Applying Green Technology in the Palm Oil Industry

by Ir. Ooi Ho Seng

THE palm oil industry has abundant biomass resources that can play a prominent role in the generation and application of green technology in this country. The successful utilisation of biomass for power generation will reduce the use of energy from fossil sources and diversify the sources of energy. At the same time, it can contribute towards mitigating greenhouse gas (GHG) emissions.

Palm oil millers in Malaysia may want to consider investing in downstream processing activities to take advantage of the available renewable energy from biomass at palm oil mills. The efficiency of heat and electrical energy generation at these mills can be significantly increased by investing in more efficient power plants, boilers and steam turbine generators.

Biomass from palm oil mills and biogas (from the anaerobic treatment of palm oil mill effluent or POME) will enable the establishment of standalone clusters of biomass power plants. Within each cluster, the biomass power plant can supply the electricity and gas requirements for domestic uses as well as for downstream industrial activities such as crude palm oil refinery, kernel crushing plants and other related industries.

1.0 INTRODUCTION

In Malaysia, electricity is generated using natural gas (70%), diesel oil (1%), fuel oil (7%), hydro (12%) and coal (10%). Electricity is also generated for use within the palm oil industry. Under the National Energy Policy, renewable energy was emphasised as the fifth fuel after gas, oil, coal and hydro. The medium target of renewable energy is a 5% share in electricity generation. In 2001, the Malaysian government launched the Small Renewable Energy Power (SREP) programme that aimed at encouraging the private sector to undertake small power generation projects using renewable resources including biomass, biogas, municipal waste, solar, mini-hydro and wind energy. However, various implementation problems were encountered which included:

a) the uncertainty of long term fuel supplies,
b) long negotiation of the Renewable Energy Power Purchase Agreement (REPPA),
c) difficulty in securing loans to finance the projects.

In 2005, TSH Bio-Energy Sdn Bhd started operating on the first grid that connected biomass-based power plants in Malaysia. Its plant in Sabah had an installed capacity of 14MW, of which 10MW was for the grid connection.

The palm oil industry, which has abundant biomass resources, is expected to play a prominent role in the generation and use of renewable energy in the country. The successful utilisation of biomass from the palm oil industry will reduce the use of energy from fossil sources and diversify the sources of energy and, at the same time, contribute towards the global effort of mitigating greenhouse gases (GHG) emissions.

Following a Cabinet reshuffle in 2009, the Ministry of Energy, Green Technology and Water was formed. Among other things, the new ministry's focus will be to ensure a healthy balance of energy generation sources for Malaysia. An ideal ratio of energy source from fossil fuel, hydro power, solar power, wind power, coal, wave power and bio-diesel will be determined so that Malaysia will not be overly dependent on only a few sources of fuel.

The strategies outlined by the Ministry include:

- Effective implementation and promotion of green technology in all sectors.
- Creation of opportunities for new green business development, including the manufacturing of "green products".
- Reorientation of existing industries to adopt green practices.
- Development of R&D strategies in green technologies toward commercialisation for the local environment, and enhancement of human capacity development on green technologies.
- Establishment of strategic alliances with various key and relevant local and international stakeholders.
- Creation of a green technology fund (e.g. under a "polluter pays" concept).
- Creation of the National Green Technology Advisory Council (to monitor the progress and implementation of green technology).
- Creation of an effective green technology implementation agency (with one of its functions being to keep an inventory of new green technologies and horizon scanning).

On the implementation level, the government is promoting the use of alternative power sources such as solar panels, biomass and hybrid engines that will reduce the dependence on fossil fuel (or other sources) that contribute to higher carbon emissions.

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1.1 Definition of Green Technology

According to the Ministry of Energy, Green Technology and Water (MEGTW, 2011), green technology is the development and application of products, equipment and systems used to conserve the natural environment and resources, while minimising and reducing the negative impact of human activities. Green technology refers to products, equipment or systems that satisfy the following criteria:

- It minimises the degradation of the environment;
- It has zero or low GHG emission. It is safe for use and promotes a healthy and improved environment for all forms of life;
- It conserves the use of energy and natural resources; and
- It promotes the use of renewable resources.

1.2 Four Pillars of Green Technology Policy

- ***Energy*** – Seek to attain energy independence and promote efficient utilisation;
- ***Environment*** – Conserve and minimise the impact on the environment;
- ***Economy*** – Enhance the national economic development through the use of technology; and
- ***Social*** – Improve the quality of life for all.

2.0 BIOMASS RESOURCES IN THE PALM OIL INDUSTRY

The Ministry of Energy, Green Technology and Water has identified palm oil biomass as the largest agricultural resource material in Malaysia for the production of renewable energy. The sources of biomass that are available from oil palm plantations include:

a) Felled palm trunks (replanted after 30 years) of 74.48 kg/ha in dry weight.
b) Palm fronds (cut during replanting) of 14.47 kg/ha in dry weight.
c) Palm fronds (pruned annually) of 10.40 kg/ha in dry weight.

