which are suited especially for the climate and conditions in Indonesia should be encouraged and accelerated.

Some field trials of Leucaena leucacephala have recently been started. One small plantation near the school of forestry in Yogyakarta showed excellent growth under very favorable circumstances. Other plantations on critically eroded soil did not grow nearly as well. This is to be expected but should not cause disappointment. Eroded soils are relatively poor now but with nitrogen fixing legumes should improve with time, resulting in increased growth. Meanwhile, the soils are covered with useful vegetation, lessening erosion and producing fodder and firewood in modest quantities. It should be pointed out that on Java the 4 million hectares of critically eroded soils and 20 million of class four lands not suitable for agricultural production is where opportunity lies for planting fuelwood trees even if their growth will be less than excellent.

8.1.2 Specific Recommendations

8.1.2.1 Species Recommended for Evaluation. In relation to a program of research and development of suitable fast growing trees, the following species are recommended for evaluation:

Acacia auriculiformis

Acacia mangium

Calliandra confusa (callothyrsus)

Casuarina equisitifolia

Gliricidia maculata

Leucanea leucocephala

Sesbania grandiflora

8.1.2.2 Hedge Row System. Parallel to a program of field plot trials (as outlined in 8.1.1 above) there should be a series of tests designed to obtain comparative growth and yield information of species planted in single rows. This type of information should then be expanded into a systematic village program to encourage each small farm or "house garden" owner to plant trees along the edge of his fields or small gardens to become self sufficient in his own fuel needs.

8.1.2.3 Small Energy Farms. A program which should be considered for the islands of Java and the NTT area is establishing two small energy farms at the village level. According to one estimate, a small village with 2000 to 3000 inhabitants would need an energy forest of about 125 ha if planted with fast growing trees such as Calliandra. They would be able to produce firewood within four or five years (Kadir, 1979).

If small forests were managed at the village level, they would not only provide energy, but would also constitute some protection of the soil from erosion caused by years of deforestation. The average rural household, traditionally accustomed to using firewood for cooking, would have no

problems of adaptation to small energy farms, and in this way the use of kerosene for household needs would also be minimized.

The chief advantage of small energy farms is that fuelwood transportation costs would be minimal. Unfortunately, the long waiting time of four to five years necessary to harvest the first crop would require a substantial investment by the owner. The government could possibly assist with low interest loans, however, as an alternative to the substantial funds now being committed to kerosene subsidy.

The Terms of Reference for a proposed Integrated Wood Energy Village are shown in Appendix C.

8.2 Charcoal Production

8.2.1 General

Standard practice which has been used for generations on a worldwide basis for concentrating the energy values in fuelwood and agricultural wastes so that they can be transported and used economically in populated areas is their conversion to charcoal. It is a curious fact that charcoal is used only very slightly in Indonesia for cooking purposes, and its use is not increasing in spite of the need to transport firewood for longer and longer distances. Rather than concentrate on charcoal, the dependence has been placed on increased kerosene usage, which is now becoming a burden to the government, and could become a nearly

intolerable burden to both the government and the low income population if allowed to accelerate into the future.

8.2.2 Specific Recommendations

8.2.2.1 Accelerated Development of Charcoal Production. Accelerated development of charcoal production techniques should be undertaken. The old method of producing charcoal in a pit, with the biomass covered with soil to limit oxygen supply in the process has been replaced in other countries by modern metal charcoal plants (retorts), which can be stationary or transportable. These can be manufactured in Indonesia and used efficiently for both firewood and agricultural wastes.

Development of standard designs for specific feedstocks should be carried out, and demonstration plants using firewood should be built in West Java, Central Java, and East Java.

8.2.2.2 Charcoal Marketing and Distribution System. In nearly all of the larger cities of Java now there is a very loose system of charcoal distribution and marketing. The charcoal is primarily used for ironing and specialty food vendors (satay). There is virtually no distribution system for supply to smaller villages and there are very few large processing centers. If a charcoal energy economy is to be developed, it should first be aimed at the rural villages in central Java and Madura where firewood usage is already denuding the landscape and then be directed to the larger urban areas for replacing kerosene. Such a program will require a rather concentrated and sustained effort by the government to reorganize

and improve the packaging, transportation and marketing system. For this report, it will suffice to focus attention on this problem which must be undertaken. Specific procedures for implementation are obviously of sufficient magnitude to require a detailed study and report in itself.

