A Study on the Malaysian Oil Palm Biomass Sector – Supply and Perception of Palm Oil Millers

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ABSTRACT

From 379 palm oil mills in Malaysia that responded to the survey, about 30% or 120 of them were involved in utilising biomass [either empty fruit bunches (EFB) or palm oil mill effluent (POME)] by turning this biomass into EFB fibre, bio-fertiliser or biogas. Nevertheless, some of the millers who have not been involved in utilising biomass actually returned the EFB to plantation as mulching. Most of the millers agreed that policy related to biomass needs to be firm up. Environment sustainability is a concern of the millers. Study suggested that policy on biomass need to be provided as well as economic evaluation on biomass projects to the millers.

INTRODUCTION

Interest in biomass utilisation in Malaysia has developed at least since the last two decades. Faridah (2001) indicated that the Department of Agriculture (DOA) had implemented a programme in 2001 where farmers were encouraged to collect rice straws for composting. With proper use of compost, the fertiliser requirement for vegetable crops was shown to reduce to one-fifth of the total nutrient requirement.

In general, forestry products are the major raw materials for forest-based industry (FBI) in the country. Norini and Peter (2000) revealed that the forestry sector in Malaysia which produced timber products such as logs, sawn timber and plywood/veneer for furniture industry was shown to be facing shortage of raw materials. With declines in timber production from natural forests, oil palm residues as alternative resources are expected to play a major role in the development of FBI in Malaysia.

As for the oil palm industry, the Oil Palm Tree Utilisation Committee (OPTUC) established in 1991, spurred discussions on strategies for commercial exploitation of oil palm biomass, updating and dissemination of information, and review on the technologies and supply. A series of seminars and conferences have been organised by OPTUC related to oil palm biomass.

The Small Renewable Energy Power Programme (SREP) launched in 2001 was among the steps taken

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by the government to encourage and intensify the utilisation of renewable energy (RE) in power generation (Anuar *et al.*, 2005). Under the SREP programme, the utilisation of all types of RE from biomass to supply power to grid up to 10 MW was encouraged. For the oil palm sector, the utilisation of methane gas captured to generate electricity using gas engine is slowly catching attention of the palm oil millers.

According to Anuar *et al.* (2006), there is a growing need for coal and piped natural gas imports especially from Malaysian-Thailand Joint Development Area (MTDJA) in view of resource constraint. Anuar suggested that the energy supply infrastructure needs to be continuously developed and since it is very capital intensive, therefore it will impose tremendous pressures on the depleting resources. The penetration of biomass into the energy mix in Malaysia needs to be further enhanced because there are still uncertainties and regulation anomalies between RE and conventional energy sources.

The Malaysian government is currently focusing on replacing 5.5% of electricity source using RE as the country progresses towards becoming a developed country by 2020. To support the biomass involvement as part of the Malaysia energy mix plan, in 2010 Malaysian Renewable Energy Act was proposed to Parliament for approval together with the Sustainability Energy Development Authority (SEDA) Act.

OBJECTIVE OF THE STUDY

The objective of the study is to determine the status of biomass activities in palm oil mills and to garner views of the millers on the future of the biomass sector in Malaysia.

MALAYSIAN BIOMASS OUTLOOK

Biomass products in Malaysia represent several wastes such as from timber, oil palm, rice husk, coconut fibres, municipal waste and sugar-cane waste (*Figure 1*). These organic materials have the potentials to be used either in the manufacturing sector for value-added eco-products or to generate energy using renewable sources. Currently, biomass in Malaysia is not fully tapped despite its plentiful supply.

Study by Hamdan (2004) shows that Malaysia produces an estimated 60 million tonnes of biomass every year, which does not include 1200 t of municipal solid waste per day. Related to this activity is an increasing number of biomass-related research work currently undertaken by public research institutions and universities.

The study also indicates that Malaysia has abundant biomass waste resources which are generated from palm oil, wood and agro-industries. Other types of biomass include those from the wood and sugar-cane industries, paddy, municipal solid waste and others. In addition, there is a substantial amount of unexploited biomass waste resources in the form of logging wood residues, rice straw, palm tree trunks and other plant matter residues.

BIOMASS SUPPLY FROM PALM OIL MILLS

Over the past few decades, the palm oil industry in Malaysia has

Empty fruit bunches

Rice husk

Sugar-cane bagasse

Sawdust

Forest residues

Municipal solid waste

Figure 1. Different types of biomass available in Malaysia.

grown significantly. Up to 2010, Malaysia has 4.85 million hectares of oil palm (MPOB, 2010) and this industry contributes about RM 60 billion in term of export revenues in 2010 for the country. Malaysia produced about 40 000 to 50 000 t of crude palm oil (CPO) per day and production is expected to enjoy steady growth in the coming years based on current trend for the past four years (*Table 1*).

The CPO production had increased from 15.82 million tonnes in 2007 to 17.73 million tonnes in 2008, an increase of 2 million tonnes. Due to weather condition and biological factors, the CPO production however experienced marginal decline of 0.17 million tonnes between 2008 and 2009 and 0.57 million tonnes between 2009 and 2010.

Table 2 shows that the total fresh fruit bunch (FFB) processing capacity in 2010 was 97 million FFB per year. The palm oil industry is capable of generating a vast quantity of palm biomass, in line with the growth of the industry. Oil palm biomass can be generated from two different sources, namely from plantations and the mills. Biomass from the plantation is mainly in the form of trunks and fronds. The trunks of oil palm is mostly available during replanting while fronds can be obtained from the pruning activity but they are mainly left on the ground for recycling as fertiliser. Biomass from the mills consists of empty fruit bunches (EFB), mesocarp fibre, palm kernel shell and palm oil mill effluent (POME). These biomass are produced daily and more consistent in term of supply compared to oil palm trunks.

In general, biomass products such as palm kernel shell and mesocarp fibres are burnt to generate steam for the mills. The EFB will normally be returned to the plantations while POME is treated before discharge. In 2010,

TABLE 1. MALAYSIAN CRUDE PALM OIL (CPO) PRODUCTION AND PLANTED AREA

Year	CPO production (million tonnes)	Area (million hectares)
2007	15.82	4.304
2008	17.73	4.487
2009	17.56	4.691
2010	16.99	4.853

Source: MPOB (various issues).