A large amount of biomass (solid wastes) and liquid wastes are produced at palm oil mills during the processing of fresh fruit bunches (FFB) as shown in Table 1.

Empty Fruit Bunches (EFB) that are not utilised need to be disposed of. The conventional methods of disposing palm oil mill wastes are as follows:

- EFB: mulching and composting (outdoor method)
- Decanter solids: dumping in the fields
- POME: pond system, polishing, land discharge, water course discharge
- Boiler ash: dumping in the fields

2.1 Empty Fruit Bunches

Previously, these were incinerated in EFB incinerators to produce bunch ash (0.5% FFB). However, this is no longer allowed by the Department of Environment. The current practice is mulching in the estates. Research at local universities has shown that they can be used for producing mats, fibreboard, etc. Ongoing studies include the evaluation and development of potential methods of extracting the high-value waxes and chemical compounds that are present in EFB. Technologies are available to extract ethanol from EFB, but this is not widely practised.

2.2 Kernel Shell

Palm nuts are miniature replica of coconuts. The nuts are cracked by machines, while the kernels and shells are separated by winnowing columns and hydro-cyclone or clay bath. The kernels are crushed to recover kernel oil (50%) by weight. Kernel shells are partly used as fuel in mill boilers, while most of it is traded as it is a much sought after raw material in other industries.

2.3 Mesocarp Fibre

The press cake consists of fibre and nuts that are almost equal in weight. The fibre portion constitutes about 13% by weight to FFB. Almost all the fibres are used as fuel by mill boilers to generate steam that drives the turbo-generators. The exhaust steam (at 3 bar) is used for process heating. The mill is self sufficient in electricity generation. The moisture content of the fibre varies from 40% to 60%. The calorific value of the fibres varies from 8,000 KJ/kg (at 50% moisture) to 10,000 KJ/kg (at 40% moisture) as shown in Table 2. The fibre contains some oil, which can boost the calorific value by about 1,000 KJ/kg.

Table 1: Biomass and liquid wastes produced at palm oil mills (Source: MPOB, 2005)

	FFB	EFB	Kernel Shell	Mesocarp Fibre	Steriliser Condensate	Centrifuge Sludge	Hydro-cyclone washing
% FFB	100	22	5.5	13.5	12	50	5
tons/ha	20.08	4.42	1.1	2.71	2.46	10.04	1.1
Dry Weight in kg/ha	10.59	1546 (35% EFB)	938 (85% shell)	1626 (60% fibre)			

Table 2: Calorific values of palm wastes (Source: MPOB, 2005)

Moisture Level	Kernel Shell		Mesocarp Fibre		EFB	
	Pure	Oily	Pure	Oily	Pure	Oily
0	20720	20930	19670	20720	17580	18836
10	17245	18836	-	-	-	-
40	-	-	10778	11344	-	-
50	-	-	-	9134	7534	8162
60	-	-	-	-	5525	6028

3.0 RENEWABLE ENERGY FROM PALM OIL MILL BIOMASS

To produce energy, biomass is combusted in the furnace of boilers to produce steam. The steam is passed through the steam turbine to generate electricity and the exhaust steam is used for all the heating needs in the mill. The technology used in the combustion of biomass for heat and power generation has remained stagnant over the years in this country. This is because palm oil mills are able to meet all their energy requirements using low-cost low-efficient steam boilers and steam turbines. Therefore, they see no reason to improve the technology.

Most of the existing biomass combustion systems in Malaysia utilise low efficiency low-pressure boilers. The average conversion efficiencies in process steam and electricity generation are 35% and 3% respectively, while the efficiency in cogeneration is around 38%.