8.2.2.3 Cooking Appliance Improvement. Stoves for direct combustion of charcoal commonly operate at 10 to 20% efficiency, but some designs are stated to have as high as 35% efficiency of heating energy. Development of more efficient stoves is well underway and should be accelerated, with standard designs developed for each particular biomass feedstock.

8.3 Utilization of Agricultural Wastes and Plantation Wastes

8.3.1 General

The development of a charcoal energy system referred to in 8.2 above will aid substantially in making more use of agricultural wastes which are now burned in the fields or at processing plants. The production of charcoal from wastes at estates should be especially fruitful in making this energy form available to village and urban dwellers. For example, a great deal of fuelwood is available from rubber estates, since rubber trees must be replanted approximately every 25 years, and the old trees make excellent fuel.

8.3.2 Specific Recommendations

8.3.2.1 Establishment of "Charcoal Centers". If residue of plantations and estates is to be utilized effectively and a

program of village utilization is established for charcoal, then an excellent opportunity exists for establishment of charcoal production centers adjacent to or as a part of a typical plantation operation. There are two clearly viable approaches to the establishment of such centers. The first approach and perhaps the most simple to implement is to pattern such a center after the thousands of small rice mills which have been in operation and organizationally assimilated into the Indonesian management system from the colonial era. This approach would require financial loans by the central government, perhaps through the local channels of KUD (Village Co-op).

The second approach could be to convince the local plantation and estate owners that they should establish and manage their own centers, and thereby increase their profit position. This approach would perhaps be very effective with the larger plantations which are generally owned and operated as government enterprises, because the central theme for these government enterprises (as often stated by the Central Government) is to devise ways to improve the living conditions of the people in their area. This program would serve that purpose plus give them an extra commodity for income.

8.4 Utilization of Wood Residue

8.4.1 General

Logging and forest product manufacture create vast amounts of

wood residue that form a potential source of energy. Estimates of logging residue amount to about 50 percent of the standing volume harvested. Sawmill residue runs to 35-40 percent of log volume processed. While total volume harvested varies considerably on the outer islands, it is safe to say that logging and sawmill waste run into many million cubic meters annually.

Energy self-sufficiency of the wood products industry should be a near term goal in Indonesia. Efforts should be made to develop data on conversion units (combustion - steam turbine - electricity or gasification) and promote their acquisition by the wood products industry.

Direct combustion of this waste to produce steam and use of turbine-generators to supply electricity for mills is one of the most common approaches. The energy needs of mills can also be met by using gasifiers. The suitability of these two alternative energy supply systems would largely depend on the relative economics, ease of operation, and comparability with the existing energy supply system, if a new mill is being constructed, then direct combustion systems would probably have an economic advantage over a gasification system. However, in the case of existing mills, the gasification option could offer better compatibility with the existing energy generation system of the mill.

8.4.2 Specific Recommendations

8.4.2.1 Sawmill/Forest Residue Conversion to Charcoal. Sawmill residue in excess of self-sufficiency needs and logging residue could be studied with respect to volume, sizes, concentrating the residue at roadside or mill-site, chipping costs, quality of chips. Continued de-development should be made of the potential of producing charcoal on Kalimantan and other islands for shipment to Java.

8.4.2.2 Portable Charcoal Retorts Development. In Indonesia logging operations require an extraordinary amount of capital equipment and expense to bring out the logs to a transportation site. During the felling operation, many secondary trees are felled or otherwise rendered as waste. This residue is left for two reasons. First, because there is no market and the cost to bring out the waste is the same or slightly more than to bring out the good logs. Secondly, because while there is a fee levied on all felled trees, the government is lax on enforcing the "letter of the law" if the contractors do not bring out the product. Large sums of money are saved by not being forced to pay the fee on trees not used. However, this causes excessive losses of biomass resource.

To help the contractors to make better use of this waste, an aggressive program of portable charcoal kilns should

be initiated. In this manner, the contractors can convert the waste "on the spot", and remove the charcoal to the transportation site without the need for heavy equipment. This would lower the tree removal cost substantially and provide the necessary incentive for contractors' participation.

8.5 Advanced Conversion Technology

The above sections 8.1-8.4 are extensions of present technology and should be strongly emphasized in order to increase the biomass to energy potential in Indonesia. Section 8.5 considers four new technologies which are being developed and which have longer-term implications. These are gasification, pyrolysis, ethanol production, and methane fermentation.

