

# Biomass Energy Potentials And Utilization In Indonesia

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## ABSTRACT

*It is estimated that Indonesia produces 146.7 million tons of biomass per year, equivalent to about 470 GJ/y. The source of biomass energy is scattered all over the country, but the big potential in concentrated scale can be found in the Island of Kalimantan, Sumatera, Irian Jaya and Sulawesi. Recently, the Indonesian government had issued several policies which put higher priority on the utilization of renewable energy. For example, renewable energy is being prioritized as the sole source of energy for the newly launched program called the distributed Small Power System, in which small power producers can generate electricity up to one MW and interconnected to the medium and low voltage national grid, and to be purchased by the national utility company (the PLN) at some percentages of the locally determined basic sales price.*

**Key words:** *Small power producer, Distributed power system, Green energy insight*

## 1. INTRODUCTION

The rapid depletion of our oil reserve, with R/P (Reserve/ Production) of 18 years will force Indonesia to find alternative energy supply to sustain economic development (Dasuki, 2000). In the future Indonesia's energy consumption is expected to increase along with economic recovery sometimes in 2003. The Directorate General of Electricity and Energy Utilization (DGEEU) (Maryam Ayuni, 2000), has estimated that the total energy consumption, excluding biomass energy, will increase from 376.22 MBOE (million Barrel of Oil Equivalent) to 474.36 MBOE in 2003 or an increment of 26%. The highest energy demand is expected to come from the transportation sector while the household sector will remain at the third place.

Rural development in the developing country such as Indonesia should be directed to provide access to basic energy services to produce the basic human needs for food, shelter and clothing. In addition, economic recovery for Indonesia should begin from rural development, where renewable energy sources are already existing to help SMEs, in processing the potential natural resources in the area. In this respect renewable energy, such as solar, wind, micro-hydro and biomass, is usually available in the rural area and hence, by transforming and converting these sources of energy to power various processing machines, added value of agricultural and marine products can be made. This in turn will provide more job opportunity to the people in the rural area and ultimately lead to gradual improvement in the quality of their life.

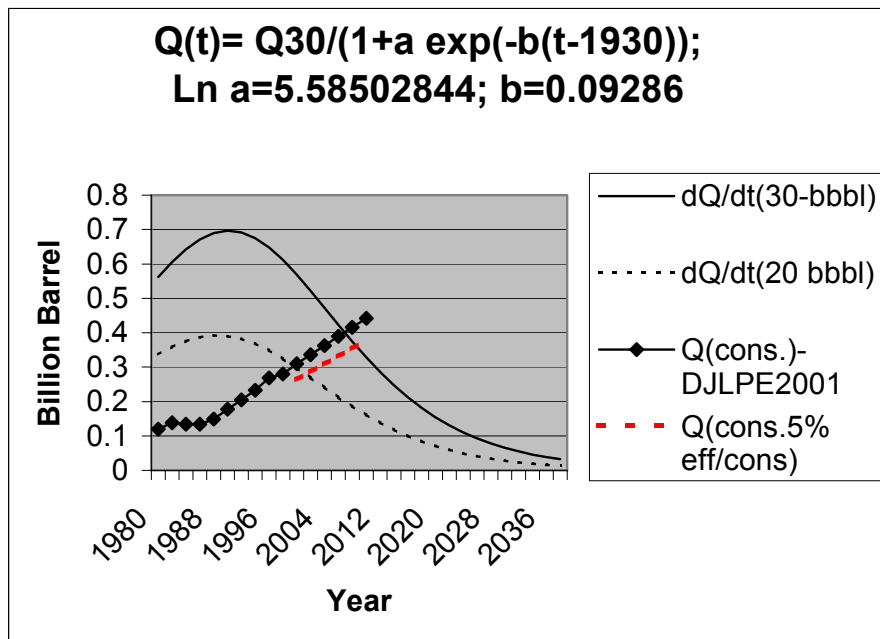
Biomass resources can be transformed into different kind of foods and energy. Solid biomass is commonly used as fuel for cooking and other thermal processes in small and medium industries, as fuel for boilers, but can also be transformed into gaseous and liquid fuel such as in the form of ethanol and bio-diesel. The rapid depletion of fossil fuel in Indonesia, has increase R/D efforts and activities related to biomass conversion technology. The Energy Minister had created a special task force, in 2001 in order to study any tangible results and breakthroughs of these efforts and recommend any required regulatory policy and incentives to promote renewable energy in the country.

