A Perspective of Oil Palm and Its Wastes

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Abstract: *Palm oil and related products represent the second largest export of Malaysia. Malaysia's palm oil production in 2005 is projected to reach approximately 15 million tonnes (301,000 barrels per day) compared to its petroleum production in 2004, estimated at 43 million tonnes (855,000 barrels per day), of which 16 million tonnes (321,000 barrels per day) were exported. This paper describes the planting of oil palms, the production of oil palm products and yields of fresh fruit bunches (FFB), crude palm oil and palm kernel from 1976 to 2006. The utilisation of oil palm waste is also discussed with its potential use as fertiliser, fuel and bio-oil.*

Keywords: empty fruit bunches, oil palm wastes, oil palm mill, bio-oil

Abstrak: *Minyak kelapa sawit dan produk-produk yang berkaitan merupakan eksport kedua terbesar Malaysia. Pengeluaran minyak kelapa sawit Malaysia pada tahun 2005 diunjurkan mencapai lebih kurang 15 juta tan (301,000 tong sehari) berbanding pengeluaran petroleum pada tahun 2004, yang dijangkakan pada 43 juta tan (855,000 tong sehari) dan 16 juta tan (321,000 tong sehari) daripadanya adalah dieksport. Artikel ini membincangkan pokok kelapa sawit yang ditanam, pengeluaran produk kelapa sawit dan hasilnya daripada buah segar, minyak kelapa sawit mentah dan isirung kelapa sawit dari tahun 1976 hingga 2006. Penggunaan buangan kelapa sawit yang mempunyai potensi sebagai baja, bahan api dan minyak-bio juga dibincangkan.*

Kata kunci: tandan kosong, buangan kelapa sawit, kilang kelapa sawit, minyak-bio

1. INTRODUCTION

The major challenge that the world faces today is the supply of energy as a result of great demands due to strong economic growth and progressive development, as well as persistent high energy prices for the past few years. Malaysia is no exception to this problem. This highly precarious situation emphasises the necessity for this country to diversify its dependency on only a few sources of energy and to include in its policy good energy management in relation to energy utilisation. Meeting the increasing demand for energy is indeed a continuing concern compounded with issues of fossil fuel depletion and the effects of burning fossil fuels on the environment.

Malaysia's National Energy Policy aims to have an efficient, secure and environmentally sustainable supply of energy, as well as efficient and clean utilisation of energy. Since 1980, the main demand of energy was petroleum products, followed by electricity, natural gas and coal and coke, as shown in Figure 1.[1–3] For the year 2007, the total demand for energy reached more than 1,600 petajoules (PJ), with the percentage for petroleum products declining to about 60%, while coal and coke increased to about 4%, in line with the national fuel diversification policy.[2] Interestingly, the final energy demand reported in 2007 is 1,852 PJ, which is an increase of 9.8% compared to the demand in 2006.[4] Even though there is an upward trend in demand for energy, which is due to the positive growth projection of the economy, the government must ensure that its fuel diversification policy is executed so as to reduce Malaysia's overdependence on oil as its main energy source. The policy focuses on four main energy sources used: oil, gas, coal and hydro, for a reliable and secure supply of energy for the country.

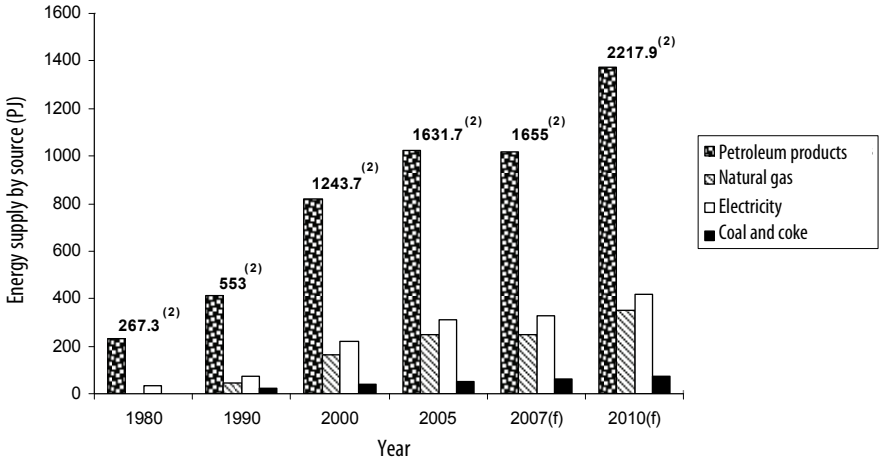

Figure 1: Final commercial energy demand by source, 1980–2010.[2–3]

