Blending of Palm Biomass and Coal: An Alternative Fuel for Power Generation in Malaysia

A B Nasrin*; Ma, A N*; Chow, M C*; H Hamdan** and Choo, Y M*

ABSTRACT

Palm oil mills in Malaysia generate vast amounts of biomass wastes such as empty fruit bunches (EFB), fibre and shell. The mills burn the shell and pressed fibre to generate their own heat and electricity, but the EFB is surplus to its requirements although a legitimate fuel in its own right. With growing environmental consciousness, high petroleum prices and depleting fossil fuels, the palm biomass can be burnt in coal-fired generating plants to produce green electricity for the country. How this can be done in Malaysian scenario is discussed.

INTRODUCTION

Energy is one of the key factors in the development of a country. Over the years, the demand for energy will increase from industrialization, more transport required and also from the growing population. On the other hand, the depletion of fossil fuels and increasing environmental concern have prompted a search for alternative fuels.

Malaysia produces abundant biomass which is grossly underutilized although there have been some attempts to use it to generate bio-energy. Yet, for decades, biomass has been used to generate electricity in palm oil mills for internal use, suggesting that generating electricity for the country should be no less viable.

In 2001, Malaysia announced its Five Fuels Diversification Strategy with renewable energy (RE) fuels, in particular, biomass, as the fifth component. This was followed by the Small Renewable Energy Programme (SREP) which allows small power producers (maximum power generated limited to 10 MW) to sell their electricity to Tenaga Nasional Berhad (TNB).

However, to date, there has not been much RE power produced. According to the Energy Commission, as of August 2006, only 47 licenses with a total capacity of 256.2 MW have been approved. Biomass-based power plants burning oil palm wastes, municipal solid wastes, rice husk and wood wastes form the largest group of licensees with 22 projects and a total capacity of 159.2 MW. Specifically, 16 will use empty fruit bunch (EFB) as their main fuel with an estimated capacity of 117.6 MW. However, only two have been commissioned, one of them a 14 MW TSH Bio-Energy plant in Kunak, Sabah which uses treated

* Malaysian Palm Oil Board,
P. O. Box 10620,
50720 Kuala Lumpur,
Malaysia.

** TNB Research Sdn Bhd.,
1, Lorong Air Hitam,
Kawasan Institusi Penyelidikan
Bandar Baru Bangi,
43000 Kajang,
Selangor, Malaysia.

EFB to supply 10 MW to the grid. The lack of solid and appropriate policies, financial support and demonstration plants have been the bane to the SREP programme. Therefore, a proactive move must be made to accelerate RE power generation in the country.

MALAYSIA'S ENERGY SCENARIO

The demand for electricity in Malaysia has grown tremendously in the last two decades, and will continue to grow. This could be seen from the total electricity consumption for Malaysia recorded a growth of 23 000 GWhr in 1990 to 77 080.8 GWhr in 2004 (National Energy Balance, 2004). The peak demand for 2003 till 2006 was recorded varies from 12 444 MW to 13 195 MW (National Energy Balance, 2003; 2004; Economic Planning Unit, 2006).

To cope with the steep growth in the short-term, Malaysia is to have a total installed generating capacity of 20 320 MW by 2010 as per the Ninth Malaysia Plan. The latest number published in the National Energy Balance is that at December 2004, the total installed capacity of the country was about 20 052.58 MW, where was about 27.7% of reserve margin.

In the use of fuel for electricity generation, fossil fuels, especially petroleum products, dominate with about 70% of total fuel used. The breakdown of the country's installed capacity in 2004 by power plants and fuel used is shown in *Figure 1*.