This paper will describe some of the results of these efforts and potential markets for biomass energy application in Indonesia

## 2. RENEWABLE ENERGY DEVELOPMENT IN INDONESIA

Shown in Fig.1 is the projection of energy supply and demand as predicted using the Hubbert curve (1983) and consumption data from the DGEEU (2001). According to this figure, Indonesia will become net oil importing country within the next 10-20 years if the energy demand will follow past trends even when conservation program is implemented and drastic improvement in energy efficiency could be achieved. Despite of the high renewable energy potential in Indonesia as shown in Table 1, only a small amount had been utilized effectively to help in reducing pressure on the depleting oil resources. In relation to the coming era of energy crisis, Indonesia has to accelerate the use renewable energy sources, particularly biomass and geothermal energy which have a significant impact due to bigger power generation capacity per unit while gas and coal have been exported to earn important sources of foreign exchange beside oil. In addition, the promotion of renewable energy utilization can trigger rural industrialization in the form of SMEs and cooperatives to help in increasing added value of natural resources in various regions of the country, create more employment opportunity, and ultimately improve the overall quality of life of the people living in the rural areas.

Recently, to accelerate the utilization of renewable energy in Indonesia, the DGEEU, had issued a draft of new energy policy in order to promote further the development of renewable energy sources, improve energy efficiency and GHG abatement last June 2002 and is called the green energy insight. In addition, Ministerial Decree No.1122 K/30/MEM/2002 on Distributed Small Power Generation (PSK Tersebar), has come into effect starting June 12 2002. This decree will provide opportunity for small power producers such as the cooperative to generate electricity up to 1 MW from renewable energy and interconnected to the medium and low tension grid and will be purchased by PLN at 80% and 60%, respectively at the medium and low tension interconnection. The formulation of government regulation for the medium and higher power generation capacity from renewable energy is now underway.



**Figure 1: Indonesian oil reserve and consumption trend.**

The curve also shows the effect of 5% improvement in efficiency, conservation and diversification program on oil reserve.

**Table 1: RE Potential and installed capacity in Indonesia.**

RE Source	Installed Capacity*) MWe	Potential (MWe)	% Utilization
Geothermal	589	19650	3.00
Micro-hydro	21	458.75	4.58
Solar/PV	5	156487	3.20E-03
Wind	0.5	9286	5.38E-03
Biomass	178	49807	0.36
Biogas	10	684.83	1.46
<b>Total</b>	<b>803.5</b>	<b>236373.58</b>	<b>0.34</b>

Source: RIPEBAT, DGEEU 1997.ACE,2002.

Note:

1. Operating time is 24 hrs/d for biomass, biogas, geothermal and micro-hydro, 8 hrs/d for solar PV & wind
2. Total land area for wind power generation per unit is 250 x 250 m<sup>2</sup>.
3. Total potential area for solar power generation = total area of Indonesia : 2 million km<sup>2</sup>.
4. Total geothermal potentials was based on the sum of proven reserves, expected and speculative possible and hypothetical reserves
5. The Wind energy potential as well as installed capacity was based of generation capacity > 20 kVA (15 kW)

### **3. BIOMASS ENERGY POTENTIAL IN INDONESIA**

It is estimated that Indonesia produces 146.7 million tons of biomass per year, equivalent to about 470 GJ/y. As shown in Table 2, the main source of biomass energy in Indonesia can be obtained from rice residues which give the largest technical energy potential of 150 GJ/year, rubber wood with 120 GJ/year, sugar residues with 78 GJ/year, palm oil residues, 67 GJ/year, and the rest with smaller than 20 GJ/year are from plywood and veneer residues, logging residues, sawn timber residues, coconut residues, and agricultural wastes (ZREU,2000). These sources of biomass can help in supplying both heat and electricity for rural house hold and industries.

