Feature Article

Maximising Biomass and Biogas Renewable Energy Utilisation in Keck Seng's Integrated Palm Oil Mill and Downstream Industry Complex

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INTRODUCTION

Keck Seng (Malaysia) Berhad, (KS) operates an integrated palm oil mill complex located in Masai, Johor. The complex consists of a palm oil mill, kernel crushing plant, palm oil refinery and other plants for downstream activities since early 1970s. The company has a far-sighted vision to maximise the use of in-house renewable energy (RE) sources, so that a large part of the very high energy demand by the whole complex can be met in a most cost-effective and environmentally sustainable manner.

MAXIMISING BIOMASS ENERGY UTILISATION IN THE INTEGRATED INDUSTRIAL COMPLEX

Spearheading the strategies to maximise the in-house renewable energy sources usage was the establishment of the biomass steam and power generation plant. This is more commonly adopted in most palm oil mills more significantly, the extension and sharing of the energy usage to meet the requirement of the down-stream palm oil refinery and kernel crushing plants. The installed capacity of the RE power plant and its contribution to savings in fossil fuels and grid power demand for the year of 2014 are summarised in *Table 1*.

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TABLE 1. KS BIOMASS STEAM AND POWER GENERATION SYSTEM - CONTRIBUTIONS TO SAVING OF FOSSIL FUELS AND GRID POWER DEMAND

System installed	Fuels or grid power displacement	Usage in refinery	% Saving to total requirements	Capacity performance
Back pressure turbine	TNB grid power supply	6757 MWh	31	Electrical power generated: 20 MWh day^{-1}
Biomass boiler steam: 688 t day^{-1}, 500 psig, 310°C (for steam and power) Steam saving from sterilisation process: 0.164 t steam / t FFB Steam saving from kernel drying: 40 t steam / t FFB	MFO	7 074 000 litre	96	Steam production: For mill use – 413 t day^{-1} For refinery use – 275 t day^{-1}

KECK SENG'S CSTR POME ANAEROBIC DIGESTER TECHNOLOGY FOR BIOGAS CAPTURE AND USAGE

The revolutionary vision in maximising RE utilisation in the palm oil mill complex in the early 1980s has motivated the full recovery of the biomass energy by the timely development of the continuous flow stirred tank reactor (CSTR) anaerobic digestion system for biogas capture. The digester system allows for the efficient removal of the high organic pollutant content in palm oil mill effluent (POME) while the biogas captured is utilised as a substantial fuel source for the boilers of the refinery plant.

The innovative design by the group in Keck Seng of the CSTR Anaerobic Digester plant was built and commissioned in 1984. After years of successful operations, improvement and expansion, the plant to-date is capable of treating POME from a 60 t FFB hr^{-1} palm oil mill processing plant. The design specifications for the system is summarised in *Figure 1*.

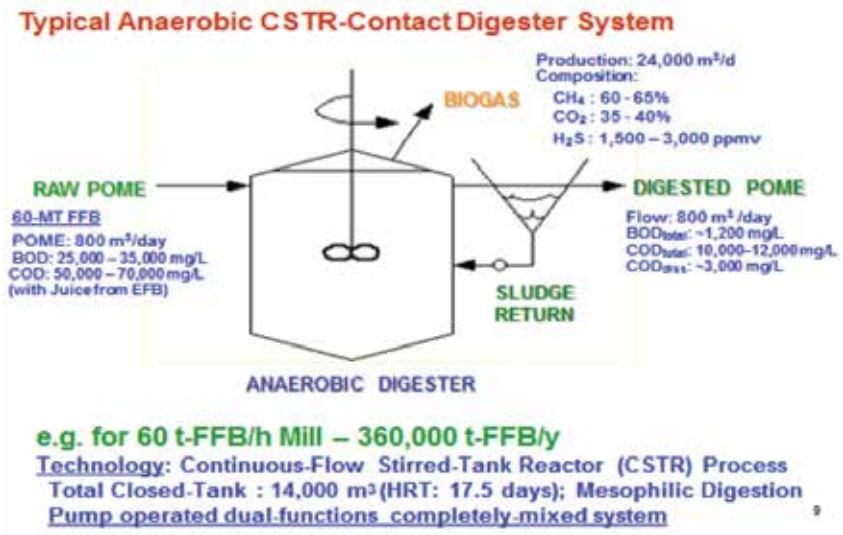

Figure 1. Design specifications of the CSTR anaerobic digester of Keck Seng.