TABLE 2. STATUS OF PALM OIL MILLS (2010)

	Peninsular Malaysia	Sabah	Sarawak	Malaysia
No of mills	247	121	50	421
Processing capacity (million tonnes)	55.157	31.059	11.164	97.380

Source: MPOB (2010).

TABLE 3. ESTIMATED BIOMASS PRODUCTION FROM PALM OIL MILLS (2010)

Type	% from FFB	Quantity (million tonnes)*
Empty fruit bunches (EFB)	23	19.3
Mesocarp fibres	13	10.9
Palm kernel shells	5	4.2
Palm oil mill effluent (POME), wet basis	60	50.3
Total	-	84.74

Note: *based on 83.9 million tonnes of FFB processed in 2010.
FFB - fresh fruit bunches.

there were 421 palm oil mills in operation which processed about 83.9 million tonnes of FFB. This implies 86% utilisation rate from the total capacity of 97.3 million tonnes. The total amount of biomass generated is estimated at about 84.74 million tonnes (*Table 3*).

DESCRIPTION ON BIOMASS UTILISATION FROM PALM OIL MILLS

The Oil Palm Fibres

The oil palm fibre is produced from EFB after the extraction of oil from the mesocarp. It is a natural fibre that is extracted from the vascular bundles of the EFB. The EFB will go through the process that involves shredding, separating, refining and drying. No chemicals were involved in the production of oil palm fibres. High quality oil palm fibres must be clean, toxic-free and meet specifications.

After the process, the end product of high quality oil palm fibre can be used in the manufacture of various fibre composites such as furniture, mattress, erosion control, paper production, sofa/car seat and also landscaping.

The specifications of the oil palm fibres are indicated in *Table 4*. The technology can be obtained locally or from abroad. The major components are the shredder, dryer and bailing machines. *Figure 2* shows the process of producing the EFB fibres.

The system starts with EFB pressing unit where EFB need to be pressed to reduce the moisture content. After moisture content had been reduced, the EFB will go through the shredding machines that turn the bunch into fibre form. A hammer mill is used to produce fibres according to specific length. To control moisture and to dry the fibres, a steam dryer is used. Bailing is done to facilitate transporting of the EFB fibres.

The total cost of establishing the system was estimated at around RM 2 to RM 3 million (as of 2007) and the average cost to produce EFB fibre is estimated at around RM 350-RM 450/t. The selling price (ex mill) was around RM 400 – RM 600/t depending on the length and dryness of the fibres. Some of the producers will not just selling EFB fibres alone but also produce finished products from EFB fibres such as oil palm fibre particleboards. Palm fibre particleboards can be turned into plywood and medium density fibres.

TABLE 4. OIL PALM FIBRE SPECIFICATION

Description	Specification
Fibre length	12.5–35 cm
Moisture	Less than 12%
Impurities (dust)	Less than 15%
Oil content	Less than 3%
Bale weight	220 kg +/- per bale
Bale size	60 × 62.5 × 112 cm
Bulk density	27.67 kg/m^3
Tensile strength	979.89

Source: fibromat.com.my

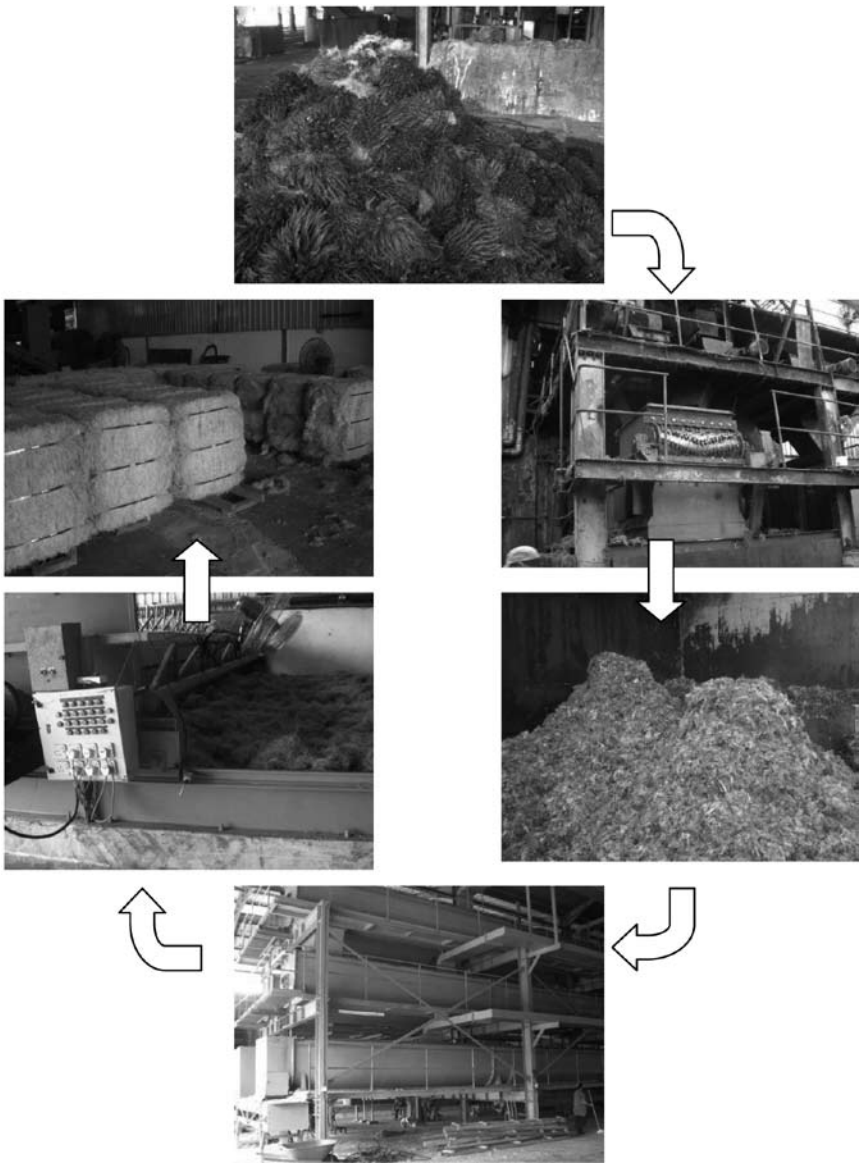

Figure 2. Stages in empty fruit bunches (EFB) fibre production.