Notes: f: forecast
2: total energy in PJ

In 2005, the main energy supply was crude oil and petroleum products at 46.8%, natural gas at 41.3%, coal and coke at 9.1% and hydro at 2.1%, as shown in Figure 2.[5] Compared to the year 2000, the dependency on crude oil and petroleum products has decreased by about 2.5%, and, for coal and coke, it has increased by almost 4%, indicating achievement in the government's effort to reduce overall dependence on a single source of energy and to utilise other alternative sources that are available. Malaysia's total commercial energy supply in 2007 was at 2,648 PJ, which is composed of natural gas at 43.2%, followed by crude oil, petroleum products and others at 40.4%, coal and coke at 14% and hydropower at 2.4%.[4] These data indicate a further decrease of 6.4% in the

dependency on crude oil and petroleum products when compared with the year 2005. However, there is an increase in the use of natural gas, coal and coke and hydropower ranging from 0.3% to about 5%.

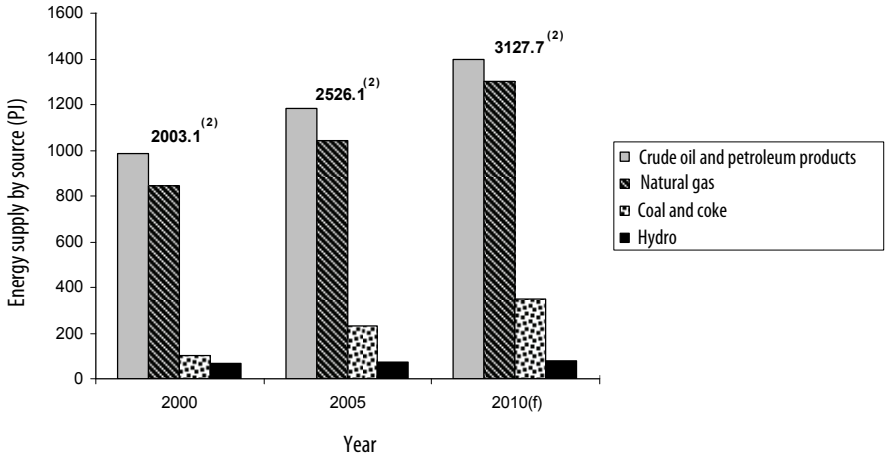

Figure 2: Primary commercial energy supply by source, 2000–2010.[5]

Notes: f: forecast
2: total energy in PJ

In the Eighth Malaysian plan, renewable energy was announced as the fifth fuel in the new Five Fuel Strategy in the energy supply mix (mixture of energy supply that originally comprises of oil, natural gas, coal and coke and hydro). Renewable energy was targeted to contribute 5% of the country's total electricity demand by the year 2005. With this objective, efforts were made to encourage the utilisation of renewable resources, such as biomass, biogas, solar and mini-hydro, for energy generation.[6] Two projects with a combined capacity of 12 megawatts (MW) were a biomass power plant at a palm oil mill site utilising empty fruit bunches (EFB) as its main fuel, and a landfill plant utilising landfill gas in one of the city's main municipal storage waste sites.[7] To promote renewable energy utilisation, the Building Integrated Photovoltaic (BIPV) program was implemented in 2000, when a 3.15 kWp grid-connected photovoltaic (PV) system was installed on roofs of dwellings. Subsequently, by 2005, almost 470 kWp of grid-connected PV systems were installed on Peninsular Malaysia, particularly at the country's technology park, where a system of 362 kWp was installed.[8]

In the Ninth Malaysian plan (2006–2010), the government made commitments to further include renewable energy as an additional source to supplement the conventional energy sources used for power generation. The current plan includes hydropower, biomass, biogas and solar energy as sources of renewable energy that can contribute to the existing fuel mix. Renewable energy

sources are abundant in Malaysia, the most important ones being biomass and solar. A recent study identified the renewable energy resource potential in the country as shown in Table 1 which indicated large amounts of forest and oil palm residues that can be utilised for energy generation, as well as addressing the environmental concerns over properly disposing of the waste.

Table 1: Renewable energy resource potential in Malaysia.