8.5.1 Pyrolysis

8.5.1.1 General. Development of pyrolysis has already occurred in Indonesia. This is especially true in the case of small appropriate technology units, but larger units could be developed.

It is recommended that support of additional improvements in pyrolysis technology be provided, and that commercialization be encouraged through low interest loans or other means.

8.5.1.2 Specific Recommendations for Large Scale Pyrolysis. A quick look at the biomass resource availability in Indonesia would indicate that only wood and wood residue could sustain the operation of large scale pyrolysis plants. Because of the fuel transportation cost limitations, these plants would have

to be located near the wood resources; this would require the plants to be located on the islands of Sumatera and/or Kalimantan. The economic feasibility of large wood-based pyrolysis plants would generally depend on the marketability of pyrolytic oil and char. Based on the results of studies conducted in the U.S.A., it could be safely assumed that the pyrolytic oil, after necessary equipment modifications, could be used in industrial residual fuel oil fired installations. The charcoal could be added to the same distribution and marketing system that should be established for kiln produced charcoal.

The gaseous product of a pyrolysis process has low to intermediate energy content, thus it cannot be economically transported over long distances. The best use of this product would be at the plant site. For example, it could be used to supply the pyrolysis heat and in-plant power to run the equipment.

The final decision on whether to install a rather capital intensive pyrolysis conversion system over a more conventional kiln system would have to be made after a careful economic study of specific site conditions and market trends.

8.5.1.3. Specific Recommendations for Small Scale Pyrolysis. At the ITB Technology Development Center in Bandung, research and development work has primarily focused on developing small rice husk pyrolysis systems for the local rice mills. Two one tonne per day pyrolysis systems have been installed near Bandung. One of these units is installed at an existing rice

mill. The main purpose of the on-going research and development activity is to test the operation of a small rice husk pyrolysis unit and fine appropriate utilization of the pyrolysis products.

Once again, from initial observations of the resource availability and economic calculations, as reported in their most recent report dated October, 1980, it is believed that there is potential application of the program that is underway now at ITB. It is recommended that this program be observed closely.

8.5.2 Gasification

8.5.2.1 General. In Indonesia research and development work is slowly expanding in the biomass gasification area. At the present time an Imbert gas generator and retrofitted diesel engine (25 kW output) is operating at the solar village in Picon. This gasifier diesel-generator set is currently being used to pump irrigation water. A small bench scale (about 3.0 kg/hr) gasifier is presently being tested for different biomass feedstock at ITB in Bandung. At the BPP Teknologi (PUSPIPTEK) plans are currently underway to construct a small charcoal gasifier to produce DC electricity. The capacity of this gasifier-engine generator will be about 5 Kw.

The low calorific (low BTU) value gas produced from an air blown biomass gasifier can be used to operate internal combustion engines, to fire boilers, to generate electricity, as fuel for drying kilns, etc. Since the gasification technology for producing low-calorific value gas is available, in the near term this technology would find application in different Indonesian energy consuming sectors. Application of this technology in

different sectors is given below.

8.5.2.2 Specific Recommendations.

8.5.2.2.1 Forest Products Industry.

The existing sawmill and plywood mills produce a sizable amount of waste wood. This waste wood can be converted to supply the in-plant energy needs of these mills through gasification. For example, with gasification the existing diesel-generators and/or engines can be used to run on a mixture (90% gas and 10% diesel fuel) of gas and diesel fuel or the engines can be retrofitted and run on 100 percent gas. In the latter case the engine will be derated considerably, however, since most of the existing diesel engines are oversized, the derating would not seriously impact the normal mill operation.

The relative economics of these two alternative energy supply options should be evaluated, however, the simple design, quick startup, and minimum attendance requirement of small gas generator plants cannot be denied.

8.5.2.2.2 Electricity Generation.

Consideration should be given to retrofitting the existing small (10 mwe) PLN oil fired electricity generating plants, in Sumatera and Kalimantan. On the island of Java, because of the lack of wood resources and the planned large (400 mwe) coal-fired central stations, small wood-based electricity production plants will not be cost competitive. For the other wood producing areas, however, it should be very cost competitive.

8.5.2.2.3 Agriculture.

Low calorific gas generators are suitable for supplying energy for different agriculture or related operations. For example, agricultural waste (crop residue) can be used to produce a low calorific gas which in turn could power a retrofitted diesel generator to drive either an irrigation pump or a rice mill. In Indonesia, rice husks and rice straw are the most commonly available agricultural residues. The higher ash content (silica) of rice husks does create some operational difficulties for the gas generators, but these difficulties can be overcome by certain design modifications.