Methane Trapping (biogas)

Anaerobic covered-lagoon bio-digester system. This technology uses synthetic high density polyethylene (HDPE) to cover existing anaerobic POME lagoon or new lagoon to capture the biogas (*Figure 3*). The technology includes multiple agitators to turn over the POME and a sludge handling system that enables sludge removal without breaking the digester's air tightness. The average biogas production is 300 m^3/hr.

Digester tank. The technology consists of a digester tank equipped with completely stirred tank reactor

Figure 3. Synthetic high density polyethylene (HDPE).

Figure 4. Anaerobic digester tank.

Figure 5. Biogas burner c/w ignites.

(CSTR) (*Figure 4*) during which POME will be fed into the closed mild steel tank at a constant rate to minimise temperature fluctuations. The technology uses both vertical and horizontal stirrers equipped in the digester tank to ensure that the content of the tank is well mixed which later will prevent scum, solid settlements and stratification of the POME. The volume of biogas that can be generated is 20 m^3 for 1 t of POME treated (MPOB, 2009). It contains 60%-70% of CH_4, 30% -40% of CO_2 and small percentage of other gases directed to an outlet gas compressor with high jet spray-nozzle (*Figure 5*).

Bio-fertiliser

Solid residues from palm oil mills are EFB, fibres and shells that account for 44% of the FFB weight. Fibre and shells are used as fuel to generate steam and power to the mill while EFB is mainly applied directly to the field. Application of EFB has been shown to increase yields of oil palm grown on acidic soils (Sharifuddin and Zaharah, 1989). Beside the 'direct applied' method of EFB to the field, converting EFB into bio-fertiliser has received much attention.

Azhari *et al.* (2010) studied the physio-chemical changes of the co-composting EFB with partially treated POME and indicated that the compost obtains good properties such as pH 7-8, CN ratio of 12 and able to comply with United States Environmental Protection Agency (USEPA) standard. The study also found that matured compost contained considerable amount of C, N, P, K, Ca, Mg, S, Fe and trace amount of Mn, Zn and Cu.

The conventional method in converting EFB into bio-fertiliser has been adopted by Felda Maokil Palm Oil Mill in Johor. The process started by spraying the partially treated POME onto the shredded EFB and the composting material were turned over, one to three times per week for aeration (*Figure 6*).

BioSmart Sdn Bhd offers a waste management tools technology to manage palm oil bio-waste by converting EFB and POME into bio-chemo fertiliser (*Figure 7*). The system called BioSmart Technology has claimed to be able to manage 100% EFB and process 100% of POME and operates continuously without any waste as compared to the conventional system. The plant is fully automatic and the area required is less than 1 ha.

The investment using the technology is approximately RM 13.5 million (www.biosmart.com.my). The first technology was successfully established in Banting, Selangor with an operating capacity of 6 t/hr of EFB. With the operating capacity of 6 t/hr, the technology can produce 60 000 t/yr of bio-chemi fertiliser with POME or 25 000 t/yr bio-chemo fertiliser without POME (EFB alone). According to Biosmart, the estimated cost for bio-chemo fertiliser with POME is RM 220/t and without POME is RM 494/t.

The technology offered by Terra-Bio Plus Corporation uses microbes to convert EFB and POME effectively into bio-fertiliser. The company together with renowned micro-biologists, Dr Eliseo Ruiz and Michael Lim stated that the technology investment was RM 8.5 million for infrastructure, equipment, machinery and building with another RM 1.5 million for working capital. Their calculation shows that the payback

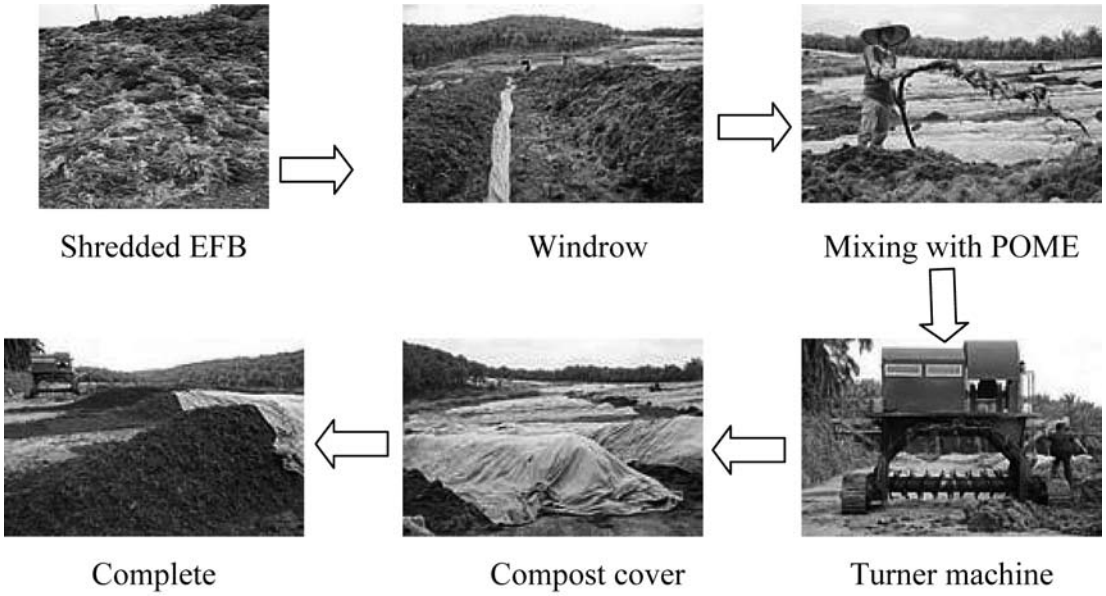

Figure 6. Flow chart of empty fruit bunches (EFB) composting.

