Use of Oil Palm Waste as a Renewable Energy Source and Its Impact on Reduction of Air Pollution in Context of Malaysia

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Abstract. One of the most efficient and effective solutions for sustainable energy supply to supplement the increasing energy demand and reducing environment pollution is renewable energy resources. Malaysia is currently the world's second largest producer and exporter of palm oil and 47% of the world's supply of palm oil is produced by this country. Nearly 80 million tonnes of Fresh Fruit Bunches (FFB) are processed annually in 406 palm oil mills and are generating approximately 54 million tonnes of palm oil mill effluent (POME), known to generate biogas consisting of methane - a Green House Gas (GHG) identifiable to cause global warming. This is 21 times more potent GHG than CO2. These two major oil palm wastes are a viable renewable energy (RE) source for production of electricity. If the two sources are used in harnessing the renewable energy potential the pollution intensity from usage of non-renewable sources can also be reduced significantly. This study focused on the pollution mitigation potential of biogas as biogas is a renewable energy. Utilization of this renewable source for the production of electricity is believed to reduce GHG emissions to the atmosphere.

1. Introduction
Energy resource is the economic driving force and correspondingly, energy production and utilization is also blamed for the environmental degradation. Malaysia has been observing a relatively high growth rate of energy demand at 9.5% per annum over the past decades and is expected to increase rapidly to 100MTOE (million ton of oil equivalent) to have a developed nation status by 2020 (Asian Pacific Economic Cooperation , APEC 2006). The energy demand is met by both renewable and non-renewable energy sources and the country is abundantly endowed nonrenewable resource such as oil (approximately 3 billion barrels), natural gas (1.61 trillion cubic meters) and coal (776 million tonnes) as well as renewable energy sources like hydro and solar power and biomass (Joanta, 1996). The most usage of primary energy resource goes into electricity production for which the maximum electricity energy demand projections are 40,515 MW for the year 2020 (Yusoff, 2006). On the other hand the gradual deregulation of natural gas prices, with price increase from RM 6.40 per MMBTU to RM 14.31 per MMBTU for power sector in 2008 has often brings natural gas to the downside and it is expected that current gas fields to be depleted by 2027 with new fields of higher carbon dioxide content. In addition, there is a proven declination of oil reserves by 3.0 billion barrels in January 2007, which was at a peak of 4.6 billion barrel in 1996 (Mustapa et al. 2010 and Ralph, 1979). According to (Gan and Li, 2008), Malaysia's total primary energy consumption and Carbon emissions will triple by 2030, since large amount of the energy demand would have to be supported by coal that is a least cost
option. On the other hand, during the COP15, Malaysia has also committed to reduce its carbon intensity by 40% of its 2005 value, which is going to be an uphill task with growing energy intensity of Malaysia and dwindling natural gas resources and increasing coal utilization (Badariah, 2010). One of the solutions would be aggressive and affirmative deployment of available RE resources to ensure supply sustainability and environment conservation. In the recently gazette National RE Act 2011, the share of RE is expected to be 11% and 17% of total electricity generation mix by 2020 and 2030 respectively. This would translate to cumulative CO$_2$ avoidance of 42.2 and 145.1 million tonnes for year 2020 and 2030 respectively.

This paper explores the potential of biomass and biogas generated form Malaysian palm oil industry, as one of the promising alternative energy source and also its impact to mitigate the environment air pollution due to its utilization.

2. Sources of Air Pollution and Air Quality Trend in Malaysia

In achieving industrial country status by the year 2020, Malaysia has undertaken various economic growth activities, which imposed costs in terms of industrial pollution and the degradation of urban environment in several large cities that does not meet national ambient air quality standards. The Air Quality Guidelines due to repeated haze episodes in Southeast Asia are also implemented by Malaysian Government. Suspended Particulate Matter (SPM), nitrogen dioxide (NO$_2$), CO, O$_3$, SO$_2$, and Pb were the major pollutants in several big cities in Malaysia. Mobile, stationary and open burning are the three major sources of air pollution in Malaysia as reported by (Department of environment, 2000). The registration of mobile vehicles such as personal cars, commercial vehicles, and motorcycles had been increased by 26% from year 1996 to 82% in year 2000 (Department of environment, 2001). Enforcement of the Environmental Quality Act (EQA), the phase-out of leaded gasoline sales and focus on prevention of emissions at the manufacturing and assembly stage had improved the situation. As a result there was a steady decrease in lead levels throughout the western side of peninsular Malaysia.

However, the increase in the sheer number of motor vehicles on the road may offset the result. Stationary sources are related to industry such as power stations produces 9%, industrial fuel burning processes 3% and the rest is domestic fuel burning. In 51 locations of Malaysia, main air pollutants are monitored continuously, while lead concentrations are measured once in every six days at two locations. The air quality trend is then calculated by averaging direct measurement from monitoring sites on a yearly basis and compared with the Malaysian Ambient Air Quality Guidelines.