TABLE 2. KS POME BIOGAS-CAPTURE PLANT - CONTRIBUTIONS TO SAVING OF FOSSIL FUELS AND GRID POWER DEMAND

Biogas utilisation	Installed system	Fuels or grid power displacement	Usage in refinery per annum	% Saving to total requirements	Capacity installed
Biogas Boilers	2 Geka Boilers, 1.23 MW hr^{-1} heating capacity (at 70 bar pressure and 320 ^{o}C)	Diesel	1 144 000 litre	96	Steam production: 33.6 M kcal day^{-1} at 70 bar at 320 ^{o}C
Biogas Chillers	Vapour absorption chiller with biogas burner	TNB Grid Power	3 520 MWh	16	2 units with 660 RT (Refrigeration ton) and 1 unit with 420 RT

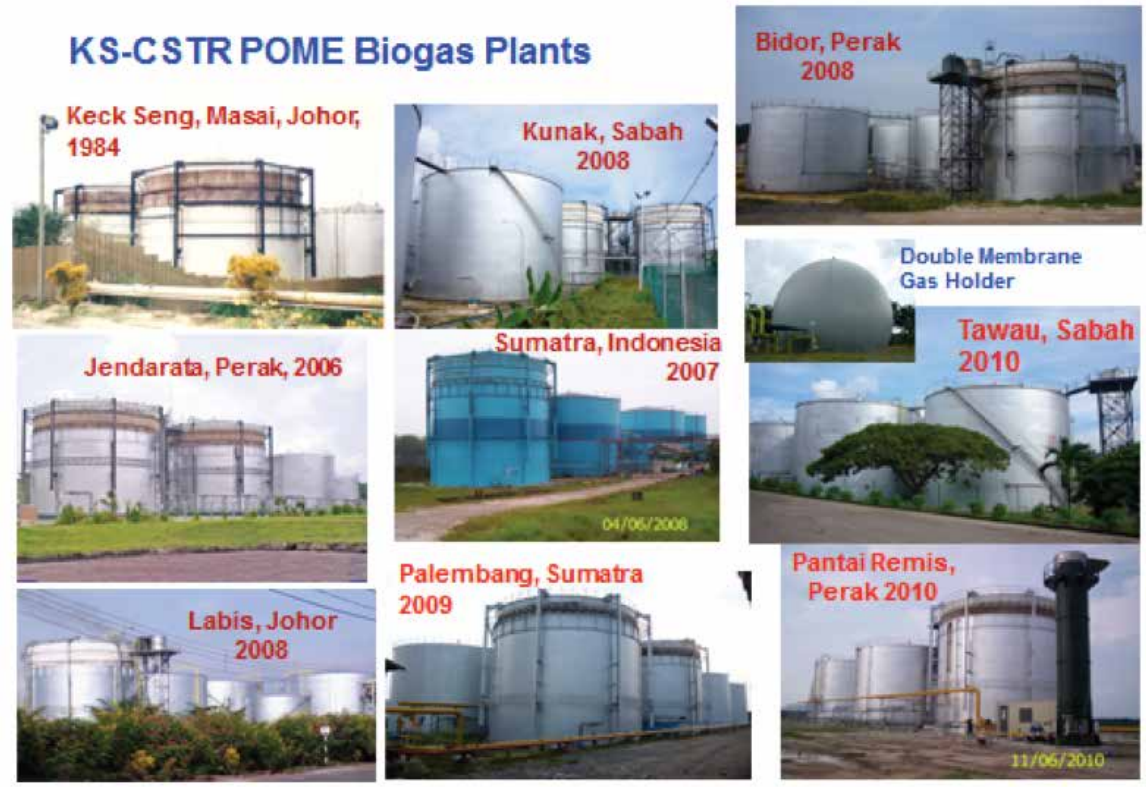

Figure 2. Installed POME biogas capture plants employing the KS-CSTR anaerobic digestion technology.