### **4. BIOMASS ENERGY CONVERSION AND UTILIZATION**

Fire wood, for example, is still the main source of energy for cooking in most of the developing countries. Table 2 gives example on the demand of fuel wood in some developing countries as compared to the use of fossil fuel in some developed countries. In Indonesia, for example, beside kerosene and gas most rural household and to some extent some of the urban households are still using fire wood or agricultural wastes for cooking. In Indonesia the energy consumption for cooking in the rural household is estimated at 0.88 m<sup>3</sup> of fuel wood /head/year or equivalent to about 17.7 MJ/person/day. (Kamaruddin, 1988). Stove efficiency used for cooking is still low from the traditional three stone with 5% efficiency to a refined wood stove such as the two pot un-insulated metal wood stove with efficiency of 27.9% (Baldwin, 1987).

**Table 2: Major Biomass Residues Potential as Energy Sources.**

<b>Biomass</b>	<b>Main region</b>	<b>Production [million t/year]</b>	<b>Technical energy potential [million GJ/year]</b>	<b>Remarks</b>
Rubber wood	Sumatera, Kalimantan, Java	41 (replanting)	120	small logs $\varnothing < 10$ cm big and medium logs are used as fire wood in brick and roof tile industry: price 20,000 – 30,000 IDR/m <sup>3</sup>
Logging residues	Sumatera, Kalimantan	4.5	19	
Sawn timber residues	Sumatera, Kalimantan	1.3	13	Residues of the factories are often used as fire wood by local communities, residues available for free
Plywood and veneer production residues	Kalimantan, Sumatera, Java, Irian Jaya, Maluku	1.5	16	Residues are generally used, yet
Sugar residues	Java, Sumatera, South Kalimantan	Bagasse: 10 cane tops: 4 cane leaves: 9.6	78	Bagasse is generally used in sugar factories (90 %) The use of cane tops and leaves needs to be investigated
Rice residues	Java, Sumatera, Sulawesi, Kalimantan, Bali/Nusa Tenggara	Husk: 12 bran 2.5 stalk: 2 straw: 49	150	Stalk and straw are generated at the field and generally burnt, in some areas used for feeding or raw material for paper industry Husks often burnt uncontrolled
Coconut residues	Sumatera, Java, Sulawesi	Shell: 0.4 husk: 0.7	7	Residues are generated decentralised and usually left on the plantation field Largely used as fire wood and for the production of charcoal
Palm oil residues	Sumatera new areas: Kalimantan, Sulawesi, Maluku, Nusa Tenggara, Irian Jaya	Empty fruit bunches: 3.4 Fibres: 3.6 palm shells: 1.2	67	Palm shells and fibres are common fuel sources, EFB are generally incinerated

Source: ZREU, CGI 2000.

A simple stoves can be made using used oil barrel with saw dust as fuel. Such stove has about 16% thermal efficiency, can be as cooking stove as main or auxiliary heating component for process heat in small processing unit (Kamaruddin, 2000) and in various agro-based industries. Such technology is also being used to dry sawn coconut wood in wooden house industry in Manado, North Sulawesi

**Table 3: Power consumption for cooking.**

Country	Fuel	W/cap
Brazil	LPG	55
Brazil	Wood	435
Canada	Gas	70
Cameroon	Wood	435
France	Gas	55
West Germany	Gas	30
Guatemala	Propane	50
Guatemala	Wood	425
India	Kerosene	50
India	Wood	260
Italy	Gas	55
Japan	Gas	25
Sweden	Gas/kerosene	40
Tanzania	Wood	590
USA	Gas	90

