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Oil palm biomass wastes as renewable energy sources in Malaysia: Potentials and challenges

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Abstract

This paper reviews the potentials and challenges of using Oil Palm Biomass Wastes (OPBW) as Renewable Energy (RE) source in Malaysia. The OPBW mainly includes Palm Oil Mill Effluent (POME) and Empty Fruit Bunches (EFB). From the present review, the major potentials of OPBW consist of their large availability, being a major sources of lignocellulosic materials for industrial, being economically viable, being a solution to the disposal problem and cost-benefit. The challenges of using OPBW as RE source are being a high dependency on the availability of the OPWB, unfair subsidies given to RE based fuel, the use of POME that produces methane, substantial amount of under-utilization of lignocellulosic wastes from OPBW, the need for further studies on the correct selection of generation plant size, and not economically competitive. Overall, the challenge is to make the OPBWs as a reliable, profitable and sustainable RE industry. Based on the present review mainly from Malaysia, there are definite potentials/advantages of using OPBW as RE source in Malaysia. Ways and suggestions on these practical issues on how to reduce problems facing the use of OPBW as RE source in Malaysia should be investigated and addressed before the large scale utilization of OPBW as RE source can be anticipated in Malaysia.

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Introduction

The utilizcation of Renewable Energy (RE) sources such as Oil Palm Biomass Waste (OPBW) can reduce global warming effect and the weak energy security [1]. According to Green Tech Malaysia [2], the Green Technology Master Plan is "fundamentally an outcome of the Eleventh Malaysia Plan (2016-2020) which has earmarked green growth as one of six game changers altering the trajectory of the nation's growth." RE has been identified globally as a key driver to achieve economic growth while ensuring minimal environmental harm [3]. Asian countries including Malaysia have been targeting on the use of biomass as an alternative RE source [4] for Sustainable Development (SD). In simple term, biomass can be defined as 'any woody-based material from plant that store energy through photosynthetic activities' [5]. According to the previous review by Shafie *et al.* [6], there are about 417 palm oil mills found in the country, in which the Oil Palm (OP) industry has been producing a lot of OPBW in field and OP mills [7,8]. The wastes from the OP mills consist of Empty Fruit Bunch (EFB), Pressed Fruit Fibers (PFF), OP Shell (OPS), OP Mill Effluent (POME), whilst the other wastes from the plantation area includes OP Trunks (OPT) and OP Fronds (OPF) during replanting after achieving its economic life spans [9]. Therefore, there are growing concerns for increasing OPBW due to the booming OP sector in Malaysia. This is because of the mounting and potentially polluting OPBW that should be disposed in a sustainable way. The use of OPBW as RE source is one of the strategies to solve the problem.

The utilization of OPBW as a RE resource in Malaysia can place harmony with ecological systems, including transition from low value-added to higher value-added transformation of OPBW into resources [10]. This has been one of the principles of SD. This also indicated that Malaysia has been in the right position to show the world that OPBW can be used as RE source [7]. Earlier, Yusoff [11] described the effective use of OPBW as the RE source to be developed for large-scale industrial applications for the OP industry. The objective of this review paper is to discuss the potentials and challenges of using OPBW as RE source in Malaysia.

Potentials of Oil Palm Wastes Biomass

Undoubtedly, the best review on the potentials of the Malaysian OPBW as a RE source has been reported by Loh [12]. Previously, Sumanthi *et al.* [13] reviewed the utilization of OPBW as a source of RE in Malaysia. Loh *et al.* [14] characterized the various forms of OPBW for their important fuel. This concerns energy potential, the related biomass conversion technologies and possible combustion-related problems. Overall, OPBW holds a huge potential as one of the huge alternative RE sources for commercial exploitation in Malaysia.

In brief, the potentials of OPBW include:

1) having large availability of OPBW with significant amount [15-17],
2) being major sources of lignocellulosic materials for industrial uses [18],
3) being economically viable from Malaysian perspectives [19],
4) using of EFB as RE source to solve the disposal problem [20],
5) giving substantial benefits to the energy security, environmental protection and the social development [17], and
6) being viable in terms of cost-benefit that using the syngas production from EFB gasification for electricity generation [1].

The introduction of the Feed-in Tariff (FiT) regime in 2011 can accelerate the development of the biomass technology as RE source [16]. The use EFB for power production can be based on dual chamber Microbial fuel cell (MFC)

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[21]. Furthermore, the power output and Chemical Oxygen Demand (COD) removal efficiency can be raised in significant amount using pretreated POME in MFC [22]. The potentials of the natural micro-flora of POME sludge was grown in dual-chamber MFC [23], and POME can be used as a source of RE to produce hydrogen [24].

Besides Loh [25], some of the potentials have been reviewed in the literature. Sukiran *et al.* [25] reviewed torrefaction of OP solid wastes for biofuel production. Zakaria *et al.* [26] provided a constructive conceptual framework for integrating OP fibre waste into a portfolio of biogas supply chain for optimal electricity engenderment. Ariffin *et al.[27]* studied the performance of OPF gasification, using a medium-scale downdraft gasification system with a reactor capacity of 500 kg of feedstock, which is a promising process for RE generation. All of the above literatures indicated the advancements and recommendations that enhance and optimize the use of OPBW as RE in Malaysia.

Challenges of Oil Palm Wastes Biomass

The challenges of using OPBW as RE source can be summarized as below:

1) High dependency on the availability of the OPWB resources [17]. According to Ong *et al.* [5], continuous reserve of OPBW can be the biggest challenge of utilizing OPBW in Malaysia which need to be maintained.
2) Discouragement due to the unfair subsidies given to RE based fuel and the maturity of conventional electricity generation system [17]. The feed-in tariff for RE is not financially attractive [10].
3) Production of biogas from POME consists of methane (a Green House Gas (GHG)) has been recognised to cause global warming [19].
4) Production of tons of lignocellulosic wastes from OPBW annually has not been well managed since most of these wastes are either left in the plantations or burned illegally [18].
5) The right selection of generation plant size is a challenge. This is because the impact on overall economic and environmental feasibility of the choice of site selection is rather significant [17]. Therefore, this requires further studies on the site selection of the plant size.
6) The use of OPBW as RE source is not being economically competitive in comparison to the conventional electricity generation system (fossil fuel) [17]. The capital expenditure of the RE system using OPBW source is relatively expensive [17]. To remain competitive, OPWB-based system must be developed in their most economical form [17].

Although POME is known to produce biogas which consists of methane (a GHG causing global warming) [19], Biogas Capture has been adopted for methane avoidance from POME that can lower the carbon footprint of OP production. Hence, GHG emission can be mitigated (Loh *et al*., 2017). Despite a major overhaul of the market structure under the new scheme, the sustainability of the grid-connected OPBW of RE industry downstream components remains questionable [16].

Concluding remarks

This review points to the potentials and challenges of the utilization of OPBW as RE source in Malaysia. Future energy policy should be positive to materialize the potentials of OPBW as RE source into practical uses by harnessing its diversity of available OPBW resources. It is recommended future energy policy likewise explore or the mix of OPBW and other types of biomass as RE sources since availability of OPWB is restricted predominantly with more strict control on the OP sector. At the same time, reduction of the

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delivery risks of the RE resources in Malaysia that remains a big challenge should be continuous researched for the possibilities of risk reduction. Also, ways and suggestions on these practical issues on how to reduce problems facing the use of OPBW as RE source in Malaysia should be investigated and addressed before the large scale utilization of OPBW as RE source can be anticipated in Malaysia.

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