All of the following are feasible feedstocks for gasification:

Rice husks	Cocoanut fibre
Paddy stalks	Sugar cane fibre
Ground nut shells	Oil nut fibre
Corn cobs	Peat
Coconut shells	Alang-alang grass (Imperata Spec.)

8.5.2.2.4 Application of Advance Gasification Technologies.

Advance gasification technologies, i.e., high pressure gasification, fluid-bed gasification, oxygen-blown gasification, and catalytic gasification, are being developed in the U.S.A. for the production of synthesis gas (CO/H_2) on a large scale. This synthesis gas in turn could be used in the production of different chemicals and fuels. Methanol is one of the chemical fuels which could be produced via this biomass gasification (oxygen-blown) and subsequent catalytic synthesis route. Since

methanol is one of the liquid fuels which is seriously being considered as a gasoline additive, in the short run, and gasoline substitute in the long run, the need for developing advance biomass gasification technologies cannot be over-emphasized.

In Indonesia there is a great amount of interest in developing an alcohol fuel (both ethanol and methanol) industry. In line with this interest, serious efforts should be made to develop advanced biomass gasification technologies, particularly for gasifying wood and wood residue.

8.5.3 Ethanol Production

As indicated in Section 7, an ethanol production plant of 5,000 kiloliters/year capacity is scheduled for construction in 1981 in a transmigration area located in South Sumatera. Feedstock will consist of sweet potatoes grown by individual farmers on their respective farms.

It is recommended that the alcohol plant in South Sumatera be observed carefully to determine the potential for further development of this program.

8.5.4 Methane Fermentation

While biogas production from animal waste, garbage and refuse, and plant materials has considerable potential, each plant requires substantial capital expenditure when constructed according to present designs. Continued development of this natural process pf producing energy from waste matter and plant materials should be encouraged, with special attention

to low cost designs which require little operation and maintenance.

8.5.5 Dendrothermal Plants

The potential of growing trees for direct combustion to produce electricity is substantial in less densely populated areas outside Java. A pilot scale dendrothermal project is on-going presently in the Philippines, where the climate and biomass production conditions are similar to those in Indonesia. It is recommended that this program be monitored by obtaining permission from the Philippine government to station a technical person on site in the Philippines to obtain data and determine potential for dendrothermal application in Indonesia.

8.5.6 Methanol

Currently, research effort in alcohol fuels production is being shared in Indonesia between ethanol and methanol production. With such a large quantity of wood residues (Section 5.2) available, considerable attention should be directed towards finding means of converting that biomass to methanol, since methanol production technology includes a gasification step most suitable for that type of waste (i.e., wood waste from forest products industry). In contrast to several thousand planned decentralized alcohol production facilities, relatively few larger methanol production plants could be built near the source of wood wastes (i.e., at saw and plywood mills or pulp mills), and be managed for export in the same manner as the finished products of the respective facility, thus keeping additional transportation costs at a minimum.

9.0 EVALUATION

Section 2 describes the biomass resource base in Indonesia. It is seen that on Java the intensive use of land for food production because of high population density has resulted in a large deficit in fuelwood production as compared with demand, while on the outer islands the production and demand are in relative balance. Where there is a shortage of fuelwood, such as on Java, the use of agricultural wastes and the home garden's potential for firewood are important. In fact, data indicate that if home gardens were well managed, they could contribute up to 60% of the fuel demand of a village community.

Section 4 describes the current utilization of biomass. It is seen that, on an equivalent energy basis, firewood and waste contribute about 50% of the energy of the country, with most of the remaining energy coming from oil. The fossil fuel resource is rapidly being depleted, however, while firewood and wastes are renewable resources. It therefore cannot be over-emphasized that all possible efforts must be made to expand the renewable firewood and waste resource base in order to conserve and become increasingly independent of fossil fuels.

Section 3 describes the trends in the extent of the biomass resource base, such as deforestation of heavily populated areas, but on the positive side there is reforestation and the introduction of fast-growing trees. Section 5 describes the potential for future use of biomass, and Section 8 describes specific recommended steps in the increased develpoment of biomass resources for energy.