Source: Prasad 1982, Williams, 1985

**Table 4: Fuel wood consumption in Kenya by large industry.**

Industry	W/cap
Tea (average)	8.9
Tobacco	2.5
Sugar	1.6
Wood Processing	9.5
Wattle	1.3
Clay, Brick	1.0
Baking	9.5
Total	34.3

Source: O'Keefe, et al, 1984

Biomass energy can be also converted to produce electricity and mechanical energy, which are necessary to support our daily activities at home, office or industries. For example, as shown in Table 5, a saw mill with 1000 – 3000 m<sup>3</sup>/y capacity can produce 40- 100kWe using CHP (combined heat and power) technology, while a sugar mill with 1000- 4000 TCD (total cane/day) can produce 3-10 MWe. Boilers working with a pressure up to 15 bar are mostly used to generate process steam e.g. for cane cooking in the sugar industry and to produce mechanical energy utilising steam engines. These types of boilers represent around 66 % of the total boilers installed at sugar mills. Boilers operating above 15 bar are mostly combined with large steam turbines for electricity generation. Despite of the huge potential of biomass energy in Indonesia its utilization in Indonesia is limited to large sugar and palm oil plantation.

From the 15 applicants for demonstration project for renewable energy six proposals had been preliminary selected by the task force team for further study on their feasibility either for commercial use or for community development program. The selected proposals for commercialization purposes comprise of three power generations using rice hull and oil palm wastes, one micro-hydro power generations and one proposal in the form of PV modules for solar home system. One selected proposal was aimed for community development by integrating solar, biomass and wind energy to power small scale processing unit of various agricultural and marine products in the rural areas. The power generation using rice hull gasifier to Riau province was proposed by BPPT and local industry and is capable to produce 18 kW electricity from a 25 KAV unit and sold at Rp. Rp406.45/kWh (or about US\$ 0.051/kWh). The quoted tariff is a little higher than the targeted purchasing price of PLN under the newly enacted Small Distributed Power Generation program (improvement of the old PSKSKSM) by the Ministry of Energy and Mineral Resources. Since the production cost of the proposed unit is still higher than the basic selling price (HPP) of electricity from the national grid, the government are requested to make further improvement in import duty and taxation scheme of some important components of the unit

Technically, however, a gasifier with capacity up to 100 kVA while co-generation systems as shown in Table 5 is capable to produce much higher capacity in order to reduce the production cost. The proposed projects were meant to help in supplying electricity to the remote community, however, many commercial biomass power generations are already being used in sugar and palm oil plantations.

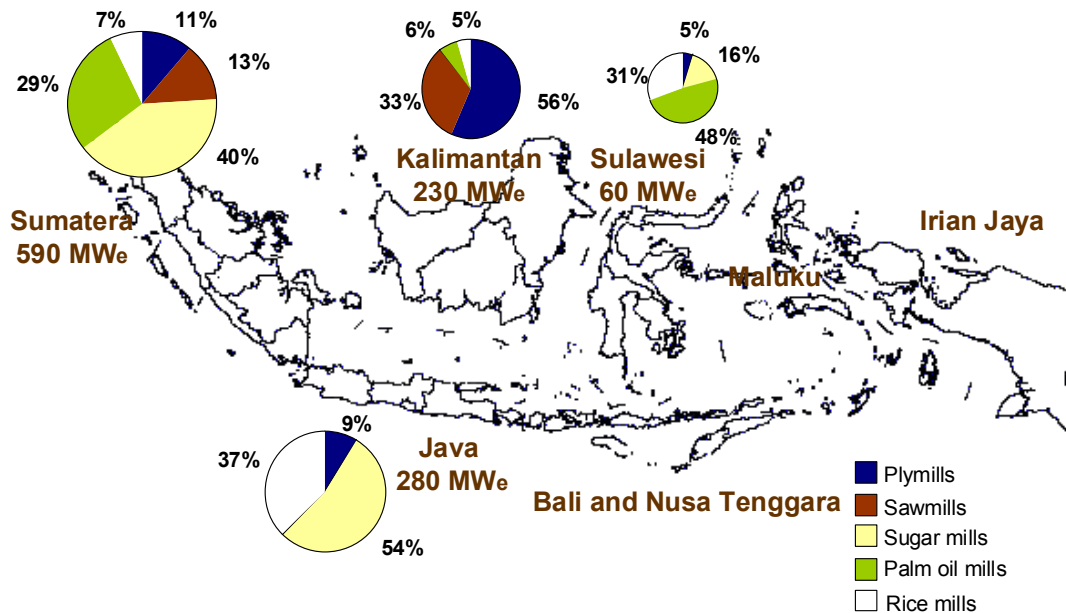
**Table 5: Potential for biomass technologies in rural industry.**

