OIL PALM BASED BIOMASS AS THE GREEN ENERGY SOURCES IN MALAYSIA

Associate Professor Dr. Luqman Chuah Abdullah and Professor Dr. Azni Idris
Department of Chemical and Environmental Engineering, Faculty of Engineering,Universiti Putra Malaysia, 43400, Serdang, Selangor.

Introduction

Malaysia is blessed with plentiful and relatively cheap supply of conventional fossil energy resources such as oil, gas, and coal which is currently quite sufficient for the country's requirement. With our ownership of some large oil fields has enabled, the government to subsidize petrol with up to 50 cent per liter to help the local industries to flourish. Past and current economic growth in the country was primarily driven by fossil fuels and little attention has been paid on alternative energy sources. However, like most industrializing countries, Malaysia too, faces the unavoidable challenges of sourcing new sources of energy for her future electricity generation.

Malaysia's target is to generate five percent of its electricity from renewable energy sources by 2005 and decrease reliance on natural gas, which is currently the primary generation fuel. Malaysia currently has approximately 13 gigawatts (GW) of electric generation capacity, of which 84% is thermal and 16% is hydroelectric. The disproportionate dependence on gas for thermal generation is a growing national concern over the eventual depletion of this particular non-renewable resource in the future. Alternative renewable energy could also be cheaper in the long run as natural gas is expensive to produce. (Chuah and Azni, 2004).

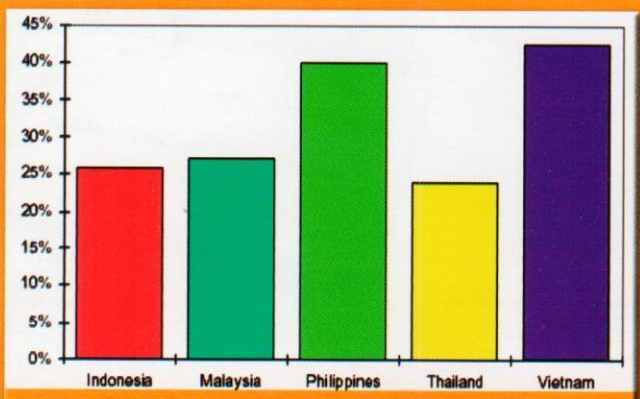


Figure 1: Energy Potential Of Agroprocessing Residues As Percentage Of Total Primary Energy Production in ASEAN countries (RWEDP, 1998).

Renewable energy has been developed to varying degrees in Malaysia. The most extensive study on the use of biomass has been on palm-oil wastes, which are used to meet energy requirement of the palm-oil mills and electricity needs of the workers (EPU, 1999). Malaysia has already generated nearly 200 MW of power from renewable sources in palm oil plantations as part of the effort at biomass utilisation (PTM, 2004). However, this power was mainly for localized use and not connected to the national distribution grid. New plants generating this new energy source should have fed into the national grid during the 8th Malaysia Plan (RM8), in 2001-2005. As incentives the government has offered tax breaks, investment allowances and waiver on import duties of equipments used in renewable energy plants. *(Figure 1)* shows the energy potential of agroprocessing residues as percentage of total primary energy production in ASEAN countries.

Biomass in Malaysia contributes about 14% of the approximately 340 million barrel of oil equivalent (boe) of energy used every year. At present more than 2.8 million hectares of land are under oil palm cultivation which generate the biggest biomass volume in Malaysia. Of primary interest, the waste from palm oil mills is utilized on-site to provide energy for the mills as well as excess electricity export to the national grid. There are some 281 palm-oil mills in operation in 1995 with an aggregate installed capacity of around 200 MWe to exclusively meet own demand (captive power). It was estimated that a total of 42 million tons of fresh empty fruit bunches (EFB) were produced in Malaysia annually which translates to around 17 million tons of waste. For low-pressure systems with an assumed conversion rate of 2.5 kg of palm oil waste per kWh, potentially 7,000 GWh could theoretically be generated.