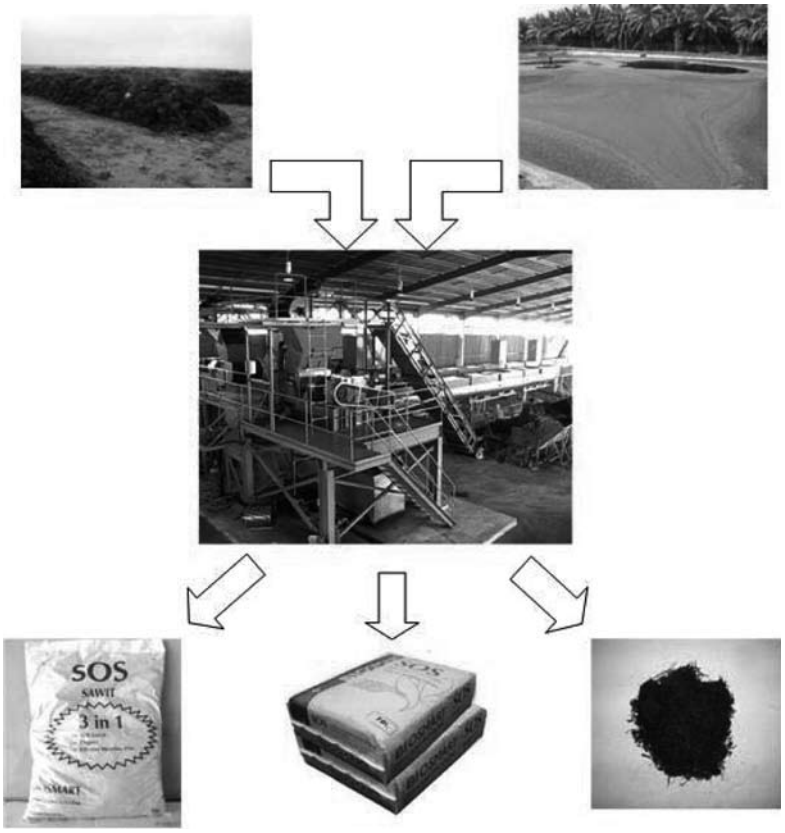

Figure 7. BioSmart technology on producing bio-fertiliser.

Figure 8. Worm cast.

period is expected within 2.3 years. The cost to produce 1 t of fertiliser is estimated at RM 250 to RM 280 which include among others cost of microbes, repair and maintenance, overheads and depreciation.

Another approach in producing bio-fertiliser is from worm cast (*Figure 8*). Worm cast is rich in humus, which improves soil aggregation. The production of worm cast is through recycling of palm oil fibres. Digestive process in worms makes the nutrients in their castings more readily available to plants. Beneficial microbes which are available inside the cast contribute for fertility of the soil.

The worm cast also contains micro nutrients such as boron, calcium, copper, chlorine, magnesium, molybdenum, iron and zinc. With high organic matters, nutrient and moisture-holding capacity will foster growth of soil organisms, and also promote healthier plant roots development. Few processes are needed in producing worm casting (*Figure 9*). EFB is compost which becomes suitable to be a breeding place for the worm. The worms will digest the composed EFB and later produce waste or cast.

Another technique in producing bio-fertiliser is called Aerobic Bunker Composting 'ABC' system that is introduced by Compost Advice and Analysis from United

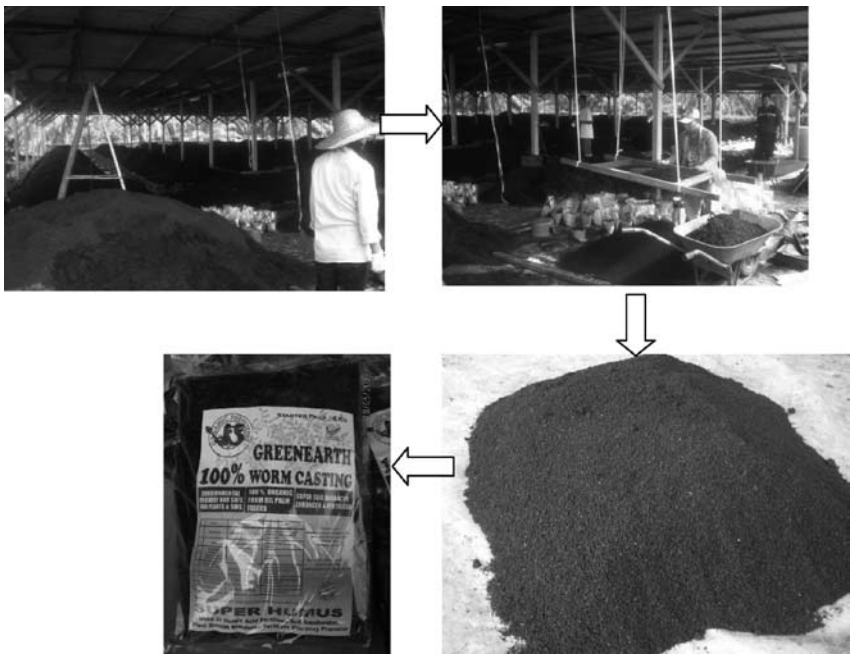

Figure 9. Worm casting process.

Source: Compost Advice & Analysis, ICOPB (2010).

Figure 10. Bio-fertiliser using ABC system.

Source: Compost Advice & Analysis, ICOPB (2010).

Figure 11. The pipes and spigots during construction stage.

Kingdom together with Sumatra Bioscience. The Aerated Bunker Composting system (ABC) provides conditions within the compost mass for the natural micro flora present in the mill waste streams to work effectively. The system can compost all mills' waste streams of EFB, POME, ash and fibres into a valuable organic fertiliser within 25 days (*Figure 10*).

