Biogas Capturing Facilities in Palm Oil Mills: Current Status and Way Forward

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INTRODUCTION

Malaysia is the world's second largest palm oil producer. In 2018, a total of 19.52 million tonnes of crude palm oil (CPO) was produced from 97.8 million tonnes of fresh fruit bunches (FFB) processed by 451 palm oil mills (Kushairi *et al*., 2019). At the same time, palm oil mill effluent (POME), a wastewater stream was also abundantly generated at about 64 million tonnes. The conventional POME treatment through a series of open ponding system via anaerobic digestion (AD) emits a greenhouse gas, biogas, to the atmosphere. The biogas containing about 65% methane (Loh *et al*., 2013) if not trapped will be released causing global warming as methane is at least 28 times more potent in terms of warming the climate system than carbon dioxide (IPCC, 2014). It also gives distinctive unpleasant odour to the surrounding ecosystem. If the biogas (methane) is trapped, it can become a renewable energy source for the country.

The palm oil milling industry in Malaysia is governed by several environmental regulations to ensure its sustainable development. These are: (1) the Environmental Quality (Prescribed Premises) (Crude Palm Oil) Regulations, 1977 on POME final discharge to watercourses, (2) the Environmental Quality (Clean Air) Regulation 2014 (DOE, 2014) on palm oil mill biomass boilers stack emissions and (3) the Draft Environmental Quality (Odour) Regulations 201X (unpublished) on source of odour emission from palm oil mills. In POME treatment, besides ensuring a final discharge of 20 ppm biological oxygen demand (BOD) into a watercourse, the biogas produced needs to be properly managed too through an integrated approach.

In encouraging biogas capture and utilisation, effective 1 January 2014, new mills and existing palm oil mills requiring throughput expansion have been mandated to install full biogas trapping or methane avoidance facilities (MPOB, 2013). This has served as an additional licensing requirement in regulating palm oil milling business, although other existing mills not categorised under the above two criteria have not been regulated yet. Nevertheless, existing mills are encouraged to venture into biogas capturing on voluntary basis based on market requirements. *Figure 1* shows biogas development trend. After a 13-year biogas implementation starting from 2007, as of December 2019, a cumulative of 125 biogas plants were in operation which corresponded to 28% nationwide biogas implementation. A total of 30 biogas plants are connected to national grid and three to local grid for external users. Also, there are now about 76 mills with composting plants under the methane avoidance category. As a whole, an estimated 5.52 million tonnes of carbon dioxide equivalent yearly has been mitigated through biogas capture and utilisation in the country.

ISSUES, CHALLENGES AND OPPORTUNITIES

The Malaysian oil palm industry has just celebrated its 102nd anniversary on last 18 May 2019. The prosperity gained through such a long journey must be upheld in the light of quality and sustainability to safeguard the industry as a whole. As such, effort to capture biogas is seen as one of the important initiatives that should be actively undertaken by the industry to accelerate sustainable development gearing towards a developed nation. As mentioned, the 28% success story in a 13-year biogas implementation period is worth revisiting for strategic realignment and governance. Timely examination of this privately-driven biogas initiative through the MPOB-Industry Consultation dated 24 May 2019 has indicated that this business is far beyond profitable means, with many positive (strength)

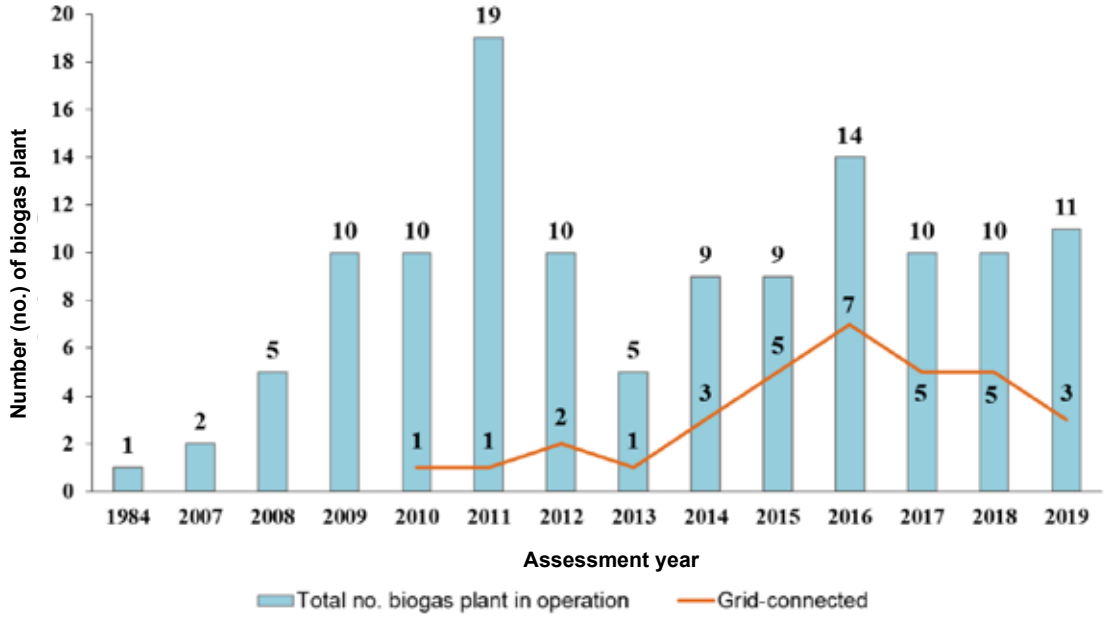

Figure 1. Biogas development trend (till end of 2019).