The biogas generated has been used as a fuel for the boilers and chillers for the refinery. The installed biogas boilers and chillers capacity and saving in fuel and power usage in the refinery are summarised in *Table 2*.

RECENT DEVELOPMENTS TO KS-CSTR ANAEROBIC DIGESTER TECHNOLOGY FOR POME BIOGAS CAPTURE AND UTILISATION

After nearly 20 years of successful operation, KS licensed its unique anaerobic digester technology for biogas generation and capture in 2003 to Novaviro Technology Sdn Bhd, to commercialise the system. To-date more than 20 POME Biogas Capture plants employing the KS-CSTR Anaerobic Digestion technology have been built in Malaysia and Indonesia. Over the last decade, further developments have been introduced and these include the improvements to the complete system, both in design and choice of new equipment such as glass-fused-to-steel (GFS) digester tanks, double-membrane gas-holders either integrated on top of the digester tanks or installed separately on-ground, the high efficient enclosed flare and biological desulphurisation systems, *etc*. A few examples of these biogas plants are shown in *Figure 2*.

The initial rapid growth momentum in the number of the POME Biogas Capture plants being installed in Malaysia had been provided through the ratification of the Kyoto Protocol in 2005 via the introduction of the Clean Development Mechanism (CDM) Scheme under the United Nations Framework on Climate Change Convention (UNFCCC). The CDM scheme played an important role for the financing some of these POME Biogas Capture projects since then till 2012/2013 when the developed countries gave clear indication for stopping the support to the CDM scheme. Although

Figure 3. Installed systems in applications and utilisation of biogas captured from POME anaerobic digester plants.

relatively short-lived, the contribution of the CDM scheme was reflected in the fact that a total of 13 out of approximately 21 projects employing the KS-CSTR technology had received official registration as CDM projects under the UNFCCC CDM scheme.

New POME Biogas Capture project development since then has to face the stiff challenges to find significant on-site beneficial utilisation of biogas recovered to justify the substantial costs of investment.

Further to the utilisation of biogas capture developed in Keck Seng as boiler fuel for displacing the conventional diesel or fuel oil usage, as well as use in chillers to replace the existing electrical chiller system, various other beneficial applications of the large quantities of biogas as a direct RE source have been adopted in these biogas plants in the last decade.

Other than the specific and localised applications and utilisation of the biogas captured, biogas power generation to meet localised use and / or connecting to the wider power grid emerged in many recent cases a viable option offering significant return to investment. In this regard, the relevant authorities had introduced the SREP (Small Renewable Energy Program) and later expanded this to the new FiT (Feed-in-Tariff) scheme under SEDA (Sustainable Energy Development Authority) to encourage the development of power to grid connection. Generally, the following power generation capacity can be readily achieved for POME Biogas Capture plants employing KS-CSTR technology:

- 30 t FFB hr^{-1} (180 000 t FFB yr^{-1}) mill: ~ 0.9 – 1.2 MW
- 60 t FFB hr^{-1} (360 000 t FFB yr^{-1}) mill: ~ 1.8 – 2.4 MW
- 90 t FFB hr^{-1} (540 000 t FFB yr^{-1}) mill: ~ 2.7 – 3.6 MW

A few photos of the utilisations of the biogas captured are shown in *Figure 3*.

The above discussed range of biogas applications and utilisation systems installed are summarised in *Table 3*.

TABLE 3. POME BIOGAS-CAPTURE PLANTS EMPLOYING KS-CSTR TECHNOLOGY – APPLICATIONS AND UTILISATION OF BIOGAS RECOVERED

Applications and Installed Systems for Utilisation of Biogas Recovered		No. of Projects/ Plants
Registered as CDM projects – UNFCCC-Kyoto Protocol		13
Direct Fuel Displacement -	i. High pressure boilers	2
	ii. Package boilers	2
	iii. Vapour absorption chillers	1
	iv. Thermal oil heater	3
	v. Hot air burner	1
	vi. Co-firing in biomass boilers	7
	vii. H_2 production – steam-methane reforming	1
Biogas for Power Generation – Gas Engines	i. Power to Grid – SREP	1
	ii. Power to Grid – FiT of SEDA	5
	iii. Power for in-house use	6