Renewable energy resource	Energy value (RM million per year)
Forest residues	11,984
Oil palm biomass	6,379
Solar thermal	3,023
Mill residues	836
Hydro	506
Solar PV	378
Municipal waste	190
Rice husk	77
Landfill gas	4

Palm oil production is steeply rising. Based on preliminary estimates of the United States Department of Agriculture, it narrowly overtook soybean oil in total production in the agricultural year 2004 to 2005 for the first time and is now the vegetable oil with the largest production volume.[9] This feat was achieved on roughly a tenth of the land area used by soybean crops, which illustrates the high productivity of oil palm; it has the highest yield among major oil crops.[10] The rise in vegetable oil demand is driven by rising incomes and population in Malaysia's traditional food market, high crude oil prices, increasing concerns about climate change and by biodiesel use, which is surging due to mandates in several key regions.[11]

2. PALM OIL PRODUCTION AND CONSUMPTION

Palm oil and related products represented the second largest export of Malaysia in the first 9 months of 2005 after electronics but just ahead of crude oil.[12] In 2005, Malaysian palm oil production is projected to reach approximately 15 million tonnes (301,000 barrels per day), which is very close to the actual value of 14.96 million metric tons recorded by Malaysian Palm Oil Board (MPOB).[9,13] In comparison, Malaysian petroleum production in 2004 was estimated at 43 million tonnes (855,000 barrels per day), of which 16 million tonnes (321,000 barrels) per day were exported. The domestic petroleum demand of 26 million tonnes represented 44% of the total energy demand of 60 million tonnes of oil equivalent.[14]

The total area in Malaysia planted with oil palm increased by 2.8% to 4.17 million hectares in 2006. The area expansion occurred mainly in Sabah and Sarawak, with a combined growth of 4.5% compared to 1.6% in Peninsular Malaysia.[15] Table 2 below shows the areas planted with oil palm by state in Malaysia for 2005 and 2006 (in hectares).

Table 2: Oil palm planted area in 2005 and 2006.

State	2005	2006	Quantity difference (ha)	% difference
Johor	667,872	671,425	3,553	0.53
Kedah	75,472	76,329	857	1.14
Kelantan	89,886	94,542	4,656	5.18
Melaka	52,015	52,232	217	0.42
Negeri Sembilan	155,164	161,072	5,908	3.81
Pahang	606,821	623,290	16,469	2.71
Perak	340,959	348,000	7,041	2.07
Perlis	278	258	–20	–7.19
Pulau Pinang	14,074	14,119	45	0.32
Selangor	132,100	128,915	–3,185	–2.41
Terengganu	163,967	164,065	98	0.06
Peninsular Malaysia	**2,298,608**	**2,334,247**	**35,639**	**1.55**
Sabah	1,209,368	1,239,497	30,129	2.49
Sarawak	543,398	591,471	48,073	8.85
Sabah and Sarawak	**1,752,766**	**1,830,968**	**78,202**	**4.46**
Malaysia	**4,051,374**	**4,165,215**	**113,841**	**2.81**

Source: Malaysian Oil Palm Board (MPOB): Review of the Malaysian Oil Palm Industry (2006).[15]

The production of crude palm oil increased further, by 6.1%, to 15.9 million tonnes in 2006 from 15.0 million tonnes the previous year, as shown in Table 3. Crude palm kernel oil production rose by 6.1% to 1.96 million tonnes in tandem with a 4.1% growth in palm kernel production, as Shown in Table 3.[15] Table 4 shows that the increase was mainly attributed to two factors: (1) the expansion by 2.0% of areas of matured oil palm and (2) the rise in the average number of fresh fruit bunches (FFB) yielded per hectare, which increased by 3.8% to 19.6 tonnes due to better management and agricultural inputs. Table 4 also shows that the oil yield per hectare increased by 3.4% to 3.9 tonnes, despite the oil extraction rate (OER) declining marginally by 0.5% to 20%, as shown in Figure 3. The decrease in OER in the years 1993 to 2001 is significant and due to the global recession, which accounts for the lower demand of export markets. However, despite a weak global economy, there was a significant recovery in 2002 as the government implemented prudent policies to assist the Malaysian oil palm industry. These included the expansion of oil palm in matured areas and the campaign to improve the productivity of the oil palm industry, coupled with

providing competitive prices on oil palm, the liberalisation of export duties and the encouragement of counter-trades for higher exports.[16]

Table 3: Annual production of oil palm products every 10 years (tonnes): 1976–2006.[12]

Year	Crude palm oil	Palm kernel	Crude palm kernel oil	Palm kernel cake
1976	1,391,965	256,015	117,205	n.a
1986	4,542,249	1,336,263	580,026	708,518
1996	8,385,886	2,488,750	1,107,045	1,383,034
2006	15,880,786	4,125,124	1,955,634	2,200,225

Note: n.a. – not available

Table 4: Yield of FFB, crude palm oil and palm kernels (tonnes/ha) every 10 years: 1976–2006.[12]

