BIO-COMPRESSED NATURAL GAS (BIO-CNG) PRODUCTION FROM PALM OIL MILL EFFLUENT (POME)

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Biogas is a renewable energy resource generated from the anaerobic decomposition of palm oil mill effluent (POME). In 2016, it was estimated that 55.80 million tonnes of POME and 1562 million m^3 of biogas were generated from 85.84 million tonnes of fresh fruit bunches (FFB) processed in 456 palm oil mills nationwide (MPOB, 2017). The typical uses of the captured biogas are for heat and electricity generation either for mill consumption or grid connection. Biogas can be further upgraded to produce high quality gaseous fuel *i.e.* bio-compressed natural gas (Bio-CNG).

Realising the needs to diversify its commercial use and add value, MPOB in collaboration with Felda Palm Industries Sdn Bhd (FPISB) and Sime Darby Offshore Engineering Sdn Bhd (SDOE) has successfully developed a 400 m^3 hr^{-1} Bio-CNG plant at Felda Sg Tengi Palm Oil Mill (*Figure 1*) to demonstrate the techno-economic viability in producing Bio-CNG from POME.

NOVELTY

The technology offers a cost-effective process system for Bio-CNG production. The gas produced is subjected to three main processes, namely pretreatment, upgrading and storage (*Figures 2* and *3*). The raw biogas captured from closed anaerobic digester is first pre-treated using a combined biological and chemical process to reduce hydrogen sulphide (H_2S) level from approximately 1500 – 2500 ppm to < 10 ppm. The pretreated biogas is compressed prior to removal of carbon dioxide (CO_2) using membrane technology. This approach enriches CH_4 content in biogas to > 94% which is similar to natural gas specification. The high purity bio-methane is compressed to 250 barg and stored temporarily in cylinders or directly dispensed to compressed natural gas (CNG) trailer for distribution and utilisation.

THE PRODUCT

Bio-CNG is a colourless, odourless and non-toxic clean fuel which can be alternatively used either for the transportation sector or industrial processes (*Table 1*). It produces less pollutants and emissions compared to other fossil fuels, thus reduces the greenhouse gas (GHG) effect to the environment. Bio-CNG can be used on-site, transported using CNG trailer to potential users' site (mobile pipeline) or injected to the gas pipeline, subject to meeting certain technical specifications. These

Figure 1. The 400 m^3 hr^{-1} Bio-CNG commercial plant at Sg Tengi Palm Oil Mill.

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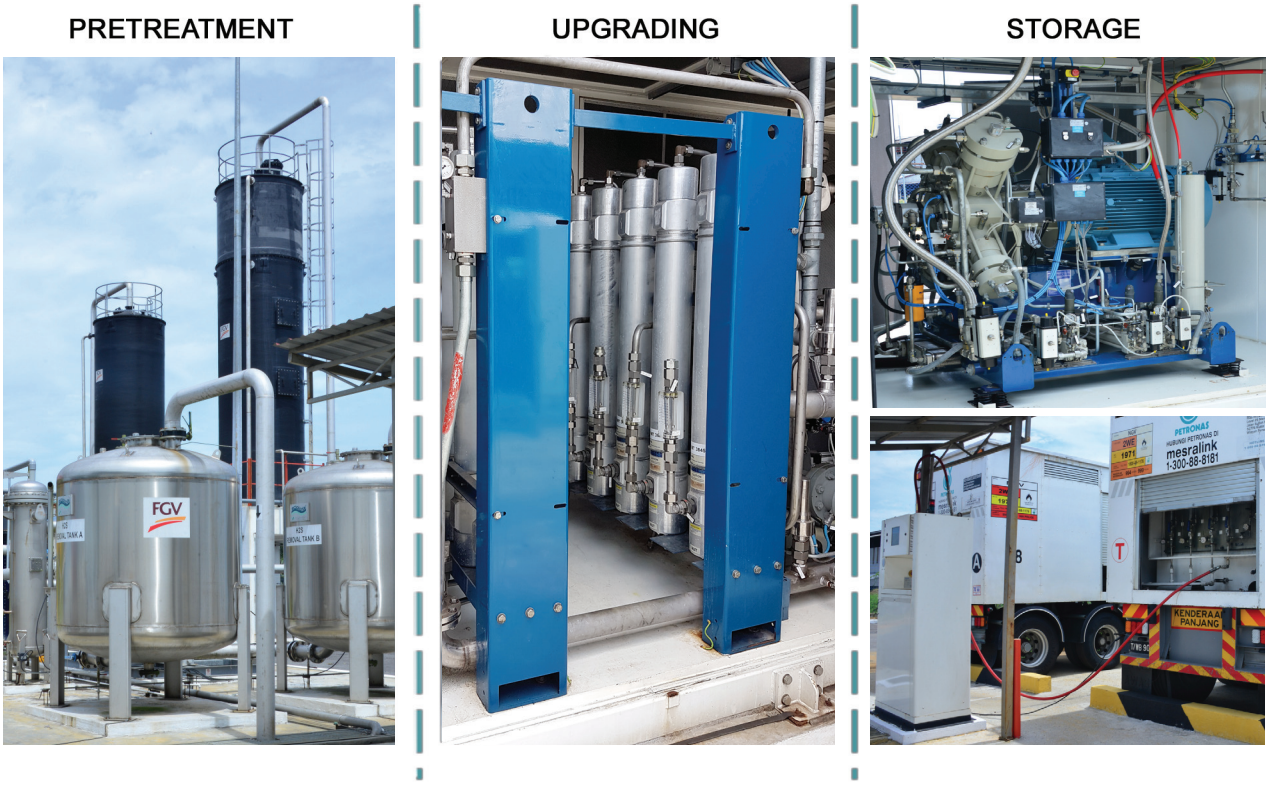