The significance of emphasizing biomass as an energy source is that because of the climate, rainfall, and fertile conditions of the soil in Indonesia there are great opportunities to grow vast amounts of biomass which can be converted to energy. Programs of accelerated growth of biomass and conversion to energy should be implemented now while there are funds available from sale of fossil fuels, and in preparation for the future years when available fossil fuels will be diminishing in quantity while the population growth and increasing use of energy continues. It is well known that the internal domestic consumption of fossil fuel energy is growing at a rate which is much more rapid than the development of new fossil fuel supplies, and that at the present rate of growth, within nearly a decade, the country would have to begin to import fossil fuels at the extremely high prices which will prevail in the 1990's. It is absolutely necessary that the country use its resources and the technologies of other countries in order to become energy self-sufficient, with much of the energy coming from biomass.

Another important significance of the potential for future use and recommended steps in the development of biomass resources for energy is that the amount of kerosene being used as an energy source is increasing at an alarming rate, and the subsidy provided is already of great economic concern. It is therefore also absolutely necessary to develop more biomass to replace kerosene, so that in the 1990's the use of kerosene as an energy source will be greatly diminished.

The benefits derived by Indonesia from the project Energy Planning For Development are extremely great. The present Five-Year Plan

emphasizes development of industry and technology throughout the country. This development cannot occur without the use of vast amounts of energy. In other words, energy must be available as one of the primary conditions to development. It appears from an examination of the amounts of energy being used that by the end of the present Five-Year Plan the amount of energy available could be the primary deterrent to achieving the goals desired in the area of industrial development. Therefore, energy planning for development is an absolute necessity in order to achieve the goals of the present Five-Year Plan and especially in order to use these goals as the foundation for developing the next Five-Year Plan.

There are several types of energy which can be harnessed for future use and which is renewable. Biomass is one of the major such energy sources, others being hydro power, solar energy, photovoltaic energy, and wind energy. The accelerated use of biomass is by far the program which will provide the largest near-term results at the least cost. It also is a program which can be carried out simultaneously throughout the entire country in small-sized projects at the village level which will benefit not only the villagers individually but also the national government if the government can reduce or eliminate the present energy and cost of subsidizing kerosene use. Biomass energy should therefore be given the highest priority in early implementation programs in order to develop self-sufficiency for Indonesia without the use of fossil fuels.

Further analyses are required in determining more specifically the amount of biomass energy which is required per family or per person

throughout the entire country. Published data on biomass requirements vary by as much as an entire order of magnitude, and therefore one of the highest priority studies, some of which are now on-going, is to develop better current data on biomass use.

Another recommendation for further analysis is to evaluate the improvement of transport between the islands. This is vitally necessary because of a disparity in distribution of population and natural resources such as biomass. Studies should be made and programs implemented to improve the transport systems by both ship and rail, and especially the construction of dock facilities in order to improve the efficiency and decrease the cost of inter-island shipping. Such shipping improvements would improve the shipping of coal, woody biomass products, and food between the islands, allowing an equal distribution in spite of the unequal distribution of population and natural resources at the present time.

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APPENDIX A

LIST OF PERSONS CONTACTED

Prof. A. Arismunandar	Director for Resource Development, DJK
Ir. Tangkas Roesad	DJK
Dr. A. J. Suryadi	DJK
Ir. E. Darianto	DJK
Ir. M. Pandjaitan	DJK
Ir. E. Utomo	DJK
Ir. L. Sumiaroso	DJK
Prof. Herman Johannes	U. Gajah Mada
Prof. Ida Bagus Agra	U. Gajah Mada
Prof. Sri Warnajati	U. Gajah Mada
Prof. Sukoharto	U. Gajah Mada
Dr. Ir. Z. Coto	I.P.B., Bogor
Dr. H. H. Sitompul	I.P.B., Bogor
Dr. K. Abdullah	I.P.B., Bogor
Dr. S. Sumintawikarta	Min. of Agriculture
Ir. H. Soewandi	Min. of Agriculture
Dr. S. Sapiie	ITB, Bandung
Dr. F. Harahap	ITB, Bandung
Dr. S. Sasmojo	ITB, Bandung
Dr. Saswanadi	ITB, Bandung
Mr. Sunariyo Hardjodarsono	Director, LPHH
Dr. W. Hartoyo	LPHH
Dr. O. Sumarwoto	Pajajara University, Bandung
Ir. Noegroho Hadi, HS.	Lemigas
Dr. L. M. Panggabean	BPPT
Ir. Wardiman	BPPT
Ambassador E. Masters	U.S. Embassy
A. W. Trick, Agricultural Counselor	U.S. Embassy
T. Niblock, Chief of Mission	USAID
W. H. Littlewood	USAID
Dr. W. P. Weatherly	USAID
R. Vincent	USAID
K. A. Prussner	USAID
M. J. Korin	USAID
E. M. Barrau	USAID
P. F. Narten	USGS
Dr. J. R. Ege	USGS
D. Fisher	President, ITCI
Dr. John Tatom	Consultant
R. D. Hardy	Consultant