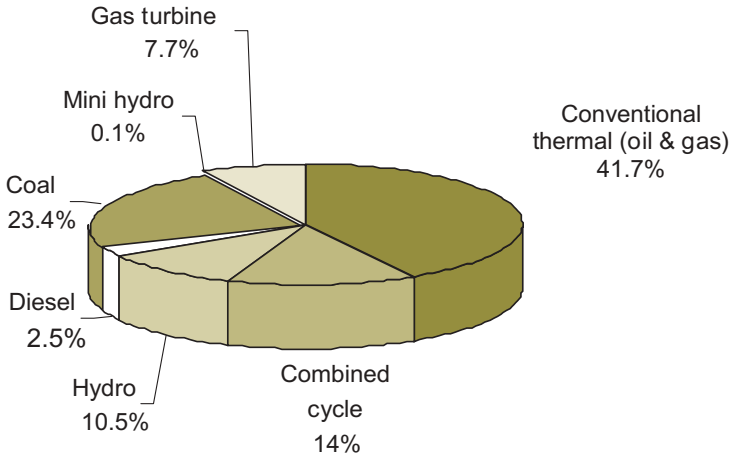
The share of coal in power generation has increased from 14.0% in 2002 to 30.0% in 2004 (National Energy Balance, 2002; 2003; 2004), and is expected to increase further as the government weans the country off over dependence on petroleum products (www.eia.doe.gov, 2006). In 2004, Malaysia consumed about 10.5 million tonnes of coal annually for both industrial sectors and power stations, with more than 80% is directly used for electricity generation by power plants. The fuel mix used by power plants in Malaysia for 2002 – 2004 is shown in *Table 1*.

Malaysia has three power plants burning coal - Sultan Salahuddin Abdul Aziz Power Plant, Kapar and Jana Manjung, and Sungai Sejingkat, in Sarawak – with a total installed capacity of 3800 MW (*Table 2*).

TABLE 1. FUEL MIX USED IN MALAYSIA FOR POWER GENERATION (2002 – 2004) BASED ON THE TOTAL CAPACITY FUEL USED

Fuel	2002	2003	2004
Natural gas,%	68.6	65.3	59.4
Coal,%	14.0	24.6	30.0
Petroleum & diesel,%	10.1	3.8	1.5
Hydro,%	7.3	6.3	7.5

Source: National Energy Balance (2002; 2003; 2004).



Source: National Energy Balance (2004).

Figure 1. Malaysia installed capacity as at 31 December 2004 based on the power plant types and fuels used.

TABLE 2. THE LIST OF COAL FIRED POWER PLANT IN OPERATION OR IN THE STAGE OF DEVELOPMENT IN MALAYSIA

Plant	Ownership	Commissioned year/ expected commercial operation date	Status	Generation capacity, (MW)
SSAS, Kapar	TNB/IPP	2001	In operation	1 600
Sg Sejingkat	IPP	2002	In operation	100
Manjung	TNB	2004	In operation	2 100
Tg Bin, Johor	IPP	2006	Under construction	2 100
Jimah, Lukut	IPP	2007	Under planning	1 400
Pulau Bunting, Sarawak	IPP	2007	Under planning	700
			Total	**8 000**

Source: Yeong, K L (2004).

There are other three coal-fired plants being planned or built. With all these plants fully operated, the estimated annual requirement for coal will be over 18.35 million tonnes (Joseph Chong, 2004).

Oil palm industry, in particular palm oil milling activity is known for self-generating and consumption of steam and electricity from palm biomass. In 2005, there were 395 palm oil mills (POM) in the country processing 84.11 million tonnes fresh fruit bunch (FFB) (MPOB, 2005). At an estimated 20 kWhr electricity to process 1 t FFB, 1682.2 million kWhr would have been generated by the POM for their own use. Based on the average monthly operating hours for a mill (about 400), the industry would have had a total generating capacity of 350 MW. With their surplus fuel and generating capacities, most of the mills would be able to generate electricity over and above their needs. Therefore, the potential for POM to generate RE for the country is undeniable.

BIO-COAL: HOW TO IMPLEMENT

Biomass and coal are solid fuels, both burning well in individual fired boilers. Blending, or co-firing palm biomass and coal, will be one of the fastest and cheapest ways to use RE in our country. The blended fuel can be burnt in existing coal-fired boilers, although currently Malaysia has yet no experience in doing so on a commercial scale.

The concept of blending biomass and coal for co-firing is simple, provided the fuel is prepared properly and that there is an appropriate feeding system. In a co-firing test at Naantali Power Plant in Finland, the combustion was successful although the particle size of the biomass, pre-treatment equipment and burner injector still needed to be improved (Savolainen, 2003). There are several ways to engineer the co-firing depending on the site's requirements of the power plant. The following are the methods that can be considered:

- mix the palm biomass and coal in the fuel yard, and feed the blend to the boiler through the existing coal feeding system. Fibrous palm biomass can be used in this approach; and
- pulverize the palm biomass and pneumatically inject into the boiler without using the existing coal feeding system. The biomass should either be pulverized or charcoal forms for a smoother operation.