Year	FFB	Crude palm oil	Palm kernel
1976	16.16	3.48	0.71
1986	22.15	4.41	1.28
1996	18.95	3.55	1.06
2006	19.60	3.93	1.02

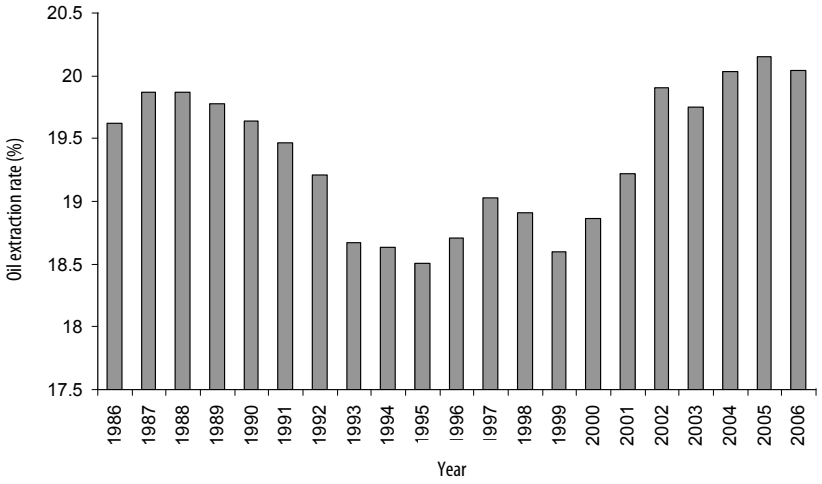

Figure 3: Oil extraction rates for 1986–2006.[15]

The rapid expansion of oil palm cultivation has raised concerns about the sustainability and environmental impact of oil palm plantations, in particular with regard to biodiversity, destruction of old growth rainforest and air pollution.[17,18] To illustrate the potential impact, it is worthwhile to remember that, with a palm

oil yield of 4 tonnes per hectare, a tropical forest roughly the size of the United States would be required to satisfy the current world crude oil demand.

3. UTILISATION OF OIL PALM WASTES

The use of oil palm biomass other than the palm oil leads to increased efficiency as more energy is obtained from oil palm plantations. For each kg of palm oil, roughly another 4 kg of dry biomass are produced, approximately a third of which is found in FFB derived wastes, while the other two thirds is represented by trunk and frond material.[19–21] On an energy basis, the palm oil represents roughly a third of the biomass yield, as it has roughly twice the heating value of the other oil palm dry matter, which therefore amounts to approximately 2 kg on a palm oil equivalent basis. Based on projected 2005 production, around 30 million metric tonnes of oil equivalent of non palm oil dry biomass matter were therefore theoretically available for energy production from Malaysian palm oil plantations, or, in other words, approximately half of the 2004 total primary energy demand. Only a small fraction of this potential was used, and very inefficiently. Open burning is still too common and is responsible for substantial air pollution problems in South East Asia, indicating that other solutions urgently need to be found. Some of the biomass is used for mulching and as fertiliser, though this use is limited by labour, logistical limitations and concerns about encouraging oil palm pests.[22]

Palm oil mills in Malaysia typically meet most of their electricity and process steam requirements by burning some of the wastes, with energy for start-up generally being provided by back-up diesel.[20,23,24] Per kg of palm oil, electricity consumption is around 0.075–0.1 kWh, and steam demand is around 2.5 kg. This represents a steam to electricity ratio of around 20 to 1, which could be met by burning 0.3–0.4 kg of waste. As the boiler efficiency is only around 70%, the actual consumption is correspondingly higher.[25] Little effort was made in the past to optimise process steam consumption or boiler or turbine efficiency, as the fuel was substantially treated as a waste that was incinerated for disposal. The electricity co-generated in Malaysian palm oil mills therefore only amounts to roughly 1–1.5 billion kWh, or less than 2% of the 2003 generation of over 82 billion kWh. The Malaysian government is now encouraging more efficient co-generation through the Small Renewable Energy Program (SREP), under which 194 MW of grid connected biomass capacity have been approved as of mid 2005.[26]

To illustrate the kinds of waste available, the process flow of a palm oil mill is summarised in Figure 4 (simplified[23]), and a typical product stream distribution is shown in Table 5 (adapted[20]).