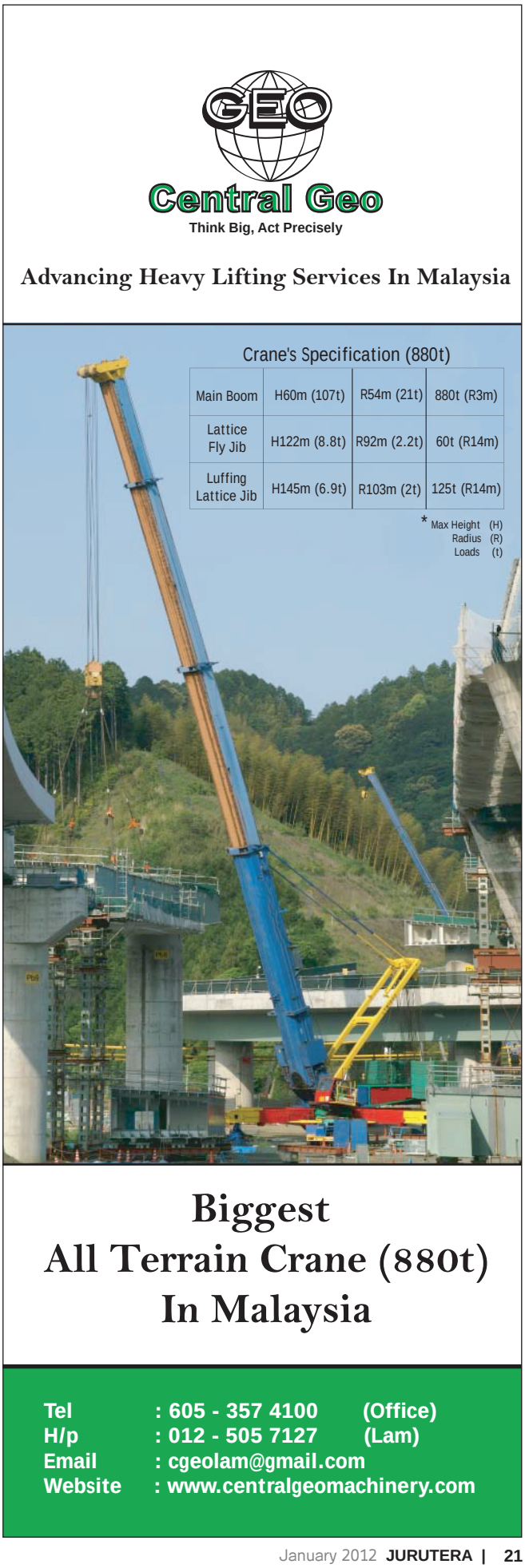
Commercially proven technologies are available in the international market for the efficient production of power and heat from biomass resources. Modern technologies that utilise efficient high-pressure boilers are capable of dual fuel burning, utilising either liquid (e.g. diesel oil) or gas (e.g. natural gas) fuel as a supplementary energy source.

Dual-fired boilers can be used in palm oil waste-fired boilers to facilitate the use of POME-derived biogas as supplementary fuel. On the down side, the latest equipment for biomass-based power generation and combined heat and power (CHP) are not manufactured locally and have to be imported. The capital costs incurred to modernise a mill can be quite high.

3.1 Utilising Biomass at the Palm Oil Mill

There are more than 400 palm oil mills in the country and the processing capacities of these palm oil mills can vary from less than 15t/h (tonnes per hour) to more than 90t/h of FFB. The strategies to be adopted for the generation and utilisation of renewable energy from oil palm mill solid wastes (or biomass) at the mill may include:

i. Minimising the production of wastes by upgrading and improving the design of the processing machinery that are used in palm oil mills.



ii. Aim towards zero discharge of the wastes by using up all the biomass (solid wastes) and liquid wastes that are produced at the mill.
iii. Improve the biomass combustion efficiency through improvement in the design of the boiler burner (furnace) and in the preparation of the biomass fuel.
iv. Replace machines in palm oil mills that use fossil fuel (diesel or gasoline) with steam driven or electrically driven ones.
v. Search for a more efficient and cost effective technology to increase the efficiency of the steam boiler and steam turbine.
vi. Eliminate all sources of GHG emission in the system, e.g. methane emission from anaerobic ponds, from EFB dumpsites, etc.
vii. Reduce heat and energy losses to improve the efficiency of energy utilisation in the mill by using insulators, waste-heat exchangers, etc.

4.0 RENEWABLE ENERGY (BIOGAS) FROM PALM OIL MILL EFFLUENT

About 150,000mt of POME (liquid waste) is produced by a conventional 45mt per hour palm oil mill a year. The liquid wastes are treated by conventional effluent treatment system, and a large amount of biogas (methane plus carbon dioxide gases) is emitted from the anaerobic ponds during the process. This biogas, if collected, can become an additional source of energy for palm oil mills. However, at present, most of the POME-derived biogas is not recovered and is just allowed to dissipate freely into the atmosphere. The biogas systems that have been investigated include:

a) digester tanks and
b) covered lagoon digesters.

Various techniques have been used for treating the wastewater by anaerobic digestion and these include the continuous stirred-tank reactor (CSTR), the up-flow anaerobic sludge blanket/bed (UASB), the advanced expanded granular sludge bed (EGSB), the up-flow solids reactor (USR) and others (Lian, 2011). Prior to pumping the POME to the digester tank, pre-treatment is done to break down the big molecules of sludge into smaller ones for easy biodegradation by microorganisms in the digester tank, thus stirring is not required.