The blending ratio would depend on the specifications of fuel for the boiler, and the calorific value, but normally at the maximum of 5% to 10% biomass. The minimum calorific value (CV) required for TNB power plants is 27 000 kJ/kg (Hamdan and Ariffin, 2004) so theoretically, the ratio can be 10:90 as shown in *Figure 2*. Problems such as overloading the fuel feed and too low combustion temperature will occur when the CV is lower than that specified for the plant. The proper ratio would also improve the coal properties, particularly the ash and sulphur contents. The high moisture content and bulk of the EFB can be reduced by pre-treatment process done at the mill. It consists of a series of mechanical processes using machineries such as screw press, shredder and hammer mill. This is to extract EFB juice and reduce EFB size to fibrous form, and to lower moisture content to desired specifications prior to delivery to the power plants. The properties of EFB after pre-treatment and coal samples are given in *Table 3*.

POTENTIAL OF BIO-COAL: TECHNO-ECONOMIC PERSPECTIVE

Environmental impacts, socio-economic concerns as well as supporting the government's policies in diversifying the country's generation fuels are among the factors to be considered in introducing new fuels for power generation. Though as a minor

TABLE 3. PROPERTIES OF TREATED EMPTY FRUIT BUNCH (EFB) AND COAL SAMPLES

Property	Ulan Australia Coal	Treated EFB
Calorific value, kJ/kg	28 117.0	18 838.0
Moisture content, %	4.4	7.3 – 40.0
Ash content, %	8.3	4.6
Volatile matter, %	28.3	74.0
Fixed carbon, %	59.0	13.9
Carbon, %	70.2	43.5
Hydrogen, %	4.6	6.2
Nitrogen,%	2.8	1.1
Oxygen, %	22.4	49.2
Sulphur, %	1.0	Not detected

Note: All analysis was performed on the dry basis except for moisture content.
Source: MPOB (2005); TNB Research Sdn Bhd (2004).

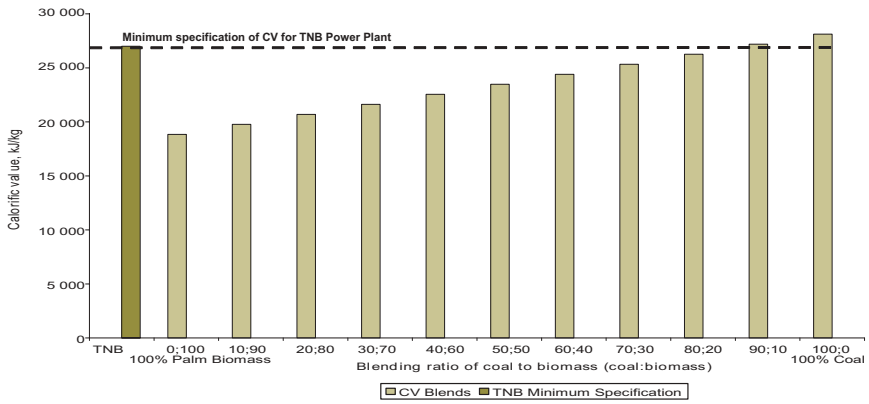


Figure 2. Calorific values of empty fruit bunch (EFB) and Ulan Australia coal blends.

substitute which may not carry a huge impact, but it is considered as a good move to reduce the use of coal while at the same time to maximize the use of underutilized palm biomass in the country.

Biomass and coal blends are considered as renewable fuels to reduce greenhouse gas emission. The use of palm biomass also offers advantages in lower NOx and SOx emissions due to its lower sulphur and nitrogen contents. Demonstration co-firings in Seward Generating, USA and Naantali Power Plant in Finland indicated a reduction in NOx emissions of by up to 15%, and the emissions of other parameters, such as SOx and particulates, to be below the limits (Savolainen, 2003; www.fwc.com, 1999).

