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Green Potential from Palm Biomass in Malaysia

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Malaysia, a tropical country with 4.98 million hectares of agricultural land covered by oil palm trees (MPOB, 2011), produces approximately 90 Mt/y of palm biomass (GGS, 2011). Over the years, the palm products have diversified from the conventional palm oil to various innovative goods such as dried fibres, bio-briquettes, pellets, plywood and so on. The previously waste which is indicated as 'carbon source', is being transformed into 'carbon sink'. A conceptual idea on the trend of palm biomass usage is illustrated in Figure 1. The paper overviewed the green potential of palm industry in the country. In Malaysia, palm oil industry has been recognised as one of the key industry in developing the country's sustainable development strategy. Malaysia is applying the 'Waste-to-Wealth' concept, which expands the country's economic and sustainable development simultaneously.

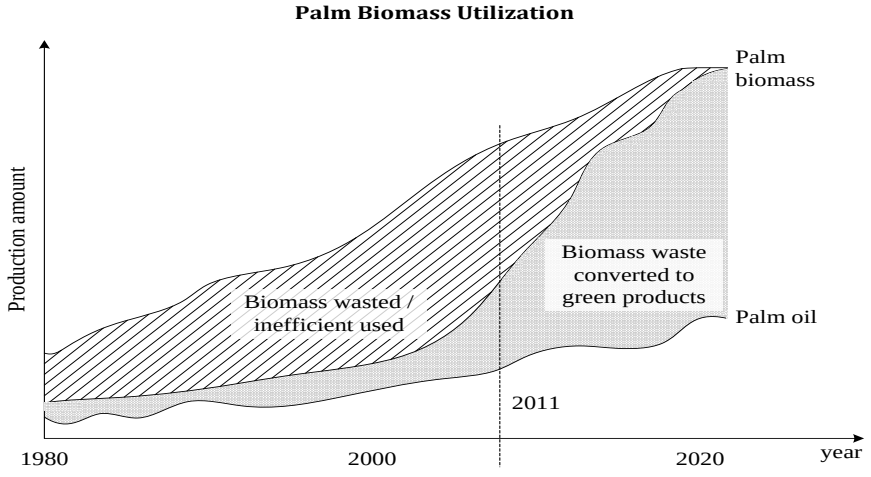

Figure 1: A conceptual idea on the trend of palm biomass utilisation

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1. Introduction

In the Eighth Malaysia Plan in 2001, renewable energy was introduced as the 'fifth fuel' after the four primary energy sources: oil, gas, hydropower and coal. The 'fifth fuel' has been gaining influence in current energy development as a potential alternative to fossil fuels (EIB, 2006). To improve energy security, Malaysia is working towards fuel diversification to reduce its dependency on fossil fuels. Palm biomass appears to be one of the potential energy sources due to its abundance. Malaysia, as a main exporter and producer of palm oil in the world, processed 88.74 Mt of Fresh Fruit Bunch (FFB) of oil palm in 2010 (GGS, 2011). The production of palm biomass resulted from FFB processing was approximated to be 87 Mt in 2010 and this value excludes oil palm fronds and trunks, which would further increase the amount of biomass produced by the palm oil industry (GGS, 2011). The potential energy that can be generated from these biomass totals up to 37 Mt/y of oil equivalent based on the amount of biomass available as of 2010 (Ng et al., 2012). To date, 60 MW out of 68 MW of biomass power is generated from palm biomass. The government of Malaysia has set a target to increase its biomass power generation capacity to 800 MW by 2020, which 500 MW is to be generated from palm biomass (KeTTHA, 2011a).

Conventionally, palm oil is the only desirable main product from oil palm that has commercial value. However, palm biomass is currently gaining more attention due to its unique potential. It is increasingly being used to produce fibrewood for furniture manufacturing, palm fibres (long or short fibres), pellets, high value chemicals and other products. Palm bio-briquettes or pellets produced from the oil palm waste can serve as an alternative to fossil fuels. This material can substitute or complement the fossil fuels in boilers, furnaces and kilns for heat generation. In addition, there are emerging industries, which process felled palm trunks into plywood, floor ply and laminated lumber. The oil palm trunks have high moisture content and are highly susceptible to degradation agents; therefore, they cannot be treated as timber. Nonetheless, the sap in the trunks (approximately 200 to 250 L of sap per trunk) can be converted into bioethanol, which provides another potential biofuel and value-added chemical application for the biomass (Wan et al., 2010).