	Mill size	Capacity of CHP technology	Biomass potential for power generation
1. Saw mills	1000-3000 m <sup>3</sup> /y	40-100 kWe	0.6 m <sup>3</sup> wood waste/m <sup>3</sup> sawn timber ~ 130 kWh/m <sup>3</sup> sawn timber
2. Ply wood mills	40 000-120 000 m <sup>3</sup> /y	1.5 – 3 MWe	0.8 m <sup>3</sup> wood waste/m <sup>3</sup> plywood ~ 200kWh/m <sup>3</sup> plywood
3. Sugar mills	1000- 4000 TCD	3-10 MWe	0.3 t bagasse/t sugarcane ~ 100 kWh/t sugar cane
4. Rice mills	< 0.7 t/h >0.7 t/h	30-70 kWe 100-300 kWe	280 kg husk/t paddy ~ 120 kWh/t paddy
5. Palm oil mills	20- 60 t FFB/h	2-6 MWe	0.2 t EFB/t FFB 0.2 t fibre/t FFB 70 kg shells/t FFB ~160 kWh/t FFB

Note: TCD= tones of Cane per day; FFB= Full Fruit Bunches; EFB= Empty Fruit Bunches.

Source: ZREU (2000)

Fig. 2 below shows market potential for power generation and process heat using biomass energy (ZREU, 2000)



**Figure 2: Potential market for biomass power generation (ZREU, 2000)**

The proposal for community development was proposed by CREATA-LP-IPB, and was aimed to supply energy for Small Agro-processing Unit to process various high value crops such as coffee, cocoa, cloves, timber, food crops such rough rice, maize, fruits and vegetable as well as marine products. In this proposal simple biomass stove is used as auxiliary heating unit to enable the unit to operate continuously day and night and during bad weather conditions. Although the project was found very potential to

generate income for the rural people, however, this project has faced difficulties in accessing micro-credits for working capital beside of the fact, the government has already creating source of funds to create micro-credits collected from the state owned company, oil subsidy, etc.

In addition to what had been discussed above, serious R/D efforts on biomass energy utilization in fact had been going on in Indonesia since long time ago. Ethanol production from cassava starch was started in 1987 in Lampung with production capacity of 8,000 liters/day and 12,000 liters/day. Other attempts using other source of biomass such as sago starch which also found in abundance in Indonesia, however, including the ethanol factory, have been terminated due to inability to compete with the subsidized fuel price.

Recently, R/D activities for ethanol production is beginning to take place. The Research Center on Materials and Energy of ITB, Bandung, estimated that the gasoline demand in 2005 would reach 9 million kilo liters. The Center study had estimated that in order to meet the demand, 136 units bio-ethanol plant with 5,000 kilo liters/year will become necessary, which consequently will reduce the yearly greenhouse gas emission by 3.35 million tons of CO<sub>2</sub>.

