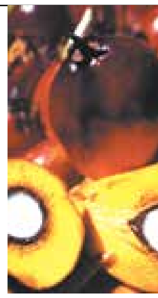
Feature Article



Co-firing of Biogas in Palm Oil Mill Biomass Boilers

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INTRODUCTION

Biogas is a gaseous by-product generated from anaerobic digestion (AD) of palm oil mill effluent (POME). As a renewable energy resource, one of the commercial uses of biogas in the Malaysian palm oil industry is as a supplementary fuel in biomass boilers. This approach adopts a co-firing concept, offers an immediate and low-cost investment option for a direct and clean conversion of biogas to steam and electricity via an existing combined heat and power (CHP) plant available at palm oil mills (Nasrin *et al*. 2014 and Loh *et al*., 2014). Biogas is added as a partial substitute fuel in oil palm biomass boilers.

A survey by MPOB conducted under the Entry Point Project No. 5 (EPP5) of National Key Economic Area (NKEA) has shown that there are at least 12 palm oil mills nationwide operating a biogas-biomass co-fired plant (Loh *et al*. 2015). Regardless of biogas compositions and flowrate, the biogas generated either from digester tank or covered lagoon technology can be directly channelled and cofired simultaneously with palm biomass in the boiler furnace, without any biogas pre-treatment. Biogas co-firing is a better near and short term utilisation option providing economic and environmental advantages compared to flaring, in particular for a newly completed and commissioned biogas plant and the existing biogas plants built under Clean Development Mechanism (CDM).

BIOGAS CO-FIRING SYSTEM

Besides the AD digester, other main equipment and devices required for biogas co-firing are burner, blower and safety devices (*Figure 1*). The modification of existing boilers is required for installation of biogas burner. In order to accommodate the grow-

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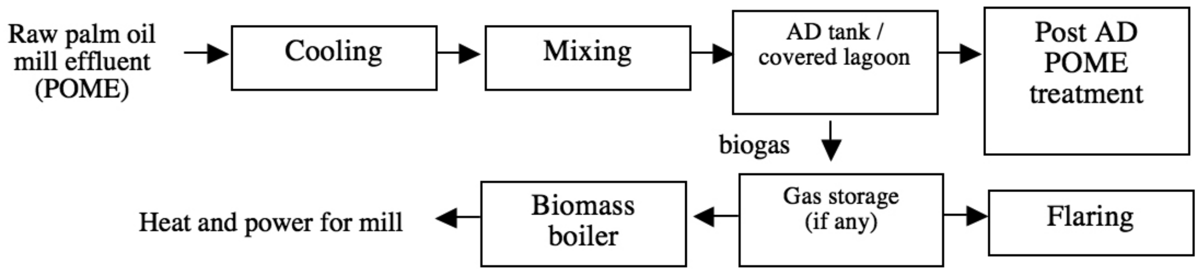


Figure 1. Co-firing of biogas in palm oil mill biomass boiler.

Source: Kevryn (2011) and Tong (2011).

Figure 2. Biogas burners installed at palm oil mill biomass boilers.

ing interests on biogas cofiring, there is an initiative between the technology provider and boiler manufacturer to provide pre-installed/built-in burner port of new biomass boiler for future installation of biogas burners, if required. The number of burners and capacities required for the installation depend on the biogas flowrate. The burner is normally installed either at the tubing side of the boiler water wall or the front side close to the fuel feeder (*Figure* 2).

In principle, the use of biogas reduces the biomass fuel intake of a typical palm oil mill boiler. Thus, there are savings in the utilisation of palm shell, and to a limited extent, of the mesocarp fibre. The saved biomass can be sold for additional income to the millers. In terms of environmental benefits, the biomass fuel saving due to the substituted biogas fuel may improve the boiler's smoke opacity which translates into reduction of the dust and particulate concentration in the flue gas emitted from the boiler chimney.

Safety is an important aspect in utilising the biogas in biomass boilers. Installation of safety devices such as flame sensor, flame arrester, U-seal, low pressure switch, auto shut off valve and safety interlock are a must in order to ensure safe working during the operation. A great deal of attention should also be given during the start-up and shutdown of the boiler.