Sector	Quantity (kton/yr)	Potential Annual Generation (GWh)	Potential Capacity (MW)
Rice Mills	424	263	30
Wood Industry	2117	598	68
Palm Oil Mills	17980	3197	365
Bagasse	300	218	25
Total	20881	4276	488
Palm Oil Mill Effluent (POME)	31500	1587	177

Table 1 Energy Potential from Oil Palm Based Biomass/Biogas (PTM, 1999)

Palm oil mill processing also produces palm oil mill effluent (POME) which is treated in tanks and then released into the water table, but could be utilised as a source of biogas. From *(Table 1)*, it is clearly seen that the yearly available biomass in 2000 was 17,980,000 tonnes per annum, with the potential to generate 3,198 GW-hours, with a potential capacity of 365 MW. The mills are estimated to produce 31,500 million m3 of POME per year, with a potential to generate 1,587 GW hours, with a capacity of 177 MW.

With the above scenario, many palm oil mill owners do actually have the potential to generate electricity which can be sold to big energy suppliers like Tenaga Nasional Berhad (TNB). All palm oil mills in Malaysia use palm fibre and shell (by products of oil palm milling) as the boiler fuel to produce steam and

Sample	Heat Value (kJ/kg)	Ash (%)	Volatile Matter (%)	Moisture (%)	Hexane Extraction (%)
Empty Fruit Bunches (EFB)	18,795	4.60	87.04	67.00	11.25
Fibre	19,055	6.10	84.91	37.00	7.60
Shell	20,093	3.00	83.45	12.00	3.26
Palm Kernel Cake	18,884	3.94	88,54	0.28	9.35
Nut	24,545	4.05	84.03	15.46	4.43
Crude Palm Oil	39,360	0.91	1.07	1.07	95.84
Kernel Oil	38,025	0.79	0.02	0.02	95.06
Liquor from (EFB)	20,748	11.63	78.50	88.75	3.85
Palm Oil Mill Effluent (POME)	16,992	15.20	77.09	93.00	12.55
Trunk	17,471	3.39	86.73	76.00	0.80
Petiole	15,719	3.37	85.10	71.00	0.62
Root	15,548	5.92	86.30	36.00	0.2

Table 2 Energy Database for Palm Biomass (PTM, 1999)

electricity for palm oil production processes. Such biomass fuel can supply enough electricity to meet the energy demand of a palm oil mill. It is estimated that in year 2004 about 1400 million kWh of electricity was generated and consumed by the palm oil mills (Ma and Yusof, 2005). However, the mills generally have excess fibre and shell, which are not used and are disposed off as wastes. In other words, the palm oil mills still have excess capacity to potentially produce additional renewable energy. Apart from palm fibre and shell, EFB provide considerable source of biomass which can be readily converted into energy. The energy data analyzed for various palm biomass is shown in *(Table 2)*. The data provides useful information for the utilization of palm biomass as boiler fuels.

No.	Type	Energy Resources	Approved Application	Grid Connected Capacity (MW)	%
1.	Biomass	Empty Fruit Bunches	25	165.9	52.8
		Wood Residue	1	6.6	2.1
		Rice Husk	2	12	3.8
		Municipal Solid Waste	1	5	1.6
		Mix Fuel	3	19.2	6.1
2.	Landfill Gas		5	10	3.2
3.	Mini-hydro		25	95.4	30.4
4.	Wind and Solar		0	0	0
	Total		62	314.1	100

Table 3. Status of SREP Projects Approved by Score as of September 2004 (Ludin et al, 2004).

The launch of the Small Renewable Energy Power Programme (SREP) in May 2001, an initiative of the special Committee on Renewable Energy (SCORE) under the Ministry of Energy , Communication and Multimedia (MECM), " kick started" the Government's policy implementation to encourage and intensify the utilization of RE in power generation. SREP's primary objective is to facilitate the expeditious implementation of grid – connected renewable energy resources-based small power plants (Husain and Alimat, 1999).Under this scheme, license is issued to generate and sell energy for 21 years and maximum power allowable for export is 10 MW and with added tax benefits. The status of SREP projects approved by score as of September 2004 by the Malaysian Government is shown in *(Table 3)*.

One of these projects is a 5.2 MW power plant at Pantai Remis Palm Oil Mill, Perak , EFB as fuel. It is connected to the national grid to supply power to a small town located a few kilometers from the station and export electricity to TNB at the rate of US$ 0.043 per kWh (Husain et al, 2003; Jamari, 2002; Nicholas, 2002; Zakaria, 2002). Pusat Tenaga Malaysia (PTM) or Malaysia Energy Centre has been given the mandate to spearhead the implementation of the Biomass Power Generation and Cogeneration in the Malaysian Palm Oil Industry (BIOGEN) project under the helm of the Ministry of Energy, Communication and Multimedia (MECM) in 2003. The project is jointly funded by the Government too repetitive, United Nations Development Programme (UNDP),

Global Environment Facility (GEF) and the Malaysian private sector. The main objectives are to reduce the growth rate of green house gases (GHG) emissions from fossil fuel fired combustion processes. It is envisaged that at the end of the project implementation, GHG emission from power generation in Malaysia is reduced by 3.8%. This reduction could be made possible through fuel substitution as a result of the expected increase in installed capacity from RE power generation. The project also aims to remove some impending barriers that have been hampering RE power project development through strengthening of technical, financial and policy frameworks (PTM, 2003).