Indonesia is one of the world producer of palm oil together with Malaysia. In order to make use of this potential resource as another fuel alternative, a group for bio-diesel experts has also been formed within the task force team of the Ministry of Energy and Mineral Resources as mentioned previously. At present the cost of production is still high and one alternative is to blend it with automotive diesel oil (ADO) or industrial diesel oil (IDO). The merit of using bio-diesel is that when burned the exhaust gas emitted 78% less carbon dioxide (CO<sub>2</sub>) than conventional diesel fuel. Bio-diesel also reduces small lung-burning particulates endemic to diesel exhaust by 68%. It reduces sulfur dioxide (SO<sub>2</sub>) by 100%, polycyclic aromatic hydrocarbons (potential cancer causing compounds) by 75%, carbon monoxide (CO) by 50%, and hydrocarbons (HC) by 37% over various engine families

In response to the increasing need for oil substitute, particularly for the transportation sector which consumes the biggest amount of energy in the country, recently the government of Indonesia had the Agency for Assessment and Application of Technology (BPPT) to build a mini bio-diesel plant with bio-diesel production capacity of 1000 tons/year. The detailed engineering design is underway and will be ready by May 2002. Total investment for the proposed plant is estimated to cost about 200,000 USD. (Budiono, 2002).

Other potential source of biomass energy can also come from organic municipal wastes. The quantity of city or municipal wastes in Indonesia as shown in Table 6 is comparable with other big cities of the world. A study by the Ministry of Public works (1999) indicated that the quantity of daily wastes produced by each inhabitants of Indonesian metropolitan cities varied between 0.458 in Semarang with total population of 1.262 million people to 3.5 kg wastes /(inhabitant.day) for Jakarta with total population of about 8.9 million. As shown in Fig.3 and 4 and Table 6 most of these wastes are originated from household in the form of organic wastes from the kitchen. Similar trend is also happened in small, medium size and big cities of Indonesia (Fig.3). As shown in Fig.5, the amount of daily wastes production is increasing each year, while the capacity of handling is almost unchanged resulting in increasing accumulation of wastes remaining in the household sector. If the problem can be solved immediately, the living environment in the cities may become unbearable.

At present the wastes are either burned at each household or collected by the municipalities and later to be dumped into a designated dumping ground or landfill. Although the government is providing facilities to collect and clean all these wastes, however, due to the increasing number of populations coupled with inadequate number of waste treatment facilities in addition to inadequate amount of allocated budget for waste management, most of big cities in Indonesia had been suffering from the increasing problem of waste disposals.

Some efforts had been tried to transform organic wastes into composts, which later can be used as fertilizer. Putting the wastes into the incinerators may cause pollution since some of the composition may

emit toxins during the combustion processes. With better design, preparation and management of the final dumping ground, landfill gas can be produced and used effectively as alternative energy sources.

**Table 6: Comparison of waste generation per inhabitant for some cities of the world.**

Cities	Kg waste /inhab.day
Sao Paulo*	0.96
Washington*	3.414
Bangkok*	0.88
Quito*	0.77
Abidjan*	0.5478
Indonesian cities**:	
1.Medan	0.5
2.Palembang	0.69
3.Jakarta (avg.)	1 to 3.5
4. Bandung	0.967
5. Semarang	0.458
6. Surabaya	0.82
7. Ujung Pandang	0.898

\*) WRI, 1996

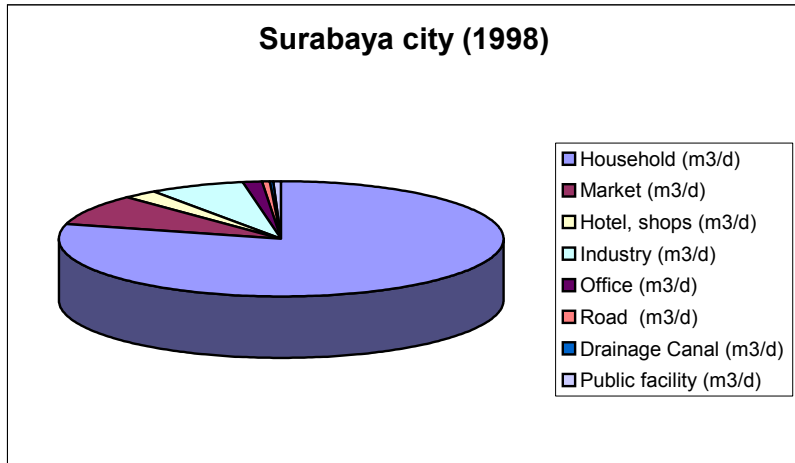
\*\*) Ministry of Public Works of Indonesia, 1999.