APPENDIX B

DAILY LOG OF MEETINGS AND SCHEDULE OF

DR. ROLF T. SKRINDE

OCTOBER 17 TO NOVEMBER 3, 1980 AND NOVEMBER 21-24, 1980

October 17

Departed from Seattle, Washington, U.S.A.

October 19

Arrived Jakarta, Indonesia - Sari Pacific Hotel

Met at airport by William H. Littlewood of USAID. We had a brief discussion of my assignment on the biomass task, Energy Planning for Development.

October 20

Met Ir. Tangkas Roesad, my counterpart associate in the Energy Resource Development Directorate of DJK. He introduced me to Dr. A. J. Surjadi of DJK. We discussed the organization of DJK. Met Ir. Endro Utomo Notodisuryo of DJK and Secretary Yanti Suyunus. Met Kenneth M. Grover of E/DI (mini-hydro, micro-hydro and geothermal) and his counterpart associate Luluk Sumiarso of DJK.

October 21

Telephone discussion with W. H. Littlewood regarding the project. Met Dr. John W. Tatom, consultant to ITB Bandung (Dr. Filino Harahap) on pyrolysis project, and Ruben Hardy, who is consultant to USAID project with BPPT on use of D.C. electrical current for remote villages not connected to central power grids.

October 22

Meeting with Dr. Paul Weatherly of USAID - Environmental Planning (He made a detailed village survey of fuel wood and kerosene uses in Klaten (Central Java), Lombok, and Luwu (S. Sulawesi) to determine the effects of rural electrification on village cultural and living habits.

Discussed biogas and alcohol projects in Indonesia with Ir. Tangkas.

October 23

Discussed program with Ir. Tangkas. Made plans to visit Bogor and Bandung. Invited to dinner at W. H. Littlewood's house. Met Mr. Tom Niblock, Director of USAID in Indonesia.

October 24

Meeting with Kenneth A. Prussner (USAID Agricultural Advisor). Meeting with Dr. Cool A. Dutto (USAID Rural Development Division). Meeting with Enrique M. Barrau (USAID Agricultural Extension Advisor) and Retno S. Sidarta of USAID Agricultural section. Met with Alan White Trick, Counselor for Agricultural Affairs, U.S. Embassy. Ir. Tangkas and I met with Dr. Antono Arismunandar, DJK Director for Energy Resource Development. We discussed the objectives of the biomass energy policy effort and my schedule taking into consideration my duties on the biomass team which will be associated with BPPT for three weeks in November.

October 25

Ir. Tangkas and I drove to Bogor, held several meetings, and returned the same day. At ITB we met with Dr. Komaruddin Abdullah, Dr. Helen H. Sitompul, and Dr. Ir. Zahrial Coto. At LPHH (Forest Products Research Institute)

we met with Director Sunariyo Hardjodarsono and also the head of the Chemical Processing Division, Mr. Hartoyo Wardi.

October 26

The day was spent in studying reports and preparing notes for use in my final report. I discussed my work in a telephone conversation with Mr. Littlewood.

October 27

Most of the day was spent in studying reports and meeting with Ir. Tangkas. He has arranged for meetings in Bandung on October 28. Met with Dr. Paul Weatherly of USAID to discuss his report on the use of wood and other biomass materials for cooking purposes in villages.

October 28

Ir. Tangkas and I went by train to Bandung. We met with Dr. Filino Harahap, Director of the Development Technology Center of ITB. We also met with Dr. Saswinadi Sasmojo, Vice-Director of DTC, and Dr. John Tatom, who serves as a consultant to Dr. Filino in the pyrolysis of biomass waste materials (rice husks). I later met briefly with Dr. Soedjana Sapiie of ITB and BPPT to make an appointment for the first meeting of the four-member USAID biomass team, which will begin a study regarding the PUSPIPTEK Energy Laboratory on November 4. We returned to Jakarta by car late in the evening.