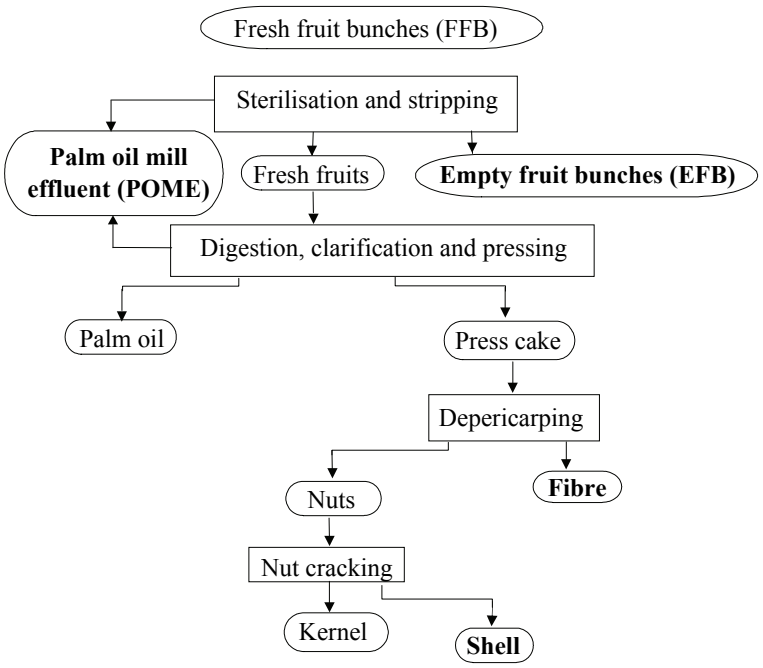

Figure 4: Simplified process flow diagram of an oil palm mill, main waste streams in bold (simplified[23]).

Table 5: Typical product stream distribution in oil palm mills (adapted[20]).

	Wet FFB basis		Dry FFB basis	
	(tonnes per hectare)	% FFB	(tonnes per hectare)	% FFB
FFB	20.08	100.0	10.60	100.0
Palm oil	4.42	22.0	4.42	41.7
Palm kernel	1.20	6.0	1.20	11.4
EFB	4.42	22.0	1.55	14.6
POME	13.45	67.0	0.67	6.3
Shell	1.10	5.5	1.10	10.4
Fibre	2.71	13.5	1.63	15.4
Total	27.30	136.0	10.60	99.8

As can be seen in Table 5, the moisture content of fresh EFB is very high. Typically, it is over 60% on a wet EFB basis. Consequently, it is a poor fuel without drying and presents a considerable emission problem, such that its burning is discouraged by the Malaysian government. Palm oil mills therefore typically use shell and the drier part of the fibre product stream, rather than EFB, to fuel their boilers.[27] Palm oil mill effluent (POME) is so wet that it is usually treated by anaerobic digestion before the discharge of the effluents.[27] The total

product stream distribution in oil palm mills is greater than 100% on a wet basis as extra water is added during the process, such as during sterilisation with steam. Most of this water ends up in POME.

For each kg of palm oil, roughly 1 kg of wet EFB is produced. As over 60% of the wet EFB consists of water, and the heating value of the dry EFB is roughly half that of palm oil, the energy obtainable from the EFB product stream amounts to roughly 0.2 kg of oil equivalent per kg of palm oil. Based on Malaysia's projected 2005 palm oil production of 15 million tonnes, the energy value of the EFB waste is therefore around 3 million tonnes of oil equivalent, which would amount to $1.2 billion for an assumed $400 per tonne ($55 per barrel). This value does not include conversion losses or consumption of fossil fuel in the transportation of the EFB waste.

Research on fast pyrolysis of biomass to derive bio-oil has received very limited attention by researchers in Malaysia. Normally, fibre and shells are burnt in the palm oil processing plants to generate fuel to produce the power for running the mill (self sufficiency).[24,28] So far, research involving fast pyrolysis has been carried out by University Teknologi Malaysia on oil palm shells, rubber waste, rice husk waste, scrapped tyres and tubes,[29–32] and the author has studied fast pyrolysis to produce bio-oil derived from EFB.[33] The first plant to commercially produce bio-oil, owned by Genting Bio-oil, has recently started production in Malaysia.[34] This pilot plant utilising fast pyrolysis technology processes empty fruit bunches to produce bio-oil.

4. CONCLUSION

This paper catalogued the palm oil production and consumption from 1976 to 2006, and the wastes available for potential utilisation. Increased utilisation of renewable energy resources, in particular oil palm wastes, is strategically viable as it can contribute to Malaysia's sustainable energy supply while minimising the negative impacts of energy generation on the environment. It will also solve the agriculture disposal problem in an environmentally friendly manner while recovering energy and higher value chemicals for commercial applications like bio-fuel, helping the government to achieve its obligation to prolong the fossil fuel reserves.

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