The Federal Land Development Authority (FELDA) is another Malaysian government agency that is actively conducting research on use oil palm waste to produce substitute fuel for diesel. The agency has completed building a biomass power plant in Lahad Datu, Sabah, East Malaysia and plans to build 10 more in Peninsular Malaysia. It will spend about USD 1 million for each plant once it receives an approval from the Energy Commission, Malaysia (Abas, 2005). Pusat Tenaga Malaysia (PTM) or Malaysia Energy Centre has been given the mandate to spearhead the implementation of the Biomass Power Generation and Cogeneration in the Malaysian Palm Oil Industry (BIOGEN) project under the helm of the Ministry of Energy, Communication and Multimedia (MECM) in 2003. The project is jointly funded by the Government too repetitive, United Nations Development Programme (UNDP),

Global Environment Facility (GEF) and the Malaysian private sector. The main objectives are to reduce the growth rate of green house gases (GHG) emissions from fossil fuel fired combustion processes. It is envisaged that at the end of the project implementation, GHG emission from power generation in Malaysia is reduced by 3.8%. This reduction could be made possible through fuel substitution as a result of the expected increase in installed capacity from RE power generation. The project also aims to remove some impending barriers that have been hampering RE power project development through strengthening of technical, financial and policy frameworks (PTM, 2003).

The Federal Land Development Authority (FELDA) is another Malaysian government agency that is actively conducting research on use oil palm waste to produce substitute fuel for diesel. The agency has completed building a biomass power plant in Lahad Datu, Sabah, East Malaysia and plans to build 10 more in Peninsular Malaysia. It will spend about USD 1 million for each plant once it receives an approval from the Energy Commission, Malaysia (Abas, 2005).

Biogas Production from POME

Besides solid residues, palm oil mills also generate large quantities of liquid waste in the form of palm oil mill effluent (POME), which, due to its high biochemical oxygen demand (BOD), is required by law to be treated to acceptable levels before it can be discharged into watercourses or onto land. In a conventional palm oil mill, about 0.7 m3 of POME is generated for every tonne of FFB processed. Anaerobic process is adopted by the palm oil mills to treat their POME the biogas produced during the decomposition is a valuable energy source. It contains about 60-70 per cent methane, 30-40% carbon dioxide and trace amount of hydrogen sulphide (Ma et al., 1999; Quah and Gillies, 1981). Its fuel properties are shown in *(Table 4)* together with other gaseous fuels.

	Biogas	Natural Gas	LPG
Gross calorific value (MJ/Nm^3)	19.85 - 25.75	3.79	100.48
Specific gravity	0.847–	0.584	1.5
Ignition Temperature (°C)	1.002	650 - 750	450 - 500
Inflammable limits (%)	650 - 750	5 - 15	2 - 10
Combustion air required (m^3/m^3)	7.5 - 21	9.6	13.8
	9.6		

All gases evaluated at 15.5oC, atmosphere pressure and saturated with water vapour.
LPG - Liquefied petroleum gas.
Source : Quah and Gillies (1981).

Table 4 Some properties of gaseous fuels

Year	Palm Oil Production (Million Tonnes)	POME (million m^3)	Biogas (million m^3)	Electricity (million KWh)
1997	9.07	32	896	1613
2004	13.98	49	1372	2470

Source: Ma and Yusof (2005)

Table 5 Potential energy from biogas

It was estimated that one cubic meter of biogas is equivalent to 0.65 litre of diesel for electricity generation. Hence the total biogas energy can substitute 582 million litres of diesel in 1997. This amounted to RM378 million. Again the amount of biogas generated by an individual palm oil mill is not significant for commercial exploitation. However, the economic viability may be attractive if palm oil mills can utilise all the fibre, shell EFB, and biogas for steam and electricity generation. So far, only a few oil mills harness the biogas for heat and electricity generation (Quah and Gillies, 1981; Quah et al., 1982; Gillies and Quah, 1984; Chua and Gian, 1986). The potential energy from biogas generated by POME is shown in *(Table 5)*. A successful example of closed tank anaerobic digester system for POME biogas capture and utilization is Keck Seng (Malaysia) Berhad.The system has been in continuous operation for over 19 years practically without any interruptions. The company has been awarded the ASEAN Energy Award 2003 for the Off-Grid category in New Renewable Source of Energy Project Competition.

