

# Availability and Potential of Biomass Resources from the Malaysian Palm Oil Industry for Generating Renewable Energy\*\*

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## ABSTRACT

Malaysia in 2006 produced 15.88 million tonnes of crude palm oil and 1.95 million tonnes of palm kernel oil. In the process of extracting these oils, a voluminous amount of biomass is simultaneously produced from the mills and also from the field. The biomass from the mills include empty fruit bunches, mesocarp fibre, palm kernel shell and liquid effluent. In the estates, fronds are regularly trimmed, while during felling for replanting the whole oil palm tree including trunk and fronds are available. These various forms of biomass have high calorific value and characteristics which make them amiable as commercial solid fuels. These biomass are also potential feedstocks for production of alternative liquid or gaseous form of renewable energy such as bioethanol, biooils and producer gas. Their abundance and availability throughout the year, mostly in partially treated form make them even more attractive as resources for renewable energy.

## ABSTRAK

Malaysia menghasilkan 15.88 juta tan minyak sawit mentah dan 1.95 juta tan minyak isirung mentah pada tahun 2006. Selain itu, industri sawit negara turut menghasilkan biojisim sawit sama ada dari kilang pemprosesan atau aktiviti perladangan. Biojisim sawit dari aktiviti pengilangan seperti tandan buah kosong, gentian mesokarpa, tempurung isirung dan efluen. Di ladang, pelepah dipangkas selalu manakala pelepah dan batang didapati semasa proses penanaman. Kesemua biojisim sawit ini mempunyai kandungan kalori yang tinggi dan berpotensi untuk dijadikan bahan api komersial. Biojisim juga berpotensi sebagai bahan mentah dalam penghasilan sumber bahan api

yang boleh diperbaharui seperti bioetanol, biogas dan biominyak. Dengan kapasiti yang besar serta separa terawat, biojisim sawit merupakan alternatif bagi sumber tenaga yang diperbaharui.

**Keywords:** biomass characteristics, biomass resources, palm oil.

## INTRODUCTION

In 2006, Malaysia produced 15.88 million tonnes and 1.95 million tonnes of crude palm oil and palm kernel oil, respectively. Both oils contributed 12% to the world production of 17 major oils and fats while making up 22.8% of the world exports of oil and fats, thereby providing a source of food, oleochemicals and energy to the world.

However, even as a major palm oil producer, oil palm only takes up 4.2 million hectares of land in Malaysia, making it one of the most productive oil yielding plants at 4.4 oil (*i.e.* 3.93 t crude palm oil and 0.5 t palm kernel oil) ha<sup>-1</sup> yr<sup>-1</sup>. This is possible as Malaysia is blessed with good soils, sunshine and rain throughout the year and, moreover, oil palm is a perennial crop bearing fruits throughout the year.

While the oils have been providing food energy, with currently more than 80% of them being used for edible purposes, the industry is also generating large volumes of biomass which has the potential to be used for renewable energy.

Palm oil, as it is, has a relatively high calorific value, and is a good fuel but its chemical transformation to biofuel (methyl ester) is preferred due to its established utilization as fuel in the transportation sector. However, this article will only discuss the lignocellulosic biomass which can be used as solid fuel for renewable energy production.

This biomass has further advantages as fuel being readily available in the mills and field in various partially treated forms.

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## SOURCES, TYPES AND QUANTITY

### From Palm Oil Mill

The extraction of crude palm oil and kernel from fresh fruit bunches is carried out in palm oil mills. For every tonne of fresh fruit bunch processed, substantial amounts of mesocarp fibre, kernel shell, empty fruit bunches and liquid palm oil mill effluent are simultaneously produced (Table 1). The biomass have high moisture content. Their characteristics as fuel with comparison to coal used in a Malaysian power station are shown in Tables 2 and 3. While in certain aspects palm biomass may not be as good as coal, it does not mean that it is an inferior solid fuel as its different properties may in fact complement its combustibility (Larry, 2003).

The fibre and shell are conventionally burnt to co-generate steam and power for the millers' own use. However, in mills with more efficient boilers there would be excess shell which is commonly sold as solid fuel. The empty bunches are usually not burnt, being surplus to the requirements, and are commonly returned to the fields as mulch. However, with the increasing demand for renewable energy, even this biomass is facing increasing demand and is being processed into solid fuel.

The total biomass produced in 2005, if all used for energy, has the equivalent calorific value to over 50 million barrels of oil (Table 4). Even the mere use of shell and fibre in the mill only is saving the equivalent of 33.8 million barrels of oil.

TABLE 1. AVAILABILITY OF PALM BIOMASS

Source	Type	*Moisture (%)	**Production (%)
Mill	Fibre	42.0	13.0
	Shell	17.0	5.5
	Empty fruit bunches	65.0	22.0
	Effluent	95.0	70.0
Field	Fronds	71.0	-
	Trunk	76.0	-

Notes: \* Moisture content as available from source and determined.

\*\* Based on 1 t of fresh fruit bunch produced.