**Table 7: Composition of garbage in Metropolitan cities (in percentage)**

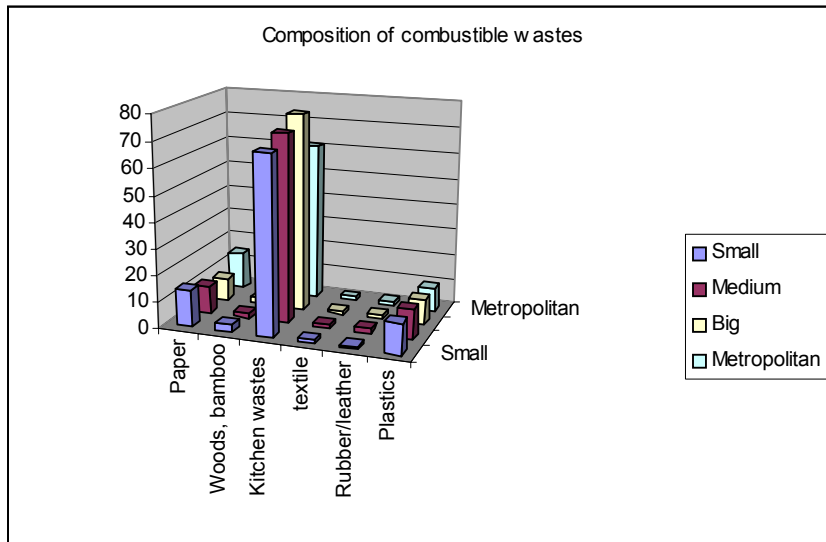
Composition	Medan	Palembang	Bandung	Semarang	Surabaya	Jakarta	U.Pandang
Papers	17.5	18.8	10.4	12.28	12.45	10.11	14.15
Wood/bamboo	0	-	0	25.74	-	3.12	1.15
Kitchen wastes	48.2	75.2	63.6	34.12	71.85	65.05	65.84
textile	0	0.3	1.8	1.56	1.94	2.45	1.22
Rubber/leather	2.3	0.5	4.1	1.08	0.54	0.55	0.36
Plastics	13.5	3.3	5.6	13.5	7.6	11.08	6.19
Metal	3.5	0.8	0.9	1.82	0.9	1.9	1.89
Sand, ceramic, dusts	-	-	-	0.49	-	-	1.28
Glass	2.3	0.4	1.5	1.74	0.9	1.63	2.33
Others	12.7	0.6	12.1	7.64	3.82	4.11	5.6

Source: Ministry of Public Works of Indonesia, 1999.