and negative (weakness) feedbacks gathered, reflecting a more challenging pursuit in current economy situation. The many issues and challenges faced by the industry though have rendered nationwide biogas implementation impossible, but the experiences gained and the availability of enormous resource in Malaysia will be able to lay strong foundation and offer great opportunity for years to come in driving the local and regional economies.

Lack of Adequately Designed Supporting Framework

Supporting framework is required to administer renewable energy fund, quota demand, Feed-in Tariff (FiT), displacement cost, E-bidding, *etc.* Current low participation rate by the industry in biogas implementation for electricity generation is due to constraints in terms of renewable energy quota as well as accessibility to the grid. It is opined that the recently introduced E-bidding system has discouraged FiT project as the bid FiT rates ranging from 23 cents to 32 cents per kWh are too low which almost equal to a total displacement cost, making projects unviable in the long run. The positive side of this occurrence is a relatively lower fund consumption, thus more quota can be released. However, the realistic aspect of implementing project with low displacement cost is questionable. The industry might see this unattractive as current framework does not reflect and support genuine business situation. Overall, there is a need to revise displacement cost and FiT for biogas, biomass and all other indigenous energy resources, so that they can be at least on par with other exported technologies such as solar. Seemingly, solar implementation has received comparatively higher fund allocation, leaving very little room for deployment of other renewable sources. Although E-bidding system is introduced to leverage on current financial situation for a fairer distribution of quota to the needed sector, it should be done credibly not to be sabotaged by interested party in order to drive renewable energy business sustainably. As current renewable energy fund and quota are limited, alternative support is seriously required to cater for future hike of demand and interests.

Interconnectivity Issue

Interconnectivity revolves around issues on distance, cabling cost, safety, load demand, distribution infrastructure, *etc.* On a basic economic point of view, only mills located within grid connection vicinities and have secured reasonable FiT would invest in grid-connected biogas project. Several factors to be considered when securing a site for grid connection are distance of biogas plant to substation, load demand and supply distribution plus safety aspect along the respective connection points. A preliminary evaluation for feasible location is crucial before embarking on a costly power system study assessing all aspects of interconnectivity to the utility. A biogas plant situated ≤5 km from the grid is normally deemed feasible but those far from the grid (>10 km) are a no-go due to the anticipated high cost for injection at a higher voltage substation point. Sometimes even with a shorter distance, possibility to be redirected to hook onto a connection point far beyond the feasible distance happens

due to overloaded and saturated connection points. Although currently there is no limitation to allow injection of biogas to national grid, the industry's greater concern is heavy investment of interconnection facilities. As the national grid is well structured and fossil fuel is heavily subsidised, it is recommended to explore new business model plan that can be implemented whereby millers can focus on palm oil production and a third party to invest on the interconnection facilities.

Biogas for grid connection via FiT is only eligible for mills located in Peninsular Malaysia and Sabah. This kind of activity in Sarawak is ineligible. Furthermore, FiT project is not feasible as hydroelectricity is much more abundant and cheaper as an option for renewable energy generation. Biogas upgrading should not be limited to gas form (bio-CNG) but others like bio-liquefied natural gas be considered, especially in Sabah and Sarawak due to huge distribution potential in the future. As an alternative, biogas can be explored to be injected to national grid via co-generation (natural gas replacement). Be it for bio-electricity (FiT project) or bio-CNG, availability of basic infrastructure *e.g.* network connectivity (in East Malaysia) to support industry players moving into this direction will remain as a big challenge for another 5-10 years. For those mills located at very remote areas and are far from national grid, integrating biogas plant for efficient internal consumption *e.g.* to reduce downstream diesel consumption such as in POME polishing and fiber pre-treatment plants are largely encouraged. In some cases, biogas implementation helps not just to address shortage of power but eventually as a part of sustainable initiative.

Poor Return on Investment (ROI)

Huge investment is required to install biogas system be it a digester (tank) or covered lagoon. In addition, quite a tidy sum is needed too for selective biogas utilisation. Investment cost can accelerate if there is lack of holistic approach in managing the POME. As a general rule of thumb, an estimated RM14 million to RM17 million investment is required for capturing biogas and producing electricity for grid connection. For bio-CNG, the amount of money required is even more. Apart from developing and producing bio-CNG, the industry has also faced issues especially on its selling price. For continual competitiveness and business sustainability, a more holistic biomass resources utilisation and diversification into other forms of power generation is encouraged rather than concentrating on a single use perspective (biogas/bio-CNG). Such an approach focusing on multiple production should be more persuasive and be forthcoming to guide and provide a good business model for the industry players to move forward because for every investment rendered, there must be a good ROI.