Due to the realisation of oil palm waste's potential for producing various useful resources, previously negative-cost (money losing) materials are now being processed into positive-earning (money earning) materials. In other words, waste has been converted into wealth. The conversion of waste into useful end products changes the status of the material from a 'carbon source' into a 'carbon sink' that captures the carbon that would otherwise be released into the atmosphere. The utilisation of palm biomass is increasing significantly over time, which creates a symbiotic situation where the 'previous waste' serves as the input for other industries, leading the palm oil industry to a zero waste path. The amount of positive-earning proportionally indicates the amount of 'carbon sources' being converted into 'carbon sinks'. The more positive the earnings magnitude, the greener the future is.

2. Utilisation of palm biomass in Malaysia and its promotion

Malaysia intends to grow its palm biomass industry to a leading position in South East Asia. The intention was clearly indicated in Malaysia's national economic plan by the introduction of the National Biomass Strategy 2020. This strategy provides a roadmap for the oil palm biomass to wealth scenario that aims to drive the development of national clusters in the biofuel and biobased chemical industries as well as to fulfil the national green energy target. The oil palm industry is recognised as one of the National Key Economic Areas (NKEA) in the Economic Transformation Programs. However, due to the nature of palm biomass and its combustible properties, the palm biomass industry crosses three NKEAs: palm oil, agriculture and oil, and gas and energy. To effectively implement the approved programs listed in the national plan and the Economic Transformation Programmes, a monitoring unit within the Economic Transformation Programmes - The Performance Management and Delivery Unit - PEMANDU - was established. Furthermore, the palm biomass industry, which provides an alternative of the renewable energy source, shares the benefits provided by the statutory body known as the Sustainable Energy Development Authority (SEDA). SEDA was established to assist and monitor renewable energy growth in Malaysia. It is proposed that by 2015, at least 6 % or 985 MW of the

national energy consumption will be sourced from renewable energy, such as oil palm derived fuel, hydro-energy and solar energy (KeTTHA, 2011a).

Ministry of Energy, Green Technology and Water (KeTTHA), the main agency to promote green technology in Malaysia, is responsible for formulating the policies and legal frameworks to protect the natural environment of the country alongside industry development. It sets the directions for the development of the water industry, energy industry and green technologies according to Malaysia's national development plans. KeTTHA emphasises the development of green technologies to reduce environmental degradation as well as to protect environmental and ecological health. Currently, green technology acts as another sector or tool to boost the country's economy. The oil palm industry, which has been identified as a main economic source to the country, is gaining attention on its sustainable growth in both the plantation and product development sectors. In an effort to promote green technology development, a fund of up to 500 MUSD has been provided under the Green Technology Financing Scheme (GTFS) to support green technology development in Malaysia.

Moreover, the Ministry of Science, Technology & Innovation (MOSTI) and the Ministry of Higher Education (MOHE) financially support Malaysia's research and development sector. These ministries provide research grants to qualified institutions to support potential research projects that are expected to bring benefits to the country's social and economic development. In addition, Malaysia possesses two chief official governmental agencies, the Malaysian Palm Oil Council (MPOC) and the Malaysian Palm Oil Board (MPOB), that manage the promotion, marketing and research and development of the oil palm industry. The MPOC aims to promote the production, procurement and utilisation of oil palm products through the development and accomplishment of credible worldwide standards. It works to improve the image of oil palm by stressing the techno-economic advantages of oil palm and its environmental sustainability. The MPOB aims to develop the Malaysian oil palm industry through research development as well as providing excellent services to position the oil palm industry towards superior competitiveness and sustainability.

Through the creation of the above agencies, Malaysia has advanced its ability to develop green technologies related to the palm industry. The development of palm biomass utilisation and an evolution in the palm biomass industry in the country are currently in progress. It is estimated that the advancement or further breakthroughs in palm biomass utilisation can be achieved by 2020. This advancement can be observed from the progressive switch of palm biomass product value from low-value palm biomass products to higher-value palm biomass products.