The system is protected from outside elements, using a small space of land to produce nutritionally rich compost throughout the year. The nutrients present in EFB and POME are not leached or lost to the environment through heavy rainfall but are returned to the plantations in rich organic substrates that the palms can absorb. The company claimed that the ABC system eliminates the risk of pollution.

The ABC system does not require effluent ponds so methane emission is totally eliminated making the system a prime candidate for carbon credits. Methane only exists in the absence of light and oxygen. ABC system provides oxygen through water sprinkles from the base (*Figures 11* and *12*). The ABC system is very effective in keeping the entire mass of compost aerated.

The system utilises all of the waste streams from the palm oil industry directly and no secondary pollutants are produced or additional microorganisms or enzymes required. The system is clean, sustainable, easy to operate and reliable. Adoption of the system would massively reduce current pollution by the industry from the effluent ponds, production and use of inorganic fertilisers.

METHODOLOGY

The study utilised two approaches, *i.e.* phone and questionnaire survey in two stages respectively where all 421 palm oil mills in Malaysia were

Source: Compost Advice & Analysis, ICOPB (2010).

Figure 12. Concrete floor covering the pipes and spigots.

included in the study. The first stage was conducted in October 2010 using phone survey with an objective to identify and classify palm oil mills into:

- palm oil mills with biomass; and
- palm oil mills without biomass.

Palm oil mill 'with biomass' is any mill having plant or machines that convert biomass into value-added products such as EFB fibres, bio-fertiliser or biogas. Palm oil mills without above activities are considered as mill 'without biomass' including those that return untreated EFB for mulching.

In the second stage, a questionnaires approach was used during which questionnaires were faxed to all mills. The duration of the survey was five months starting from January to May 2011. Two sets of questionnaires were prepared, one each for mills with biomass and mill without biomass.

Besides questions on biomass activities, questions on perceptions were also included in the questionnaires. For mills with biomass, there were eight statements to measure millers' perceptions on factors influencing future development of the biomass sector. The five point Likert scale was used to measure the perception where 1 indicate 'Totally Not Agreed' while 5 indicate 'Totally Agreed' with 3 indicate 'Undecided' on those statements. Similarly, mills without biomass were given seven statements to measure their perceptions.

RESULT AND DISCUSSION

Result from the First Stage Survey

A census on 421 mills was carried out between August and September 2010 through phone interviews. From the total, 39 mills (9.1%) could not be reached either due to numbers no longer in service or unattended (*Figure 13*). Most of the mills that could not be reached were located in Sabah (13 mills or 33%), followed by Pahang (six mills or 15.8%), Johor (six mills or 15.8%), Perak with four mills (10.5%), Negeri Sembilan and Kelantan (three mills each or 7.9%), Terengganu (two mills or 5.3%) while Sarawak and Selangor with one each or 2.6%. All mills in Melaka, Pulau Pinang and Kedah were contactable.

From the 379 mills that responded, 120 mills (31.6%) indicate that they are involved in biomass utilisation (either producing EFB fibre, biogas or bio-fertiliser), while the other 259 mills are not involved in any biomass activities. The number of mills engaged with biomass activities by states is shown in *Table 5*.

Sabah with 36 mills or 9.5% has the highest biomass activities, followed by Johor (5% or 19 mills) and Perak and Pahang (both states 4.5% or 17 mills). Based on the information obtained, Sabah also has the most mills that do not utilise biomass (73 mills), followed by Pahang (48 mills) and Johor (41 mills).

Mills Producing EFB Fibre

Figure 14 shows the location of the mills that produce EFB fibres by states. In Sabah, there were 19 palm oil mills that produced EFB fibre, followed by Perak with 10

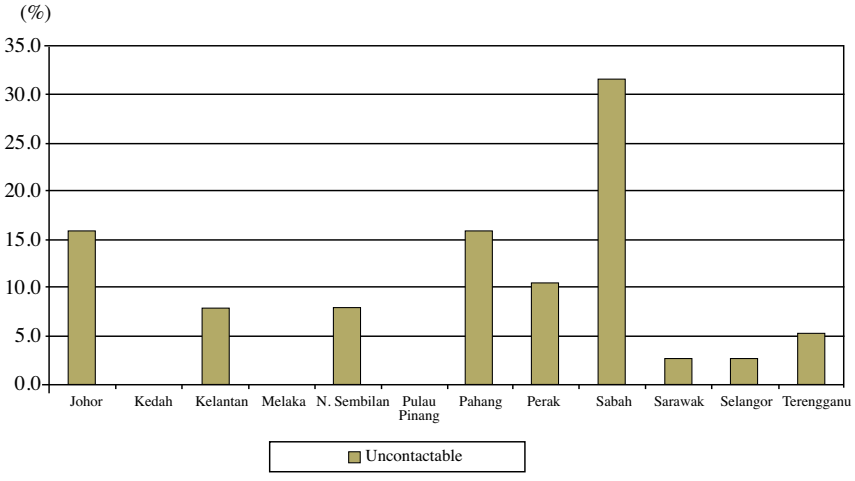

Figure 13. Un-contactable palm oil mills by states.

TABLE 5. NUMBER OF MILLS ACCORDING TO INVOLVEMENT IN BIOMASS

State	Involved in biomass	Not involved in biomass	Total mills	% mills involve in biomass
Johor	19	41	60	5.0
Kedah	2	5	7	0.5
Kelantan	1	6	7	0.2
Melaka	2	1	3	0.5
Negeri Sembilan	5	6	11	1.3
Pahang	17	48	65	4.5
Perak	17	24	41	4.5
Sabah	36	73	109	9.6
Sarawak	6	36	42	1.6
Selangor	10	11	21	2.6
Terengganu	5	6	11	1.3
Pulau Pinang	0	2	2	0
Total	120	259	379	31.6

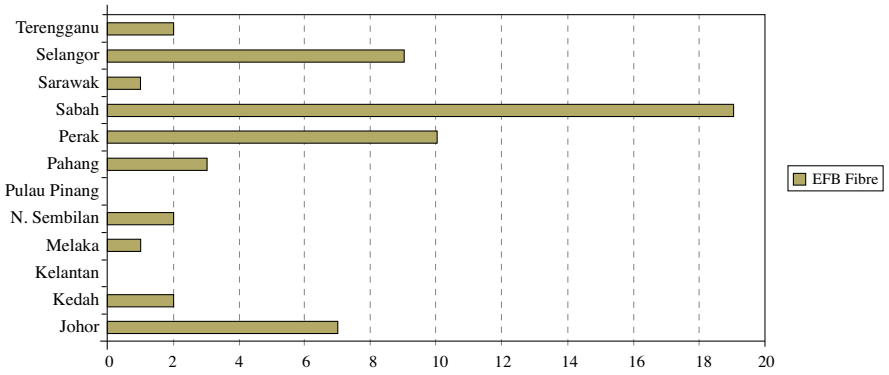

Figure 14. Number of mills producing empty fruit bunches (EFB) fibre.