Heavy Fuel Subsidy

Fossil fuel use in Malaysia is heavily subsidised and mostly political-driven, leading to unattractive competition for new energy market be it biogas or bio-CNG. Moving forward, subsidy ought to be demolished to encourage deployment of renewable energy. A holistic policy framework to gradually reduce federal subsidy for fossil-based energy and feasible support be provided instead to spearhead renewable energy is very much sought-after. Renewable energy price could be lower once there is a good deployment of affordable technology and at that time, subsidy from the government might not be required anymore.

Crop Season and Milling Capacity

The volume of fruits received by a mill for processing can vary a lot dependent on high or low crop season, which has indeed shown certain degree of influence while having biogas plant in place. Designing a robust AD-based biogas system that can cater to the fluctuating POME volume is vital as the resulting environment in the system containing microorganisms would have insufficient nutrients for metabolism during low crop season, hence less biogas will be generated. During high crop season, only limited fruits can be handled based on available approved capacity, beyond which a biogas plant must be established (requirement for throughput expansion approval). For independent millers buying at least 80%-90% of crops from independent smallholders, they cannot buy directly but have to go through a dealer network. As such, utilisation of biogas either for boiler combustion, electricity generation or bio-CNG must be decided based on optimum scale of operation as the respective ROI will be affected.

Strengthening Existing Governance

Alignment across the various relevant stakeholders, agencies and renewable energy players for efficient resource leveraging is very important. Relevant ministries and agencies such as Ministry of Primary Industries (MPI), Ministry of Energy, Science, Technology, Environment and Climate Change (MESTECC), Sustainable Energy Development Authority (SEDA) Malaysia, Suruhanjaya

Tenaga (ST), Tenaga Nasional Berhad (TNB), *etc*. should involve in facilitating and solving the biogas-to-bio-CNG technicality and finance. A centralised governance such as a concerted one-stop center is proposed to assist the industry in addressing issues concerning insufficient quotas/fund, long process for grid-connected biogas plant to reach commercial operation date (COD) from initial operation date (IOD), *etc*.

In summary, as most palm oil mills concentrate on producing just the main commodity *i.e*. CPO, lack sufficient knowledge on efficient side stream biogas utilisation coupled with unconvincing companies' biogas track record, the development in this area has been rather disappointing. In reality, most mills are already self-sufficient in energy by combusting oil palm biomass in boilers to produce heat and power to support operation (Vijaya *et al.,* 2008). Thus, AD-based biogas production in Malaysia has far lesser relevance in deploying biogas to address energy shortage issue than its neighboring countries, which saw better development in this area over the years. This coupled with the fact that palm oil mills are normally far from one another and isolated from any energy-intensive industrial activities within their vicinities, making some of the well-developed utilisation approaches such as domestic biogas production and use, rural electrification and decentralised power production irrelevant, less attractive, lack of demand and have little success (Loh *et al.,* 2017). To overcome this, new uses of biogas already in the pipeline such as bio-CNG as a transportation and industrial fuel is seemingly a promising future approach.

RECOMMENDATION

In order to stay as a profitable business, the Malaysian palm oil industry should act proactively, be responsible and bold ahead in addressing biogas emissions via AD and championing biogas capturing to stay competitive in facing the ever changing sustainability demands of the global marketplace. At national level, capturing biogas via digester tank or covered lagoon will give rise to a lower BOD level making further polishing treatment of POME in achieving 20 ppm much easier. Besides, capturing biogas for co-firing has potential to mitigate air pollution issue pertinent to particulate matters and odour emissions. Biogas co-fired with mesocarp fibre in palm oil mill biomass boilers, with proper control of air-fuel ratio, has been proven able to meet the particulate matters threshold of 150 mg m^{-3}, as stipulated under the Environmental Quality (Clean Air) Regulation 2014 (Nasrin *et al.,* 2019). Mitigating odour emissions from POME via quarantine method through capturing the produced biogas can be recommended as results have shown that in-field odour concentrations at biogas capturing sites (digester tank or covered lagoon) are well below the proposed odour limit of 12 000 OU m^{-3} for palm oil mills (Yap, 2018). Internationally, palm oil-derived biodiesel from mills with biogas capturing facility provides a higher life cycle greenhouse gases savings threshold (*e.g.* 35% and 50%, respectively) to be recognised as a renewable fuel as stipulated in the EU Renewable Energy Directive (RED II) and EPA Renewable Fuel Standard (RFS2). It is thus important for the industry to take part in biogas capturing in views of the manifold benefits it can render, by properly managing the emitted biogas so as to stay competitive and be relevant in the global market. It is hoped that more efforts spearheaded by the industry can be pushed, with technical assistance from MPOB.

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