4.1 Utilising Biogas at the Palm Oil Mill

A typical biogas system comprises four components, namely, the anaerobic digester (AD), the gas holder or storage, the flare stack, and the CHP plant. Biogas is produced at the AD, while the gas holder acts as the biogas buffer or storage tank. The flare stack will burn up excess biogas, while the CHP plant generates electricity from the biogas source (Dickinson, 2011).

A typical piping system design and installation (including safety and controls) in fuel gas reticulation systems can be used to pipe the biogas from the anaerobic digestion tanks or covered lagoon bio-digester. The collected biogas can also be stored in a central storage tank and then treated to remove the hydrogen sulphide. Even though burning or flaring the biogas will release carbon dioxide into the atmosphere, this method is being encouraged because methane as a GHG is 21 times more potent than carbon dioxide.

The conventional effluent treatment plant is a low-cost system, and has no provision to prevent methane gas from being released into the atmosphere. Biogas projects that are based on POME are generally limited in size because the POME produced by a 90tph mill can only generate enough biogas for a 150kW micro-turbine.

5.0 BENEFITS FROM APPLYING GREEN TECHNOLOGY AT THE MILLS

The benefits of applying green technology at oil palm mills are in line with the Four Pillars of the Green Technology Policy listed in Section 1.2. The sustainability of the environment may be promoted as described in the following.

- Congestion around the mill due to the heaps of solid wastes (EFB) and the degradation of the mill environment are reduced. The emissions of GHG from EFB heaps and POME treatment ponds are reduced.
- Machines within the mill that run on fossil fuel can be replaced with machines that are steam-driven or electrically-driven.

At the same time, the sustainability of this energy source may be promoted as described:

- Savings in energy costs for the handling and disposal of mill wastes.
- Supply of mill wastes (biomass energy source) is assured.
- Dependence on fossil fuels is reduced.
- Fuel sources at the mill are now diversified.
- Supply of biomass and biogas is right at the mill and no delivery cost is incurred.

6.0 DISCUSSION

The present design and operation of palm oil mills are extremely inefficient from an energy usage point of view. A large amount of solid and liquid waste are produced by a palm oil mill, and only some of the biomass is used as fuel to generate steam and electricity for use by the mill itself. Excess biomass is considered as having no marketable value. This situation has contributed to very inefficient energy usage at the mills where energy is considered to be virtually free. The measures that can improve energy usage at a mill include:

i. Use of more energy efficient boilers, steam turbines, process design and operation, efficient electrical motors, variable speed drives and automation. Mill personnel may be trained to maintain and operate the machines efficiently.
ii. Palm oil mills that are located in remote locations may consider setting up factories within its cluster for related

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downstream processes to use the excess energy to produce value-added products such cellulose fibres, bio-plastics, bio-chemicals, health products, biomass fuel pellets/briquettes, etc.

iii. The government can provide incentives to millers to capture the biogas (methane gas and carbon dioxide) that is emitted from their POME anaerobic effluent pond.

iv. The solid biomass, namely, mesocarp fibre, kernel shell and EFB, and biogas (65% methane gas generated by mill effluent) will allow for the establishment of standalone clusters of biomass power plants that provide a domestic supply of electricity and gas within each cluster exclusively to power downstream activities (crude palm oil refinery and kernel crushing plants) and all other related industries such as the production of cellulose fibres, bio-plastics, bio-chemicals, health products, biomass fuel pellets and briquettes.

The treatment of POME to produce biogas has been listed by the Malaysian government as one of the 12 National Key Economic Areas (NKEA) together with tourism industries, business services, wholesale and retail, etc (Lim, 2011). The NKEAs will receive focused government attention and support by the government and its implementing agencies. The government has introduced the Entry Point Projects (EPPs), under the NKEA of the palm oil sector to encourage all palm oil millers to install a biogas system by 2020. According to the Malaysian Palm Oil Board (MPOB), 38 biogas projects have been completed, 34 biogas projects are under construction, and 47 biogas projects are currently in the planning stage.

The Malaysian government has also introduced the Green Technology Financial Scheme (GTFS) in which it will bear 2% of the total interest or profit rate of the companies involved in this sector (Mahfuzah, 2011). It will also provide a guarantee of 60% on the financial amount via Credit Guarantee Corporation Malaysia Bhd (CGC) while the remaining 40% financing risk will be borne by the participating financial institutions (PFIs). The types of financing provided under the GTFS include term loan, overdraft/revolving credit, bank guarantee, working capital, trade lines, etc (Liew, 2011).

7.0 CONCLUSION

The utilisation of biomass from palm oil mills, namely, mesocarp fibre, kernel shell and EFB, and biogas (from the anaerobic treatment of POME) will enable the establishment of standalone clusters of biomass power plants. Within each cluster, a biomass power plant can provide the domestic supply of electricity and gas, as well as power the downstream industrial activities and other related industries. ■

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