Biodiesel as RE in Malaysia

The government has announced the introduction of a National Biofuel Policy on 10 August, 2005. The policy is primarily aimed at reducing the country fuel import bill, promoting further the demand for palm oil which will be the primary commodity for biofuel production (alongside regular diesel), as well as to shore up the price of palm oil especially during periods of low export demand. Palm oil based methyl ester has been studied thoroughly as a diesel substitute in Malaysia (Mukti et al, 1984; Ong et al, 1985; Azhar et al, 1989; Masjuki and Sohif, 1991; Masjuki et al, 1993; Choo et al, 1995; Choo and Ma, 2000; Ali and Tan, 2005). Crude palm oil, crude palm stearin and crude palm kernel oil can be readily converted to their methyl esters. Ho et al (2005) proposed the application of immobilized lipase as an enzymatic catalytic tooptimize the transestrification process. They claimed that this process could lower the production cost of biodiesel.

The production by PORIM/PETRONAS patented technology (Choo and Ma, 2000; Ong et al., 1989) has been adequately described (Ma et al., 1993). Methyl esters from crude palm oil and crude palm stearin produced by PORIM/PETRONAS technology have very similar fuel properties as the petroleum diesel *(Table 6)*. It also has a higher cetane number than diesel *(Table 7)*. It can be used directly as fuel in unmodified diesel engines.

As an initial step to commercialize biodiesel in Malaysia, two biodiesel plants will be built at Port Klang, Selangor and Pasir Gudang, Johor, respectively. The project is a co-operation between Malaysian Palm Oil Board (MPOB) and three selected palm oil manufacturers. Each plant is estimated to have biodiesel production capacity of 60,000 metric ton.

Property	Malaysian diesel	Methyl esters from CPO	Methyl esters from CPS	Palm diesel with low pour point
Specific gravity ASTM D 1298	0.8330 at 15.5°C	0.8700 at 23.6 °C	0.871 at 25.5 °C	0.8803 at 15.5 °C
Sulphur content (% wt) IP 242	0.10	0.04	0.02	<0.04
Viscosity at 40°C (cSt) ASTM D 445	4.0	4.5	4.6	4.5
Pour Point (°C) ASTM D 97	15.0	16.0	17.0	-15.0
Distillation D 86 (°C) I.B.P 10% 20% 50% 90% F.B.P.	 228.0 258.0 270.0 298.0 376.0 400.0	 324.0 330.0 331.0 334.0 343.0 363.0	 320.2 331.0 332.0 335.0 343.0 349.0	N/A
Final recovery (%)	N/A	98.0	98.5	N/A
Cetane Index ASTM D 976	53	50	52	N/A
Gross heat of combustion (kJ/kg) ASTM D 2382	45, 800	40, 135	39, 826	39,160
Flash point (°C) ASTM D 93	98	174	165	153
Condrason carbon residue (% wt.) ASTM D 189	0.14	0.02	0.05	0.01

Sources: Ma and Yusof (2005).

Table 6 Fuel characteristics of Malaysian diesel, methyl esters from crude palm oil (CPO), methyl esters from crude palm stearin (CPS) and palm diesel with low pour point

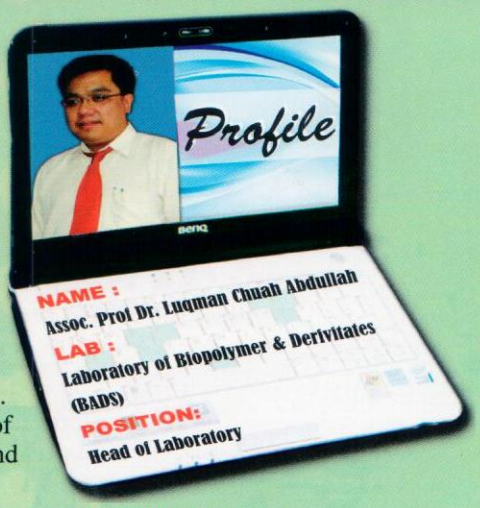
Blends		Cetane number ASTM D613
CPO methyl esters (%)	Petroleum diesel (%)	
100	0	62.4
0	100	37.7
5	95	39.2
10	90	40.3
15	85	42.3
20	80	44.3
30	70	47.4
40	60	50.0
50	50	52.0
70	30	57.1

Sources: Ma and Yusof (2005).