**Figure 3: Origin of wastes in Surabaya city**



**Figure 4:Composition of wastes in small, medium, big and metropolitan cities of Indonesia**

which later can be further transformed to produce

- Process heat
- Electricity
- Fertilizer

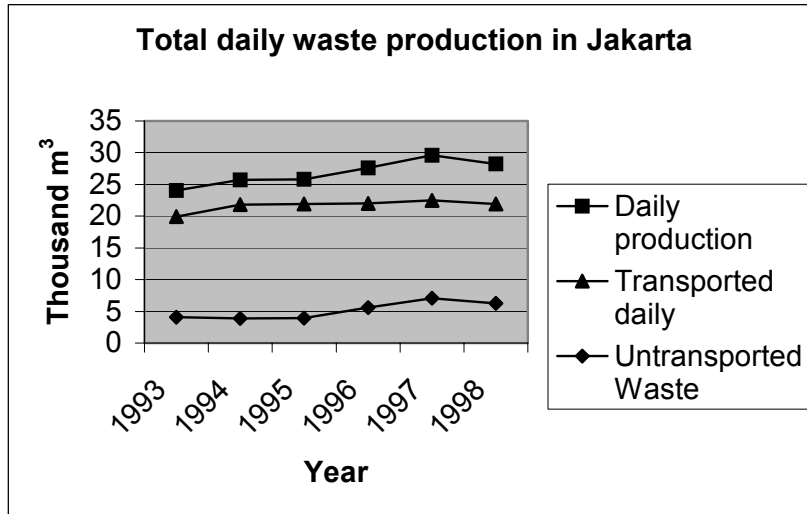
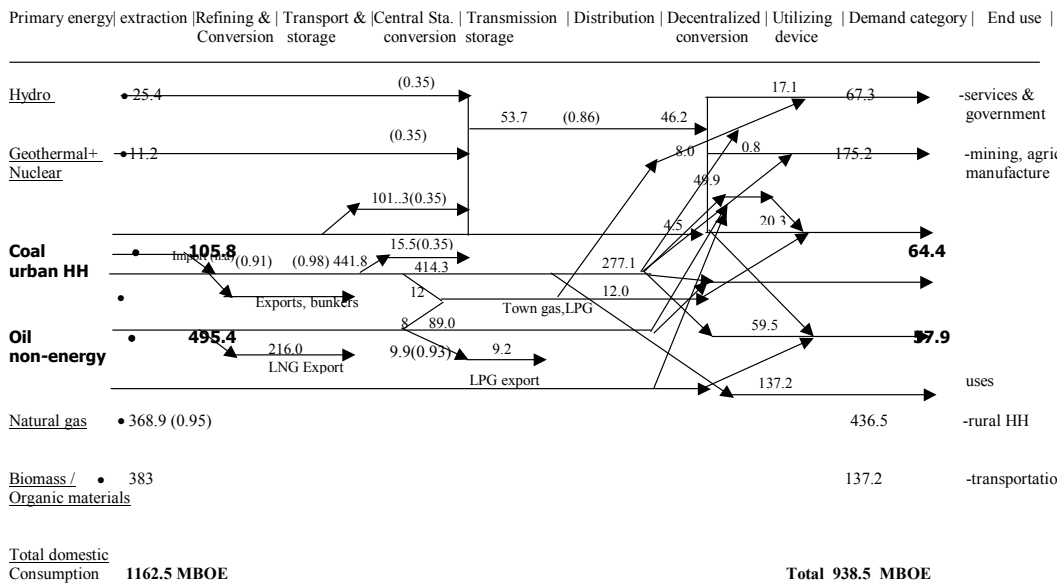


Figure 4: Total daily waste production from the city of Jakarta (Wakabayashi, 2001)

### 5. SUPPLY-DEMAND ANALYSIS

Fig.5 shows a result of how different primary energy sources are being utilized to meet the demand from different end uses (DGEEU, 1981). It shows also possible cross substitution among energy sources as well as the respective efficiencies through different pathways and conversion devices. Such picture of energy utilization will change according to the change in economic growth of a country. Therefore, by issuing such picture on regular basis, one can determine the optimum strategy to determine the best energy mix for the country, particularly in increasing the role of renewable energy such as the biomass energy.

Figure 5. Energy Balance- Indonesia (MTOE)  
Year 2000-Low growth scenario of 5.5%/annum



## 6. CONCLUSIONS

1. Indonesia's potential biomass is estimated to reach 46.7 million tons of biomass per year, equivalent to about 470 GJ/y.
2. Biomass use covers a wide area from household cooking, rural electrification, fertilizer (municipal wastes, composting, etc.), process heat in small industries in the rural area and fuel for cogen facilities in oil palm and sugar plantation.
3. New government policy and regulation on "green energy insight" and being implemented in the form of distributed power generation program may provide a greater opportunity for biomass energy to play role in helping the utility to provide power for the country.

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