3. Green policies in Malaysia to promote palm biomass

Malaysia has introduced several green policies to support the above ministries and agencies more efficiently in promoting the palm biomass industry. Realising the potential of palm biomass, Malaysia has demonstrated its intention to develop the palm biomass industry since 2001. The Small Renewable Energy Program (SREP), which was implemented in 2001, promotes the utilisation of renewable energy sources available in Malaysia. The POME generated from the palm industry has been identified as one of these potential renewable energy sources. Through SREP, a renewable energy-based power producer is allowed to sell its generated electricity to the national grid at a maximum capacity of 10 MW. In 2010, Malaysia introduced the National Renewable Energy Policy 2010, which aims to further increase the exploitation of local renewable energy resources, such as oil palm, and contribute to national energy security and sustainable socio-economic development. Malaysia has proposed the introduction of the Feed-in Tariff (FiT) from USD 0.09 $kWhr^{-1}$ onwards for biomass-based renewable energy production (KeTTHA, 2011b). The Renewable Energy Act, which will contain the FiT, was projected to be brought to the parliament house by the end of 2011. This act allows the producer or industries to trade in any surplus energy to the national power grid or utility companies. In addition, incentives will be offered to the industries employing renewable energy. This approach is expected to further promote the adoption of renewable energy sources.

In addition, Malaysia has implemented the Promotion of Investments Act, 1986. This act offers incentives to companies that generate energy from renewable resources that is then either sold to other companies or retained for self-consumption. Furthermore, Malaysia has introduced the 'Green Technology Financing Scheme' since 1st January 2010. This scheme offers financial funding up to 500

MUSD and is applicable to both the producer and user of green technology with the expectation that it will benefit more than 140 companies in Malaysia (GTFS, 2011).
The execution of the official policies in Malaysia, especially in the field of renewable energy, has induced the development of power generation through the utilisation of local renewable energy sources. Palm biomass as one of the readily available renewable energy sources is gaining attention for power generation due to its heat energy content.

4. Research in palm biomass promotion

Currently, various research and developments carried out by both public and private institutions have contributed to the pool of new knowledge. The development of knowledge has led to the utilisation of oil palm and its classification as 'bio-energy' and 'biomass' in general. The diverse applications of the palm biomass are being developed and investigated to convert the previous 'waste' into 'value-added products'. For instance, EFB and POME have been successfully converted into cattle feed, cow flooring and fertiliser in a pilot study carried out by the Malaysian Agricultural Research and Development Institute (MARDI). Additionally, a collaborating research team from different nations shows that oil palm trunks appear to be a promising source of sugars for bio-ethanol production (Yamada et al., 2010). This has improved the competitiveness of oil palm, which has become more prominent relative to other renewable energy sources in terms of producing different products. In addition, research is being carried out to develop cleaner production technologies to reach the 'zero waste' target in the oil palm sector.

5. Opportunities of palm biomass

Being highlighted as a key indicator of Malaysia's economic performance, the palm biomass industry is catching attention of investors. The palm biomass industry did not expand in the past due to its previously low economic value. Other factors that led to the underdevelopment of the palm biomass industry are the lack of available proven processing technologies and the 'closed-door' attitudes exhibited by industrial players. In addition, the lack of mature technologies, in turn, caused a decrease in the confidence level of financial institutions and led to an unsuccessful financing status for most palm biomass investors. However, palm biomass is growing its market value. For instance, EFB, which is sold at 3.33 USD/t locally by palm oil mills, can be further processed into dried long fibre, which is then sold at 170 USD/t. This possibility raises interest and attracts more investors to the palm biomass industry. With respect to environmental sustainability, the utilisation of palm biomass generates carbon sinks, boosts the economy of the country and simultaneously introduces Malaysia as a green country to the world through the exploitation of renewable energy.
Nevertheless, it is predicted that the economic value of moderate value products such as dried long fibre and bio-briquette will decrease in the coming few years. This decrease will most likely be resulted from the overwhelming production of moderate value products by millers or industrial players. On the other hand, the market of the palm biomass industry is expected to grow by moving up the value chain. It is also predicted that by 2020, the biomass industry will evolve to produce value added biochemicals, such as bioethanol, to fulfil the global market demand and the industrial players' profit orientation. Malaysia will proceed to an advance generation of biomass conversion in near future.