TABLE 2. FUEL CHARACTERISTICS OF BIOMASS (dwb)

Biomass type	Calorific Value (kJ kg <sup>-1</sup> )	Proximate analysis (%)		
		Volatile Matter	Ash	Fixed carbon (by diff.)
Empty fruit bunch	18 795	87.1	4.6	8.4
Fibre	19 055	84.9	6.1	9.0
Shell	20 093	83.5	3.0	13.5
Palm kernel cake	18 884	88.5	3.9	7.6
Trunk	17 471	86.7	3.4	9.9
Fronde	15 719	85.1	3.4	11.5
Coal *	23 195	>28.8	10.1 max	35.8-49.8

Note: \*Some indicative coal specification of TNB Fuel Services Sdn Bhd, Malaysia for Manjung Power Station.

TABLE 3. ULTIMATE ANALYSIS OF BIOMASS (% , dwb)

Biomass type	C	H	N	O (by diff.)
Empty fruit bunch	45.9	5.7	0.8	47.6
Fibre	45.2	5.5	1.1	48.2
Shell	49.7	5.7	0.4	44.0
Palm kernel cake	45.3	10.2	2.5	42.0
Trunk	41.9	6.0	3.8	48.4
Frond	42.4	5.8	3.6	48.2
*Coal	52.5-65.4	3.8-4.3	0.6-1.4	8.0-13.4

Note: \*Some indicative coal specification of TNB Fuel Services Sdn Bhd, Malaysia for Manjung Power Station.

TABLE 4. BARREL OF OIL EQUIVALENT (2005)

Biomass	Dried wt. produced (mil. tonnes)	Total energy (MJ)	Barrel equivalent* (mil.)
EFB	5.77	1.14 x 10 <sup>11</sup>	19.4
Fibre	5.85	1.22 x 10 <sup>11</sup>	20.8
Shell	3.83	0.77 x 10 <sup>11</sup>	13.0
Effluent**	37.5 (wet)	0.18 x 10 <sup>11</sup>	3.1

Notes: \*Based on 1 barrel crude oil equivalent to 5.904 GJ.

\*\*Based on 1 m<sup>3</sup> effluent emits 22.4 m<sup>3</sup> biogas, 60% CH<sub>4</sub>.

Palm oil mill effluent has to be treated before discharge into public waterways. In view of its high organic content, anaerobic treatment is usually practised resulting in generation of biogas which has a high calorific value. The biogas generated *in situ* can be used to fire the boiler, saving the fibre and shell (which are more easily transportable) for use as fuel in locations away from mills.

#### From Field

**Replanting.** The oil palm has an economic life of about 25 years after which it becomes too tall to harvest. It is then replanted. The biomass available from replanting is shown in Table 5. The woody biomass has a relatively high calorific value and is thus suitable for use as solid renewable fuel too (Tables 2 and 3). The trunks usually take a long time to degrade in the field and are preferably

removed, but the fronds, are best retained for soil conditioning.

Although there is a considerable volume of biomass to be had, it would be from scattered places all over the country. The availability would be more reliable in large estates with a regular replanting programme to ensure a continuous steady source. However, the availability from the individual smallholders, which accounts for about 10% of the total oil palm land, would be rather unpredictable.

**Harvesting.** Fronds can be obtained on a regular basis from estates as during harvesting, some fronds are pruned to gain access to the bunches.

These fronds are left in the field to recycle their nutrients and improve the soil condition. However, the petiole can possibly be utilized as it takes an

TABLE 5. \*PROJECTED AVAILABILITY OF FIELD RESIDUE

Year	Felled trunks (mil. tonnes, dwb)	Felled Fronds (mil. tonnes, dwb)
2006	9.7	2.5
2008	9.0	2.4
2010	10.5	2.7
2012	11.2	2.9
2014	10.2	2.7
2016	10.0	2.6
2018	10.6	2.8
2020	11.1	2.9

Notes: \*Based on hectares of immature palm (from Malaysian Oil Palm Statistics, 2005, 25<sup>th</sup> Edition, MPOB) 25 years back from year expected to be felled.

Trunks computed based on 136 palms ha<sup>-1</sup> at 274 kg trunk<sup>-1</sup>.

Fronds computed based on 32 fronds palm<sup>-1</sup> at 2.24 kg frond<sup>-1</sup>.

extremely long time for it to degrade in the field. The quantity of pruned fronds available in 2006 was estimated at 27.1 million tonnes (dwb).

## AVAILABILITY

### Location

As at 2006, there are 397 operating mills - 249 and 148 in the Peninsula and east Malaysia, respectively. *Table 6* shows the distribution of the mills by state. The mills are usually sited amidst large areas of oil palm, and thus, logistics may not be a problem in gathering the biomass. The same basic infrastructure and transport used to deliver fresh fruit bunches to the mill and crude palm oil to the more developed industrial area for further processing can possibly be used to alleviate the transport costs.