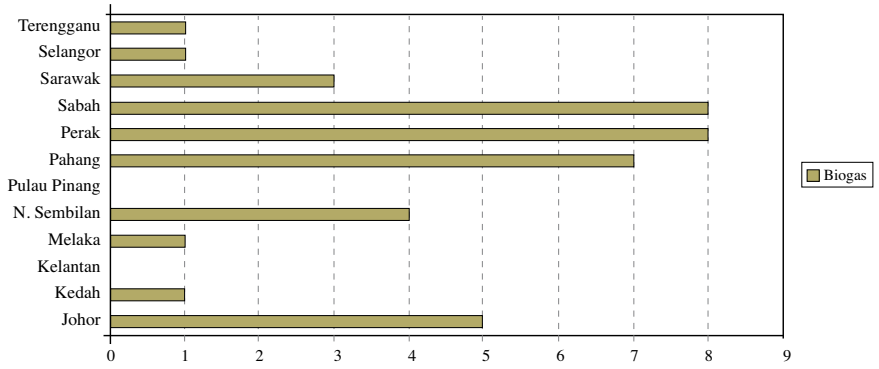

Figure 15. Number of mills producing biogas.

mills and Selangor with nine mills. There were also seven mills from Johor, three mills from Pahang and two each from Kedah, Negeri Sembilan and Terengganu. Both Sarawak and Melaka had one mill each.

Mills Producing Biogas

There are 39 mills in Malaysia which are involved in methane gas capture (*Figure 15*). Both Perak and Sabah have eight mills respectively while seven mills are located in Pahang then followed by five mills in Johor and four mills in Negeri Sembilan. There were three mills in Sarawak and one each in Kedah, Melaka, Selangor and Terengganu.

Mills Producing Bio-fertiliser

Figure 16 indicates that, out of the 53 mills that are involved in producing bio-fertiliser, 16 mills are located in Sabah. There were 10 mills in Pahang and nine mills in Perak which are also producing bio-fertiliser while eight mills having the same activity are located at Johor. Sarawak has three mills while Selangor and Terengganu had two mills each. Composting activity was also carried out by one mill each in Melaka, Kelantan and Kedah.

Out of the 120 mills involved in biomass activities, 95 mills (79.2%) of them are involved in at least one biomass activity either in producing EFB fibres, biogas or bio-fertiliser (*Table 6*). For this type of mills, most of them are involved in producing bio-fertiliser (37 mills), with another 33 mills in producing EFB fibres and 24

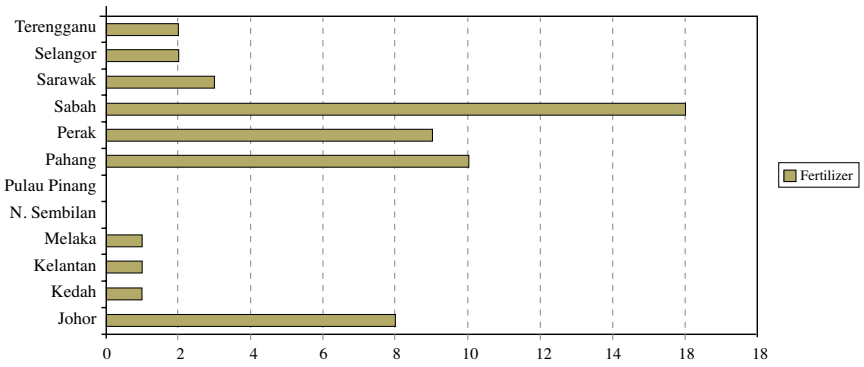

Figure 16. Number of mills producing bio-fertiliser.

TABLE 6. COMBINATION OF BIOMASS ACTIVITIES IN PALM OIL MILLS

	One	Two	Three	Total
Johor	17	2	0	19
Kedah	0	2	0	2
Kelantan	1	0	0	1
Melaka	1	1	0	2
N. Sembilan	4	1	0	5
Pahang	15	1	1	17
Perak	9	6	2	17
Sabah	30	5	1	36
Sarawak	5	1	0	6
Selangor	8	2	0	10
Terengganu	5	0	0	5
	95	21	4	120

TABLE 7. DOUBLE BIOMASS ACTIVITIES

Biomass products	EFB fibre/ biogas	Bio-fertiliser/ biogas	EFB fibre/ bio-fertiliser	Total
Johor	2	-	-	2
Kedah	1	-	1	2
Melaka	-	-	1	1
Negeri Sembilan	1	-	-	1
Pahang	-	1	-	1
Perak	2	1	3	6
Sabah	3	-	2	5
Sarawak	-	-	1	1
Selangor	-	-	2	2
	7	2	10	21

mills in harnessing biogas. There were four mills involved all the three biomass activities (EFB fibre, biogas and bio-fertiliser), *i.e.* two of the mills are located at Perak, and one each in Pahang and Sabah.

There are also mills which are involved in more than one activity (*Table 7*). There were seven mills producing EFB fibres together with biogas in Sabah (three mills). Johor and Perak had two mills each, while Kedah and Negeri Sembilan had one mill each. There are two mills producing bio-fertiliser and biogas one each in Pahang and Perak. For EFB fibres and bio-fertiliser, there are 10 mills involved in these activities with Perak having three mills, Sabah and Selangor with two mills each whilst Kedah, Melaka and Sarawak with one mill each.