![Figure 1. Malaysia: Annual Average Concentration of Particulate Matter (PM$_{10}$), 1998-2008](image1)

![Figure 2. Malaysia: Annual Average Concentration of Sulphur Dioxide (SO$_2$), 1998-2008](image2)

Major air pollutants in different locations of Malaysia such as Klang Valley, West Coast Peninsular Malaysia, East Coast Peninsular Malaysia, Sabah, Labuan and Sarawak are monitored routinely. The six major pollutants as presented in Figures. 1-5 are within the range of Malaysian air quality guidelines. The particulate matter is the predominant pollutant. The concentration of NO$_2$ has
increased by 6% from 2007 to 2008. It remains high in industrial areas and urban areas mainly due to the increase of motor vehicles and combustion process of industrial source. CO emission was increased by 5% from 2007 to 2008. In urban areas the concentration of CO was higher, where the sources of emissions were motor vehicles, which contributes 97% of CO emission (Department of environment, Malaysia, 2008).

Figure 3. Malaysia: Annual Average Concen. of Carbon Monoxide (CO), 1998-2008

Figure 4. Malaysia: Annual Average Daily Maximum Hour Concen. of Ozone (O₃), 1998-2008

Figure 5. Malaysia: Annual Average Concen. of Carbon Monoxide (CO), 1998-2008

3. Potential Green House Gas Emission Reduction by Biomass & Biogas

Although palm oil waste can be a huge source of energy as data presented in Tables 1 but biogas utilization has not been implemented fully in Malaysian Industry. By implementing biogas plant from palm oil wastes GHG gas emission can be reduced significantly as estimated in different project proposals (SSC-CDM-PDD), UNFCCC, version 8 2009).

4. Biomass and Bio-Gas: A Promising Alternative

Malaysia is the world leader in the production and supply of crude palm oil and the plantation industry is projected to grow steadily (Lee, 2009). Consequently, the growth produces more palm oil waste such as fibers, and palm kernel shells. The generated biomass and its heat value are presented in Table 1.

The biogas produced from anaerobic digestion can be captured and utilized as RE to replace fossil fuel/diesel for steam or electricity generation. It has been estimated that a 60 tons FFB/hr mill, will generate about 12,000 m³ of gas/day and the energy that can be generated is estimated to be 1.04 MW capacity (Joanta, 1996). The total 261.1MW installed capacity of power from the potential of 406 mills would generate 1.88MWh of electricity (NKEA 2011). It is worth to mention that the CO₂ emissions for the generation of electricity by electric power plants by coal or oil is 1100 g of CO₂ per kW h, whereas, the figure is 600 g of CO₂ per kW h for using gas and biomass use can reduce it dramatically to 16 g of CO₂ per kW h (Yusoff, 2006; Bazmi et al., 2011).
In recent years, a project has been successfully undertaken by Serting Hilir Palm Oil Mill which captures methane and the existing open anaerobic digester tanks in the mill are converted to closed type digester tanks. It is estimated that 647 kW and 1,294 kW of electricity can be generated respectively at phase I and phase II. The emission reduction of methane from open lagoon system can thus be utilized to reduce GHG especially equivalent carbon dioxide. The report by Saad M.F.M., 2010 on this project has shown that annual reduction of 37,251 million tonnes of CO$_2$ equivalent GHG can be achieved.

### Table 1. Biomass generated by palm oil mill

| Biomass | Quantity (million tonnes) | Moisture content (%) | Oil content (%) | Heat value (dry) (kJ/kg) |
|---------|---------------------------|----------------------|----------------|--------------------------|
| EFB     | 18.25                     | 67                   | 5              | 18,883                   |
| Fibre   | 11.11                     | 37                   | 5              | 19,114                   |
| Shell   | 5.55                      | 12                   | 1              | 20,156                   |
| POME    | 53.16                     | 93                   | 1              | 17,044                   |

### 4 Conclusions

A holistic approach must be undertaken for the promotion of biogas as a renewable energy and for implementation of green energy development. It can be a sustainable source of energy and can play a major role to supplement energy demand, reduce the GHG and mitigate global warming. Affirmative actions need to be taken to reduce environmental effect of nonrenewable energy sources by the GHG gas emissions. Methane generated from effluent of palm oil processing waste is 21 times more potent than CO$_2$. Hence, it is viable to capture the biogas and utilize to replace non renewable energy to generate electricity which has annual reduction of 37,251 million tonnes of CO$_2$ equivalent. However, a more detailed study needs to be done to improve on the production of biogas from palm oil waste.

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