From the national economy point of view, substituting biomass for coal will reduce the imports of coal. As Malaysia's coal imports are mainly from Australia and Kalimantan, the country is expected to face a significant high and fluctuating coal price in the near future to high cost of mining and transportations. The current coal price varies about USD 40 to 51.5/t compared to USD 24 in 2003 (Rindi White, 2005). In addition, the demand for coal to generate electricity has shot up due to the high oil prices, thus significant changes in coal price will be more realistic in future. These factors may increase the cost of electricity and affect the consumers and the country's economy as Malaysia uses >90% of its coal imports for electricity generation. Therefore, using palm biomass for generating electricity will diversify the country's fuel mix to ensure electricity at a reasonable tariff to the users.

It was estimated that the national coal demand for power plants usage in Peninsular Malaysia will increase to 18.35 million tonnes in 2010 (Joseph Chong, 2004). There are no figures on the use of EFB in the country, although empirical evidence suggests that it is not very efficiently used – mainly as mulch in the fields.

Substituting 5% to 10% coal with palm biomass will require 1 to 2 million tonnes (dry) biomass annually, or 6% to 28% from the annual EFB production on the dry basis. Hence, the amount of palm biomass used for energy should not compete too much with its non-energy uses. The plantations may object on the grounds of plant nutrients lost from the crop from not recycling the biomass in the field. But there is more money to be had by burning as a fuel for RE power.

Ascribing a price for EFB of RM 50/t, the minimum annual saving would be about RM 17.25 million. The calculation is based on the coal prices at RM 100 and RM 150/t and the substitution of EFB at 5% to 10%. This figure does not include extra profits that can be claimed through the trading of carbon credits. EFB costs at RM 50/t used for the cost-saving analysis seem reasonable as the recent trading trend shows that treated EFB for fuel at moisture content less than 40% is sold at less than RM 30/t. The co-firing looks attractive and competitive as long as EFB cost is less than coal market price. *Figure 3* projects the country's savings in coal cost by using EFB for co-firing and *Table 4* the availability of EFB until 2010.

From the experience of co-firing, all the plants have had good combustion properties. The indicators of performance - slagging and fouling behaviour, heat transfer, ignition and flame stability - were all normal as the presence of biomass were not significant in the bio-coal blend (Savolainen, 2003). Hence, biomass can be burnt with coal in existing coal fired plants without any major technical problems. Therefore, co-firing can be a cheaper alternative than building a new biomass power plant. It can also be cheaper and simpler than other biomass thermo-chemical processes. But, despite the many advantages in co-firing, there remain several problems to be resolved before its implementation, mainly the logistical issues of supply and transport. A good collection system must first be set up to ensure a continuous supply of the biofuel.

Besides that, incentives and subsidies should be introduced in order to encourage major players in palm oil industry and energy sectors to actively involve in making this effort a reality.

TABLE 4. FORECAST OF MALAYSIA'S ANNUAL COAL DEMAND AND PALM BIOMASS AVAILABILITY (2003-2010)

Year	Coal demand, (MT)	5% substitution of biomass, (MT)	10% substitution of biomass, (MT)	FFB production, (MT)**	EFB available, (MT)	EFB available @ DB	Utilization factor, % of 5% substitution	Utilization factor, % of 10% substitution
2003	6.90	0.35	0.69	67.60	14.87	5.21	6.63	13.26
2004	9.20	0.46	0.92	69.77	15.35	5.37	8.56	17.12
2005	9.50	0.48	0.95	74.68	16.43	5.75	8.26	16.52
2006	10.10	0.51	1.01	75.80	16.68	5.84	8.76	17.52
2007	13.10	0.66	1.31	76.93	16.93	5.92	10.89	21.79
2008	14.85	0.74	1.49	78.09	17.18	6.01	12.01	24.01
2009	16.85	0.84	1.69	79.26	17.43	6.10	13.18	26.37
2010	18.35	0.92	1.84	80.45	17.70	6.19	13.98	28.00

Notes:*MT - million tonnes, DB - dry basis.
Source: **Ramli Abdullah (2004).