Figure 2. Main operation units of Bio-CNG plant.

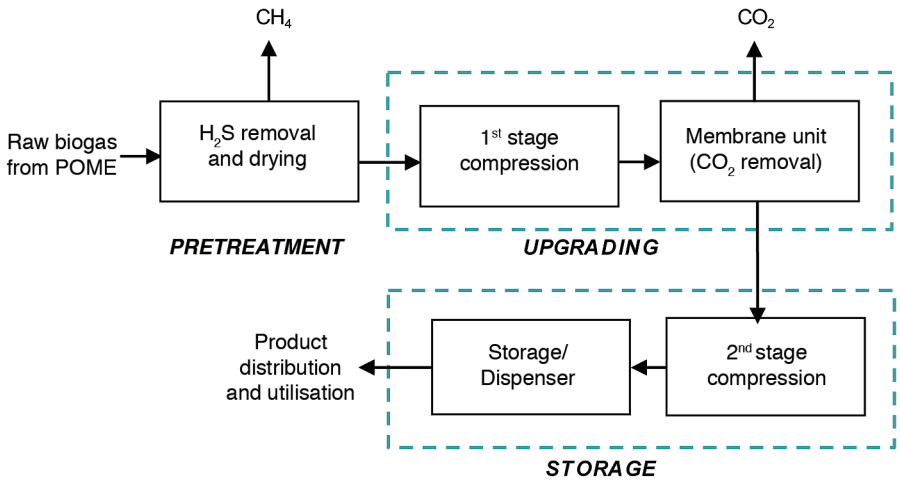

Figure 3. Process flow diagram for the production of Bio-CNG from palm oil mill effluent (POME).

TABLE 1. SPECIFICATION OF BIO-CNG AND OTHER SIMILAR GASEOUS FUELS

Parameter	Biogas (POME)	Bio-CNG	Natural gas
CH_4, %	55 - 65	> 94	> 92
Other hydrocarbons, %	-	-	6
CO_2, %	35 - 40	< 4	< 2
H_2S, ppm	2 500 - 4 000	< 10	< 3
Pressure	2 - 5 mbar	250 bar	250 bar
Calorific value, MJ Nm^{-3}	20	35.95	36.61

Source: Nasrin (2016).

have been commercially implemented in some developed countries such as Germany, Sweden and the Netherlands. For this invention, the Bio-CNG can replace the liquefied petroleum gas (LPG) used at the factory of OMI Alloy (M) Sdn Bhd, with fuel cost reduction up to 30%.

THE BENEFITS

Bio-CNG is a feasible commercial alternative for biogas utilisation (*Table 2*) which offers both economic and environmental benefits to the producer and the industrial user. The developed technology is compact, environmental and user friendly. As an alternative fuel, substantial savings can be made by switching Bio-CNG from fossil fuel, in particular for industrial application. The commercial production and utilisation of Bio-CNG supplements the country's primary energy supply, reduces high dependency on fossil fuel and supports the government's voluntary commitment in reducing up to 45% in terms of carbon emissions intensity based on gross domestic product (GDP) by 2030 (relative to emission intensity of GDP in 2005) (Carbon Brief, 2017).

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TABLE 2. ECONOMIC ANALYSIS OF THE 400 m^3 hr^{-1} BIO-CNG PLANT

Description	Value	
	Bio-CNG plant only	**With biogas plant**
Investment cost, RM (million)	7.0	12.0
Annual production, million m^3 @ 7200 hr yr^{-1}	2.46 (~80 000 MMBTu)	
Assumption: • Bio-CNG selling price @ RM 40.00 – 46.00 $MMBTu^{-1}$ • Operational expenditure @ RM 25.50 $MMBTu^{-1}$		
Net present value (NPV) @10%, RM (million)	1.82	0.17
Internal rate of return (IRR), %	14.36	10.25
Payback period, year	**6.03**	**7.50**

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