Table 7 Cetane numbers of crude palm oil methyl esters, petroleum diesel and their blends

Conclusions

In the 8th Malaysia Plan, renewable energy is considered the fifth fuel in addition to petroleum, gas, coal and hydro. However, Malaysian energy supply is still mainly sourced from fossil fuels. The progressive escalation of fuel price in recent times has led to an intensive study in using renewable energy. Oil palm based biomass is the most potential source of renewable energy in Malaysia. Residues obtained from the harvesting and milling of the oil palm plantation can be utilised as fuel for energy generation. Palm oil industry is bestowed with huge supply of by-products that can be readily used as energy source with ease. Efforts are being made to connect the excess energy supply in the form of electricity from the palm oil mills to National Grid. Besides, Malaysia is also strongly promoting the use of palm diesel as replacement of fossil fuel. Currently, biofuel policy framework has been drafted by the government and will soon be implemented in the country to encourage the uses of biofuels.



REFERENCES

By : Assoc. Prof Dr. Luqman Chuah Abdullah

Abas A. 2005. Biomass does Felda a power of good. New Straits Time, 31 August, 2005.

Ali A. and Tan A. M. (2005). Biodiesel fuel from palm oil: feasibility and yield study, in proceeding of 2nd International Conference on Chemical and Bioprocess Engineering, Kota Kinabalu, Sabah, Malaysia, Paper no. PPI-2.

Azhar, A.A, Zainol Anuar B.M.S and Darus, A.N. 1989. Investigation into the use of palm diesel as fuel in unmodified diesel engines. In proceedings Second ASEAN Science and Technology Week, 30 - 31 January 1989, Manila, Philippines, 430-448.

Borja R.and Banks C.J. 1995. Comparison of an anaerobic filter and an anaerobic fluidized bed reactor treating palm oil mill effluent. Process Biochem 30:3 511 –521.
Choo Y. M., Ong A. S. H., Cheah K.Y. and Bakar A. 1988. Production of methyl esters from oils and fats. Australian Patent No. P J 1105/88.

Choo Y. M., Ma A. N. and Yusof B. 1995. Production and evaluation of palm oil methyl esters as diesel substitute. Elaeis Special Issue 5: 25.

Choo Y. M. and Ma A. N. 2000. Plant Power. Chemistry & Industry 8: 530-534.

Choo Y. M., Cheng S. F., Yung C. L., Lau H. L. N., Ma A. N. and Yusof B. 2002. Low pour point palm diesel. Malaysian Patent No. PI 20021157.

Chua N.S. and Gian H. F. 1986. Biogas production and utilization-Keck Seng's experience. In proceeding of National Workshop on Recent Developments in Palm Oil Milling Techniques and Pollution Control, 5-6 August 1986, Kuala Lumpur, Malaysia.

Chuah T. G. and Azni I. 2003. Biomass as the renewable energy sources in Malaysia. Buletin Ingenieur 20: 50-52.

Economic Planning Unit (EPU),1999. Support to the Development of a Strategy for RenewableEnergy as a Fifth Fuel in Malaysia, Kuala Lumpur, Economic Planning Unit, PrimeMinister's Department, Government of Malaysia.

Faisal M and Unno H. 2001. Kinetic analysis of palm oil mill wastewater treatment by a modified anaerobic baffled reactor. Biochem Eng J. 9: 25– 31.

Gillies D. and Quah S.K. 1984. Tannamaram Biogas Project. In proceeding of 2nd ASEAN Workshop on Biogas Technology, Kuala Terengganu, Malaysia, 277-292.

Ho K. C, Chan E. S. and Ravindra P. (2005). Production of biodiesel using transesterification of palm oil. In proceeding of 2nd International Conference on Chemcial and Bioprocess Engineering, Kota Kinabalu, Sabah, Malaysia, Paper no. PPI-23.

Husain Z, Alimat A. 1999. Use of condensing steam turbine in palm oil mill—A new approach (case study). Journal of Institution of Engineer 60(2): 75–81.