6. Challenges in green future

The main challenge for the development of the palm biomass industry relates to the growth of oil palm industry. A report has been published by 'Friends of the Earth International (FOEI)' claiming that the clearance of lands or forests for oil palm plantation is threatening some of the last habitats of endangered species, including the orangutans (Buckland, 2005). Other claims which resulted from these land use issues include the loss of ecosystems preservation and the homes of indigenous people. The projection of land use change in Malaysia has been analysed in detail by Wicke et al. (2011), and the study revealed that the increasing palm oil demand up to 2020 can be met without further forest cover loss through improving yield and degraded land conversion. Additionally, oil palm

uses relatively little land area for oil production compared to other crops. In terms of both economic and sustainability values, oil palm outperforms other oil crops.
On the other hand, it has been claimed that land or forests clearance releases large net amounts of greenhouse gases such as carbon dioxide that will not be reabsorbed by the oil palm trees. Through the development of biomass utilisation, this condition can be improved. The conversion of palm biomass into fibres, fibreboard as building materials turns the products into carbon sinks that reduce the amount of carbon emissions released into the atmosphere. Furthermore, the combustible properties of the palm fibre and shell allow the biomass to act as an alternative energy source (Čuček et al., 2010). By replacing fossil fuels with palm biomass for incineration, the amount of carbon originally emitted from the combustion of fossil fuels can be omitted. Another significant source of carbon emissions is the greenhouse gases emitted from the transportation sector. Raw materials such as oil palm are transported from plantation sources to processing sites and finally to demand points. Therefore, a proper management system or efficient supply chain is needed to reduce greenhouse gas emissions and secure the product supply, In Malaysia, the field of biomass supply chain optimisation is under development. This research in supply chain development is expected to further advance the country's sustainability practice and ensure the supply security of oil palm-based products.
Other than the biodiversity and emission issues mentioned above, the existence of challenges facing a green future depend on national policy, the amount of research being performed and society. As ‘greenness’ is often inversely proportional to the size of the carbon footprint, the accomplishment of a green future can be attained by reducing this footprint. With respect to oil palm, this reduction can be realised through the optimisation of the total oil palm utilisation as a whole. This may be accomplished by carrying out Life Cycle Analysis (LCA) on the oil palm industry. Other than the conventional LCA, some other footprints should be analysed in the future, e.g. Sustainable process index – SPI (Kettl et al., 2011) and Environmental Performance Strategy Map – EPSM (De Benedetto and Klemeš, 2009)
Furthermore, there are other concerns over the development of green potential in Malaysia. One of the concerns relates to business viability in that the success of a project launch depends greatly on funding availability from sources such as the Clean Development Mechanism (CDM) scheme and the Ministry of Science, Technology and Innovation (MOSTI) for research funding. Nevertheless, Malaysia actively promotes and supports green technology. This could be observed in 2009 when Malaysia launched the National Green Technology Policy, which aims to minimise environmental pollution, conserve the utilisation of natural resources and promote the use of renewable resources. All of these green policies, schemes and funding programs aim to provide continuous support to the development of green potential in this country.
Malaysia encourages the replantation of oil palm trees to restore the economic yield of the oil palm, which declines as a result of tree aging. However, this replanting activity will result in a holdback period of at least seven years, not including the seed preparation and land clearing periods. Currently, the country's oil palm replanting rate is quoted at 4 %. Based on the best FFB yield of 25 %, the critical replanting rate is found to be 10 %. If the replanting rate exceeds the critical value, the KeTTHA projected biomass power generation target may not be realised. This poses a difficult trade-off between yield and replanting, as yield is inversely proportional to the replanting rate.

7. Conclusions

Malaysia has shown strong desire to promote itself as a major biomass hub in the South East Asia region. Supportive policies such as the SREP and the National Renewable Energy Policy of 2010 have been introduced to enhance implementation and investment from the private sector. Various agencies and policies have been set to control and direct the development of the palm biomass industry in Malaysia. The new trend of business opportunities speeds up the development of the palm biomass industry in terms of technology development, product improvement, process synthesis and supply chain optimisation. Research and development of palm biomass by governmental institutions and universities supports new product synthesis and improves process efficiencies. This ongoing research and development on palm biomass is expected to promote a more advanced generation of palm biomass products, where high value added products and bio-based chemicals are produced. In future, Malaysia will be able to exert significant green potential by developing a solid supply network for proper

biomass supply and demand connection. In addition, facilities can be clustered by functions in centralising resources and management. From facilities clustering, an industrial symbiotic approach can be introduced for optimising resources usage and recovery among facilities and different industries.

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