October 29

Most of the day was spent at our DJK office reviewing reports and discussing biomass energy with Ir. Tangkas. I also visited the office of Mr. Littlewood of USAID and discussed the various energy projects in Indonesia with which

he is associated. In the afternoon I had a meeting with Mr. David Fisher, President of International Timber Corp., which is partly owned by Weyerhaeuser of U.S.A. We discussed the use of timber waste materials for energy purposes. Address: Kartika Plaza Building, Jalan Thamrin 10, First Floor, Tel.: 342206 or 354740.

October 30

Visited Robert Vincent of USAID regarding forestry in Indonesia. Received report from him on forest research carried out at Bogor. Ir. Tangkas and I visited the Ministry of Agriculture Research and Development Agency in Jakarta. The Head of Research and Development is Mr. S. W. Sadikin. We actually met with Ir. Hariwijaya Soewandi of Information Service and Abdul Hammand of Statistical Data.

October 31

Most of the day was spent in review of biomass energy reports. Visited briefly with Mr. Perry F. Narten of U.S. Geological Survey, who suggested that a New Zealand company is interested in using waste biomass materials for purposes such as housing. The company is P. T. Sudagu. The sales executive is Oemar H. Wirasaputra, with an office at Jalan Kali Besar Timur, Tel.: 673303 or 673317.

November 1

I reported to Dr. A. Arismunandar on my progress to date. Later in the day Ir. Tangkas and I met with Ir. Soedjadi Martodiwirjo, Director of Perum Perhutani, and Mr. Sujadi, Chief of the Bureau of Production. Fermentation expert Kurt H. Vause from my company arrived in Jakarta today. We spent several hours discussing the use of biogas and alcohol plants in Indonesia

to provide energy sources. Ir. Tangkas arranged for Mr. Vause and me to meet with faculty of Gajah Mada University in Yogyakarta on November 3.

November 2

Ir. Tangkas, Mr. Vause, and I traveled to Yogyakarta and visited rural areas to understand more fully the relationship between food production and use of biomass materials for food and waste products as energy sources.

November 3

Ir. Tangkas, Mr. Vause and I held meetings with the following faculty members of Gajah Mada University:

Prof. Herman Johannes - Biomass production

Prof. Ida Bagus Agra - Pyrolysis of biomass waste products

Prof. Sri Warnajati - Chemical processing of biomass materials

Prof. Sukoharto - Methane fermentation of animal wastes

We returned to Jakarta in the evening. During our return trip we discussed the assignments that Mr. Vause and I will have during the first part of November, and how we will continue to make progress on the Energy Planning for Development - Biomass Sub-task - during that time.

November 4-21

I participated as coordinator of a Biomass Energy Team consisting of four specialists who were responsible to recommend design concepts and equipment requirements for biomass activities which may be carried out at PUSPIPTEK Laboratories. The four-person team specialized in forestry and biomass production, thermo-chemical conversion of biomass to energy, and fermentation processes for converting biomass to energy. Meetings were held with officials and research and development personnel in the field of biomass

energy at Bandung, Bogor, Surabaya, Kalimantan, and Jakarta. These meetings and the interaction with other members of the Biomass Energy Team were helpful in gaining additional knowledge relating to the Biomass Sub-task in the program of Energy Planning for Development. Mr. Kurt H. Vause was helpful especially in providing assistance to me for several days after completing his assignment as a member of the Biomass Energy Team.

November 22-24

Analysis of documents and notes taken during previous five weeks of meetings were completed in preparation for preparing recommendations for the Biomass Sub-task report.

November 25

Ir. Tangkas and I met with Ir. Neogroho Hadi, HS., who is responsible for the biogas program at LEMIGAS. A good discussion was held of the biogas projects which have been completed thus far on a pilot scale, using both animal waste and garbage and solid wastes as feedstocks. One demonstration project each is presently planned for Cepu, Bali, and East Java. These projects are funded by DJK.

APPENDIX C

TERMS OF REFERENCE

INTEGRATED WOOD ENERGY VILLAGE FOR TRANSMIGRATION

OBJECTIVE

An integrated energy village using wood from fast growing trees as the biomass resource base for the primary purpose of producing power for use in a transmigration area is planned. The power produced would be used to improve the life of the people in the transmigration area, provide lighting, operate low energy consuming appliances such as refrigerators and TV sets, and for commercial activities which may be undertaken in the area. Activities which consume large amounts of energy, such as cooking of food, will also be supplied by the integrated wood energy village. In this case the wood used will be grown on the wood plantation, but rather than conversion to electricity it will be used most efficiently if burned directly or converted to charcoal or other materials prior to use as a cooking fuel.