Husain Z., Zainal Z.A., Abdullah M.Z. 2003. Analysis of biomass-residue-based cogeneration system in palm oil mills. Biomass and Bioenergy 24: 117 – 124.

Jamari I. 2002. Introduction to SREP and application. Regional Road Show on SREP for Palm Oil Industry, Kuantan, April, 2002.

Ludin N. A., Bakri M.A.M., Hashim M., Sawilla B., Menon N. R., Mokhtar, H. 2004. Palm oil biomass electricity generation in Malaysia. Jurutera 11: 16-20.

Ma A. N., Choo Y. M., Cheah K. Y., Ahmad, H., Rusnani M., Yusof B., Abu B., Ariffin A. and Ong A. S. H. 1993. New Technology for production of methyl esters from crude palm oil and palm oil products. In proceeding of PORIM International Palm Oil Conference, 20-25 September, 1993, Kuala Lumpur, Malaysia.

Ma A. N., Toh T.S., Chua N.S. 1999. Renewable energy from oil palm industry. In Oil Palm And The Environment: A Malaysian Perspective, edited by G. Singh, K. H. Lim, T. Leng and L. K. David. Kuala Lumpur: Malaysia Oil Palm Growers' Council.

Masjuki H.H. and Sohif M . 1991. Performance evaluation of palm oil diesel blends on small engine. Journal of Energy, Heat and Mass Transfer 13:125-133.

Masjuki H.H., Zaki A.M. and Sapuan S.M. 1993. Methyl ester of palm oil as an alternatives diesel fuel. In proceeding of Second International Seminar on Fuels for Automotives and Industrials Diesel Engines, IMechE , London , UK, pp. 129-137.

Ma A. N. and Yusof B. 2005. Biomass energy from the palm oil industry in Malaysia. The Ingenieur 27: 18-25.

Mukti M.A.A., Yusuf M.Z.M and Ali, A.R. 1984. Palm oil as alternative fuel diesel engines, PORIM Bulletin 9: 22-34.

Mustapha S, Ashhuby B, Rashid M, Azni I. 2003. Start-up strategy of a thermophilic upflow anaerobic filter for treating palm oil mill effluent. Trans IChemE 81: 262– 266.

Najafpour G, Yieng HA, Younesi H, Zinatizadeh A. 2005. Effect of organic loading on performance of rotating biological contactors using palm oil mill effluents. Process Biochem 40: 2879–2884.

Nicholas L. 2002. Power generation from palm oil mills: design option and costing. Regional Road Show on SREP Program for Palm Oil Industry, Kuantan, April, 2002.

Ong A.S.H., Choo Y.M., Hiam H.A and Hock G.S. (1985). Palm Oil as Alternatives Renewable Energy, Proceeding of 3rd ASCOPE Conference, Kuala Lumpur, Malaysia, pp. 441-458.

Ong A.S.H., Hiam H. A., Yusuf B., Choo Y. M. and Gapor M. T. 1989. Palm vitamin E and palm diesel pilot plants. In proceeding of Symposium on Development in Palm Oil, Kuala Lumpur, Malaysia, pp. 45-55.

Pusat Tenaga Malaysia (PTM). 1999. Renewable energy Resources and applications in Malaysia, Pusat Tenaga Malaysia (PTM), internal report.

Pusat Tenaga Malaysia (PTM). 2004. Renewable Energy-A Legacy Worth Fighting For? BioGen News .1(2): 2-3.

Pusat Tenaga Malaysia. 2003. Annual Report. Kuala Lumpur: PTM.

Quah S.K. and Gillies D. 1981. Practical experience in production and use of biogas. In proceeding of National Workshop on Oil Palm By-Product Utilisation, PORIM, Kuala Lumpur, pp.119-125.

Quah S.K., Lim K. H., Gillies D., Wood B. J. and Kanagaratnam K. 1982. Sime Darby POME treatment and land application system. In proceeding of Regional Workshop on Oil Palm Mill Technology and Effluent Treatment. PORIM, Kuala Lumpur, pp.119-125.

RWEDP. 1998. Biomass energy in ASEAN member countries. Food and Agricultural Organisation (FAO) Regional Wood Energy Development Programme in Asia Report.

Zakaria I. 2002. Renewable energy program from national perspective. Renewable Energy Power (SREP) Program for Palm Oil Industry, April 2002.