### Fluctuations of Biomass Supply from Mills

In order to be able to use the biomass as fuel, it must be available regularly. While temperate countries have to cope with the seasonal availability of their crops, the oil palm is a perennial having the advantage bearing fruit throughout the year.

As the fresh fruit bunches are processed in the mill, the biomass generated need to discarded continuously. *Table 6* shows the mills are rather consistent in their operation working 305-430 hr a

month and using their capacity from 73.3% to 108%. This would ensure the regular availability and supply of palm biomass.

### Biomass Preparation and Handling

Of the biomass produced in the mill, the empty fruit bunches are the most bulky and difficult to handle compared to the fibre and shell. The fibre and shell also have the advantage of being in comminuted form and are thus, easily combusted in the mill. The shell has a higher calorific value and better physical form and combustion properties, and is most highly sought after as alternative fuel.

The empty bunches not only contain a high content of water but are bulky and need much pre-treatment before they can be burnt. Precautions are also needed to ensure that they are not mishandled resulting in an odoriferous and repulsive environment. At present, there are many machines developed to pulverise the fibre (Tan *et al.*, 2001), allowing them to be densified for easier transport and handling. This pre-treatment is usually carried out in the mill as the initial stage of pressing allow some oil to be recovered while the final products can be sold.

## COMPETITIVE USES

While there is constant production of empty fruit bunches from mills, getting the millers to commit to supply on a long-term basis of 5-10 years, as is

**TABLE 6. LOCATION OF MILLS IN MALAYSIA AND ITS OPERATIONAL CONSISTENCY (2006)**

State	Number of mills	Milling (hr month <sup>-1</sup> )	Milling capacity utilization rate, per month (%)
Johor	67	427	93
Kedah	6	364	108
Kelantan	10	305	69
Melaka	3	436	99
N. Sembilan	15	393	85
Pahang	69	377	88
Perak	3	313	73
P. Pinang	43	430	103
Selangor	21	418	92
Terengganu	12	389	76
P. Malaysia	249	401	90
Sabah	112	406	96
Sarawak	36	352	92
Sabah/ Sarawak	148	393	95
Malaysia	397	398	92

Source: Malaysian Oil Palm Statistics, 2005. 25<sup>th</sup> Edition, MPOB.

necessary for any industrial power plant, is difficult and this uncertainty of supply has delayed many planned biomass power plants.

This is partly due to the active research and development of alternative uses of palm biomass in particular for substitution of rubber wood which is slowly depleting due to replanting of many of these rubber plantations to oil palm. Many products can be manufactured using palm biomass. These include medium density board, moulded particle board and a range of building materials and consumer products (Malaysian Palm Oil Board). Some mills have also embarked on converting the empty bunches to compost using indigenous technologies developed (Foo, 2006) which returns much of the organic and inorganic nutrients back to the soil.

The steadily rising price of fossil fuel and projected high price of alternative solid fuel has also forecasted a demand for palm biomass especially from local industries with small capacity biomass boilers generating energy for own consumption. Palm kernel shells are being used in large quantity by the local cement factory to substitute coal and it is also being used to co-fire biomass boiler to generate green electricity in Europe (Kay and Andre, 2007). Enhancement of the biomass through densification to reduce its bulkiness and increase its calorific value is foreseen to increase its demand

from overseas where at this time specifications are being drawn up by the European community for biomass pellets (Rombrecht and Krautz, 2007). This may possibly give a new perspective for the opening of new markets for the Malaysian palm industry.

The combustion technology is well established to transform the biomass to heat. There are also a number of technologies being actively pursued to transform these biomass into a more convenient liquid or gaseous fuel for more specific uses. These include pyrolysis, gasification and bioconversion. However, these technologies are still in their early stages and more work needs to be carried out before full scale commercialization is possible (Manatis, 2007).

#### **NATIONAL POLICY AND PROGRAMME**

The quest to develop renewable energy is also enshrined in many of our various national policies. These include having target of 350 MW of green electricity to the national grid in the Ninth Malaysia Plan. As biomass is still available in abundance and not yet fully utilized, this target is expected to be mostly derived from the oil palm industry.

In 2002, the Malaysian Government implemented the Small Renewable Energy Power (SREP) programme to intensify and encourage the utiliza-

tion of palm biomass for power generation and link to the grid. To date, many licenses have been approved to construct such plants but only one plant utilizing biomass has been constructed and is operating. It is foreseen that together with the incentives offered by the Clean Development Mechanism (CDM) and Kyoto Protocol, more projects shall be implemented. Malaysia has already registered 12 CDM projects which are utilizing palm biomass as fuel feedstock, displacing the use of fossil fuel and thus, reducing emissions.

### CONCLUSION

The oil palm industry not only provides food to the world but also has the potential to generate renewable energy from its biomass. The biomass will be in the partially treated form and readily available throughout the year. Pre-treatment to reduce its volume will enhance its value as fuel with the potential to be exported if the logistics can be worked out.

The biomass now can already be combusted as solid fuel. But, should the technology emerge to convert it to other physical forms, liquid or gas, its versatility as a fuel would be increased.

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