Result from the Second Stage Survey

Mills with biomass.

i. Response rate

Out of 120 mills identified from the first stage surveyed involving in biomass activities, 72 mills or 60% responded by returning the questionnaire (*Table 8*). Sabah has the highest response rate (34.7%), followed by Johor (18.1%) and Pahang (12.5%). From the response, 45 mills or 62.5% are integrated with estate while 19 mills or 26.4% are not integrated. Another 11% or eight mills did not answer the question.

The distribution of biomass activities according to states is as shown in *Table 9*. Most of the mills are involved in producing fibres from EFB with 27 mills while 22 mills are involved in biogas activity. Only 16 mills from the survey are involved in producing bio-fertiliser.

On the location of biomass processing facilities, 42 mills (58.3%) stated that the processing facilities are located within their

TABLE 8. DISTRIBUTION OF MILLS WITH BIOMASS

State	Mills	Percentage
Johor	13	18.1
Pulau Pinang	1	1.4
Melaka	1	1.4
N. Sembilan	4	5.6
Pahang	9	12.5
Perak	7	9.7
Sabah	25	34.7
Sarawak	3	4.2
Terengganu	2	2.8
Kelantan	2	2.8
Selangor	5	6.9
	72	100

TABLE 9. DISTRIBUTION OF MILLS WITH BIOMASS

State	EFB fibre	Bio-fertiliser	Biogas
Johor	4	4	6
Kedah	-	-	-
Kelantan	1	-	-
Melaka	-	1	-
N. Sembilan	1	-	4
Pulau Pinang	1	-	-
Pahang	-	5	2
Perak	5	1	4
Sabah	10	5	4
Sarawak	-	-	-
Selangor	4	-	1
Terengganu	1	-	1
	27	16	22

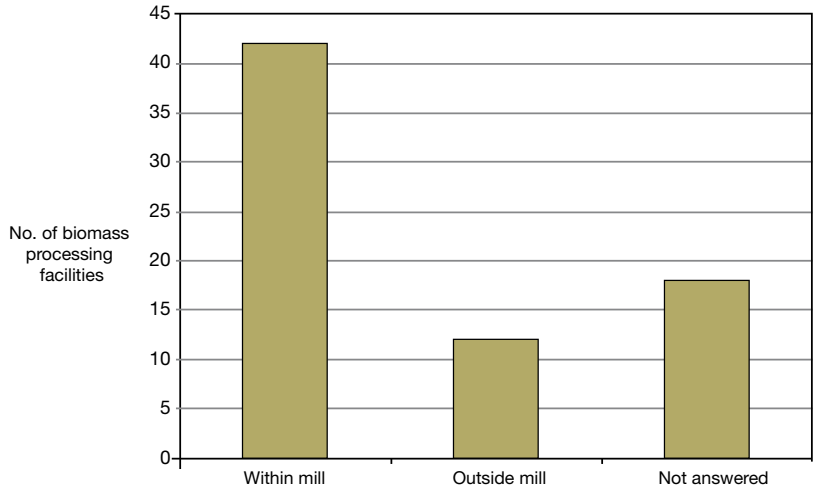

Figure 17. Location of the biomass processing facility.

mill compound (*Figure 17*). Another 12 processing facilities (16.6%) are located outside the mills while another 18 mills did not answer.

There are three types of ownership of the biomass processing facilities, *i.e.* company owned, joint ventures and third party (*Figure 18*). From the survey, 44 mills (60%) noted that their biomass processing facility is owned by them. Another four mills (6%) indicated that their processing facility is a joint venture and another four mills (6%) claimed that it was owned by a third party. The rest of the respondents did not answer the question.

ii. Perception on the future of biomass sector in Malaysia

On the perception section, millers were asked to rate using five point Likert scale on statements given. *Table 10* indicates the mean score from Likert scale obtained from the survey.

The highest score is 4.5 on statement about biomass sector having a potential to grow further in the next 10 years. Other statements that score more than four points are on the willingness to adopt 'recycle concept' for environmental sustainability with 4.4 and biomass sector can provide employment opportunities with score of 4.3. Biomass sector helps in improving the image of oil palm internationally and products from biomass have good potential for international markets, both score 4.0 points.

Mills without biomass.

i. Response rate

Out of 259 mills that are not involved in biomass activities, 131 mills or 51% responded by returning the questionnaire (*Table 11*). Mills in Sabah showed the highest response rate with 32%, followed by Johor (19%) and Pahang (17%). Even though these

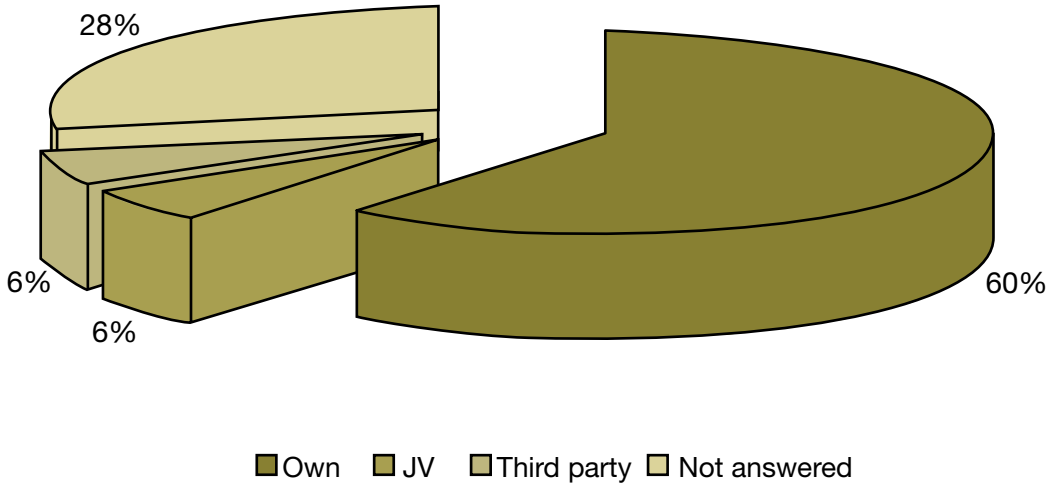

Figure 18. Type of biomass processing facility ownership.