Power production from the integrated wood energy village will serve as a demonstration of the use of the vast biomass potential available near transmigration areas for energy purposes. So-called dendrothermal plants are already in use in some countries where the biomass availability is less than in Indonesia, such as in the United States, and other projects are being started in the Philippines.

To summarize, the objective of the integrated wood energy village is to provide power and energy required for a transmigration area, thereby

improving the quality of life of the people and making them totally self-sufficient in energy. The goal in commercialization would be to manufacture the dendrothermal plants and other conversion units such as pelletizing plants and charcoal kilns in Indonesia, thus adding jobs and enhancing development.

SCOPE

It is estimated that a transmigration area will contain 4,000 families, or a total population of about 25,000. During the feasibility study the following two concepts should be investigated. One would be to locate the wood village in a central area, surrounded by the transmigration farms. This would allow the shortest and most equitable distances from the wood growing area to the individual farms for electric power lines and the transport of cooking fuels. The other concept would be to have the wood growing village located adjacent to the transmigration area. For a transmigration area of 4,000 families or 8,000 Ha, it is estimated that approximately 2,000 Ha of wood village would be required, but this number should be analyzed more carefully during the feasibility study.

The estimated 2,000 Ha of land near the transmigration area would be initially a forested area, and therefore the production of power using these forests could occur as soon as the power plant were constructed. Additionally, some of the biomass removed in clearing the land for farming by the transmigration farmers could be used as feedstock to the dendrothermal plant.

The scope of the project would consist of initial site preparation, construction of the electric power plant, and development of the power supply grid of electric lines to the homes of the transmigration families. In

order to conserve electricity so that it is not used for such high energy consuming activities as cooking, the next step in the scope of work will be to provide sufficient cooking fuel to serve the transmigration area. After the first area of plantation has been used for the dendrothermal plant and for cooking fuels, then the planting of fast growing trees will occur on a continuous basis, so that a constant supply of trees will be growing and thus provide energy indefinitely to the transmigration area.

The cooking fuels used in the homes of the transmigration area will consist of firewood which can be burned directly, for those people who are located close to the wood energy forest. For those who live several km away there may be interest in converting the firewood to higher energy forms for ease and economy of shipment. For this reason, a program will be undertaken to convert some firewood into charcoal, and to pelletize firewood and residues. Other biomass conversion processes which would be economical on the scale of serving a transmigration area may be utilized as the technology develops throughout Indonesia.

PROGRAM SCHEDULE

The program is expected to have a duration of six years. This time period is divided as follows:

1. Year 1 - Feasibility study, selection of site, site preparation for initial planting of fast growing trees
2. Year 2 - Continuation of site preparation and planting of trees. Beginning of design of dendrothermal power plant.
3. Year 3 - Maintenance of tree farm, beginning construction of dendrothermal power plant, construction of pelletizing plant, and charcoal kiln.
4. Year 4 - Construction of dendrothermal plant for electric power generation, continuation of tree farm maintenance.

5. Year 5 - Installation of distribution lines, completion of dendrothermal power plant.

6. Year 6 - Beginning of operation of dendrothermal power plant. Operation of other facilities for firewood conversion, such as pelletizing and charcoal kilns.

EVALUATIONS TO BE MADE

As the program progresses, and especially after initial results are obtained sufficient for establishment of equilibrium conditions, evaluations will be made to determine the potential of large scale commercialization of the concept of integrated wood energy villages. These evaluations will include the following:

1. Technical feasibility - Technical feasibility evaluations will relate to the best type of fast growing trees, technical aspects of their conversion to electric power in dendrothermal plants, and conversion to such fuelwood sources as charcoal and wood pellets.

2. Socio-economic evaluations - Analyses will be made of the social acceptance of the integrated wood energy village concept. Special attention will be given to the potential for providing power for sale to outlying areas away from the transmigration area, and thereby bringing in a source of revenue to the transmigration people. Cost/benefit evaluations will be made as to the economics of providing energy using the integrated wood energy village concept for both the transmigration area inhabitants and for potentially other customers for the energy who live near the area.

3. Energy input/output - Evaluations will be made of the total energy budget in providing energy self-sufficiency to the transmigration area through the integrated wood energy village concept. This includes

analyses of energy inputs and outputs, as well as energy modelling to develop predicative models for improving the later commercialization of this energy system.