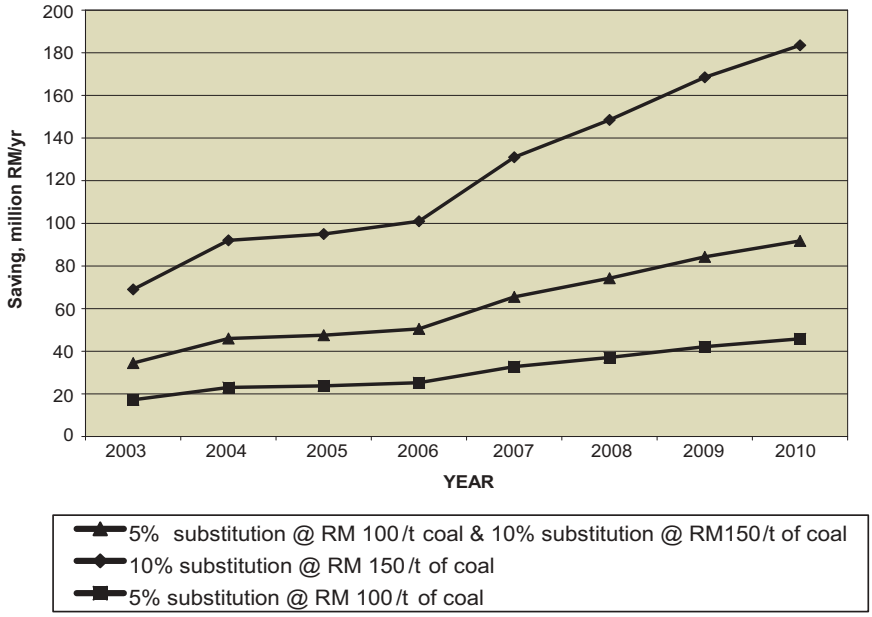


Figure 3. Annual savings by substituting coal at RM 100/t and RM 150/t with 5% and 10% palm biomass at RM 50/t.

CONCLUSION

Palm biomass has been identified as an easily available fuel for RE in Malaysia. One of the faster ways to use it is to co-fire it in existing coal-fired power plants. The above discussion on palm biomass and coal blends indicates their possibility to be demonstrated in our country. Besides adding value to a local underutilized material, the cost calculations have shown co-firing as likely to save foreign exchange for the country as well as give TNB and the IPPs an alternative fuel with which to overcome rising fossil fuel prices that may affect the electricity tariff.

The potential reduction of greenhouse gases through co-firing reflects the palm oil industry concerns over global environment preservation then privilege the involve parties for getting extra incomes through the trading of carbon credit. In view of the above, co-firing of palm biomass and coal is recommended to be in the national agenda for the development of renewable energy.

ACKNOWLEDGEMENT

The authors wish to thank the Director-General of MPOB for permission to publish the paper. Thanks are also due to Ir Ravi Menon and Ramli Abdullah of MPOB, Pusat Tenaga Malaysia (PTM) and TNB Research Sdn Bhd (TNBR) in providing technical data and assistance.

REFERENCES

ECONOMIC PLANNING UNIT (2006). Personal communication with Energy Division, Prime Minister's Department.

HAMDAN, H and ARIFFIN, B (2004). Potential of biomass-coal blend as renewable fuel for power generation. *Proc. of the Advances in Malaysian Energy Research 2004*. p. 33-40.

http://www.fwc.com/publications/heat/heat_tml/spr99/confiring.cfm (1999)

JOSEPH CHONG (2004). *Malaysia Power Sector Demand for Coal*. Coaltech 2004.

K SAVOLAINEN (2003). Co-firing of biomass in coal fired utility boilers. *Applied Energy, 74 (2003)*: 369-381.

LEONG, K Y (2001). Developing coal-fired generation: A legal perspective. www.apec-agcfe

MPOB (2005). *Malaysian Oil Palm Statistics 2005*. MPOB, Bangi. 118 pp.

MINISTRY OF ENERGY, WATER and COMMUNICATIONS MALAYSIA (2006).

NATIONAL ENERGY BALANCE (2002, 2003 and 2004).

PRIME MINISTER DEPARTMENT (2006). *Ninth Malaysia Plan Report.*

http://www.eia.doe.gov/emeu/cabs/Malaysia/pdf.pdf (2006).

RAMLI ABDULLAH (2005). Personal communication. MPOB, Bangi.

RINDI WHITE (2005). Rising coal prices fuel Sutton re-mining project. *Anchorage Daily News*. 9 May 2005.