TABLE 10. MEAN SCORE ON PERCEPTION ON BIOMASS SECTOR

Statement	Mean score
1. We are willing to adopt 'recycle concept' for environmental sustainability.	4.4
2. Standard of local technologies are at par compares to technologies from abroad.	2.6
3. Biomass sector have potentials to grow further in the next 10 years and more.	4.5
4. Biomass sector help in improving the image of palm oil internationally.	4.0
5. Government provide firm policy on biomass sector.	2.8
6. Biomass sector can provide employment opportunities.	4.3
7. Products from palm biomass have good market potentials in local market.	3.9
8. Products from palm biomass have good market potentials in international market.	4.0

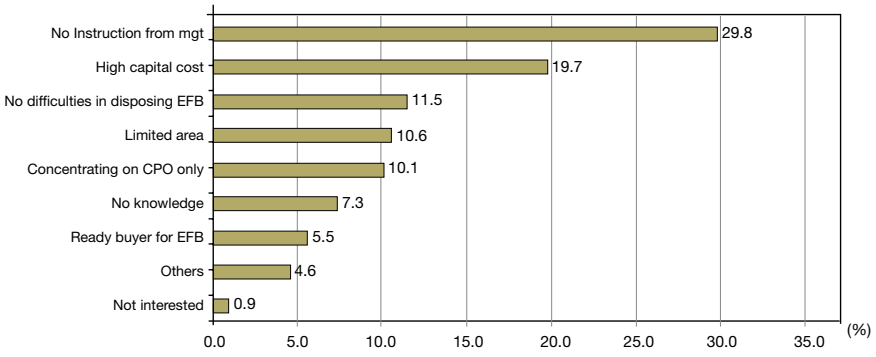

Figure 19. Reasons for not utilising palm biomass.

mills are not involved in any biomass activities, 80% of them indicate that they do mulching that implies sending back EFB either to their own plantations or other plantations. In term of integration, 98 mills (74.8%) indicate that they are integrated with estates while 24 mills (18.3%) are not.

The biggest reason (29.8%) for not being involved in utilising biomass (*Figure 19*) was 'No instruction from management' followed by 'High capital cost' (19.7%), 'No difficulties in disposing EFB' (11.5%). Reasons due to 'Limited area' and 'Concentrating on CPO only' were about 10% each.

ii. Perception on the future of biomass sector in Malaysia

Table 12 showed the mean score from Likert scale obtained from the survey. The highest score is 4.4 on statement that only top management that make decision either to embark on biomass project. Other statements that score more than four points are on 'Willingness to adopt *recycle concept* for environmental sustainability' with a score of 4.3, 'Willing to invest if returns are

TABLE 11. DISTRIBUTION OF MILLS WITHOUT BIOMASS

State	Mills	Percentage
Johor	25	19.1
P. Pinang	1	0.8
Melaka	-	-
N. Sembilan	1	0.8
Pahang	23	17.6
Perak	8	6.1
Sabah	42	32.1
Sarawak	16	12.2
Selangor	7	5.3
Kelantan	4	3.1
Terengganu	2	1.5
Kedah	2	1.5
	131	100

TABLE 12. MEAN SCORE ON PERCEPTION ON BIOMASS SECTOR

Statement	Mean score
1. Local technologies produce for biomass development are below standard with technologies from abroad.	3.0
2. Willing to adopt 'recycle concept' for environment sustainability.	4.3
3. Willing to invest if returns are reasonable	4.1
4. Willing to invest if the policy specifically for biomass sector is put in order.	4.1
5. Products from palm biomass have wide market potential in the local market.	3.7
6. Products from palm biomass have wide market potential in the international market.	3.6
7. Only top management that make decision either to embark on biomass project.	4.4

TABLE 13. FUTURE PLAN TO INVOLVE IN BIOMASS ACTIVITIES

	No of mills	Percentage
Yes	66	50.4
No	62	47.3
Not answered	3	2.3
	131	100

reasonable' and 'Willing to invest if the policy specifically for biomass sector is put in place' with a score of 4.1 each.

iii. Future plan on investment in biomass in next five years

Table 13 shows that from 131 millers' responses, 66 mills indicate that they have an intention to get involved in utilising biomass in the next five years. This represents about 50.4% of the total mills without biomass activities. Another 47.3% indicate that they have no plan to get involved in biomass activities in the next five years.

CONCLUSION AND RECOMMENDATION

The abundant supply of biomass especially from palm oil mill provides good justifications for the government to give focus on this sector. With around 30% of the palm oil mill involved in biomass activities, more promotion needs to be carried out to persuade another 70% millers to also get involved in utilising biomass, even though some of them already have a plan on the next five years.

Millers who have been involved in utilising biomass believed that the biomass sector can further develop and grow in the next decade. Their involvement in biomass utilisation is because of their concern on environmental issues and they also believe that utilising biomass can improve the image of palm oil in international arena. Nevertheless, they felt that policies on biomass development are not adequate to support continued growth of the sector.

Millers who have not been involved in utilising biomass rely on decisions from top management either to get involved on utilising the biomass. Basically they are willing to invest for two reasons, i.e., if return on the investment is acceptable and if policy on biomass is clear and put in place. Nevertheless, they are also concerned on environmental sustainability and as a result, they return the EFB for mulching at the plantations.

The study would like to recommend:

- government to provide comprehensive and clear

policy in supporting the biomass sector to ensure that biomass players understand and able to assist them in their decisions;
- to provide industry with economic evaluation related to biomass project as a reference to those interested in investing in this sector. (with high capital costs, the government may consider providing a subsidy);
- use biomass utilisation as part of components in promotion campaigns on palm oil especially abroad; and
- the top management of the mills needs to be informed correctly on the benefits of utilising biomass.

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