TECHNICAL ASSESSMENT OF THE SYSTEM

A study conducted by MPOB in one of the palm oil mills that co-fired biogas in the palm oil mill boiler has shown its technical feasibility with substantial economic and environmental benefits (Nasrin *et al*, 2012). However, this could only be achieved if issues related to biomass-biogas combustion, boiler performance and biomass saving were optimised without jeopardising the basic needs of heat and power for mill operation.

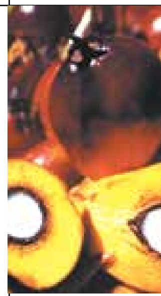


TABLE 1. ECONOMIC ANALYSIS OF BIOGAS – BIOMASS CO-FIRED BOILER FOR A 60 t hr^{-1} PALM OIL MILL

	Technology	
	Digester tank	Covered lagoon
AD and burner (capital expenditure, CAPEX), RM (million)	9.0	6.5
Annual shell displacement, t yr^{-1} (at 80% of total shell produced)	13 824	
Annual gross profit from selling of palm shell, RM 160 t^{-1} of shell, RM (million yr^{-1})	2.2	
Annual operational expenditure (OPEX) at 3% of CAPEX, RM (million yr^{-1})	RM 0.270	RM 0.195
Net profit (Annual gross profit – annual OPEX) , RM (million yr^{-1})	1.930	2.005
Payback period, years	4.66	3.24
Internal rate of return (IRR), %	21.4%	30.0%

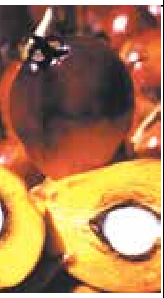
The system studied comprised a covered lagoon biogas plant with a capacity of 32 000 m^3 to treat 1000 m^3 day^{-1} of POME. This capacity should also cater for the increased POME generated from fresh fruit bunches (FFB) processed up to 60 t hr^{-1} throughout the year. With the proper mixing and sludge discharge systems, the biodigester offers an efficient system, a larger gas storage capability and less maintenance and operation costs. The chemical oxygen demand (COD) removal efficiency and the biogas production were approximately 90% and 25 Nm^3 (or 15 Nm^3 of methane, CH_4) for every tonne of FFB processed, respectively (Kevryn, 2011).

The biogas and combustion air were channelled to the boiler via the burner and co-fired with palm biomass. This can only be done after the slow combustion in the boiler has been completed and the induced draft (ID) fan has been switched on. Shell usage as a fuel has almost displaced up to 2.9% of total FFB processed (MPOB, 2014). The mesocarp fibre was also gradually reduced when the desired operating boiler pressure was achieved. Additional income is possible by sales of palm shell and fibre.

From the environmental protection point of view, the utilisation of biogas can improve the boiler stack opacity by about 20% consistently as compared to about 40% without the biogas. In addition, the mill has demonstrated that more than 50% reduction in dust and particulate concentration in the flue gas emitted from the boiler was achieved (MPOB, 2014). The study also showed that the mill consumed about 90% of biogas generated for co-firing and another 10% was flared to combust excess biogas especially during the maintenance period of the boiler and the mill.

ECONOMIC ANALYSIS

The main economic benefit through biogas co-firing is on the displacement or savings of palm shell as fuel in the biomass boiler (*Table 1*). This shell can be sold to other industries, either as a fuel or as a feedstock for non energy purpose. The savings of the palm shell depends on the efficiency of the boiler as well as energy requirement of the mill. From the study, the palm shell savings varied from 80% to 90% of its total generation in palm oil mills.



CONCLUSION

An appropriately configured and optimised biogas -biomass boiler in palm oil mills has demonstrated the techno-economic and environmental benefits of such a plant. Reduction of biomass fuel was significant, in particular the palm shell, and further reduction of particulate emission from the chimney is possible. Selling of the saved biomass, mainly palm shells to potential buyers as premium fuel created additional income to the industry.

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