Introduction To Biogas Technology

What Is Biogas?

Biogas formed when microorganisms, especially bacteria, degrade organic material in the absence of oxygen. Biogas consists of 50% to 75% methane (CH4), 25–45% carbon dioxide (CO2), and small amounts of other gases. The table below shows the detailed composition of biogas.

Elements	Formula	Concentration (Vol. %)
Methane	CH_4	50–75
Carbon dioxide	CO_2	25–45
Water vapor	H_2O	2–7
Oxygen	O_2	< 2
Nitrogen	N_2	< 2
Hydrogen	H_2S	< 2
Ammonia	NH_3	< 1
Hydrogen	H_2	< 1

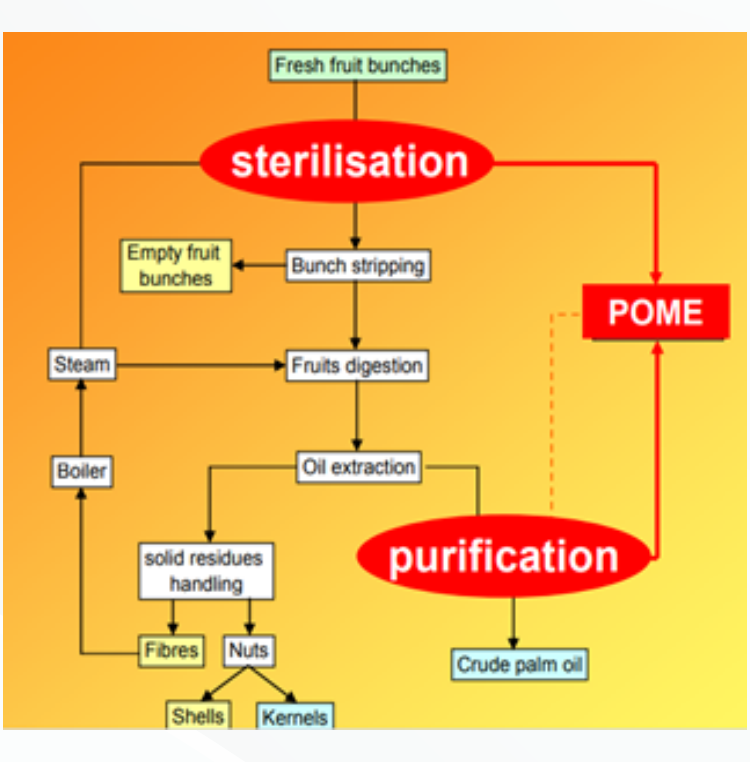
Methane (CH4), the main component of biogas, can combust with oxygen. The energy released from combustion makes biogas as a potential fuel. Biogas can serve as any heating purpose, from cooking to fuel for an industrial burner. In gas engines, biogas converts its energy content into electricity and heat.

How is biogas produced?

Biogas formed when microorganisms, especially bacteria, degrade organic material in the absence of oxygen. Biogas consists of 50% to 75% methane (CH4), 25–45% carbon dioxide (CO2), and small amounts of other gases. The table below shows the detailed composition of biogas.

Any biodegradable organic material can serve as a feedstock to produce biogas. One of the main attractions of biogas technology is its ability to generate biogas from abundant, inexpensive organic wastes such as POME. Biogas production using readily available biodegradable wastes has two key advantages. At the same time, project owners like the palm oil industry gain a safe way to process biodegradable waste that might otherwise end up in landfills or waterways, avoiding negative environmental impacts.

Biogas Generation From Palm Oil Mill Effluent (POME)



Biogas generated from anaerobic digestion of palm oil mill effluent (POME). POME or Palm Oil Mill Effluent is a liquid waste stream from palm oil mills which produce during the palm oil extraction (Crude Palm Oil).

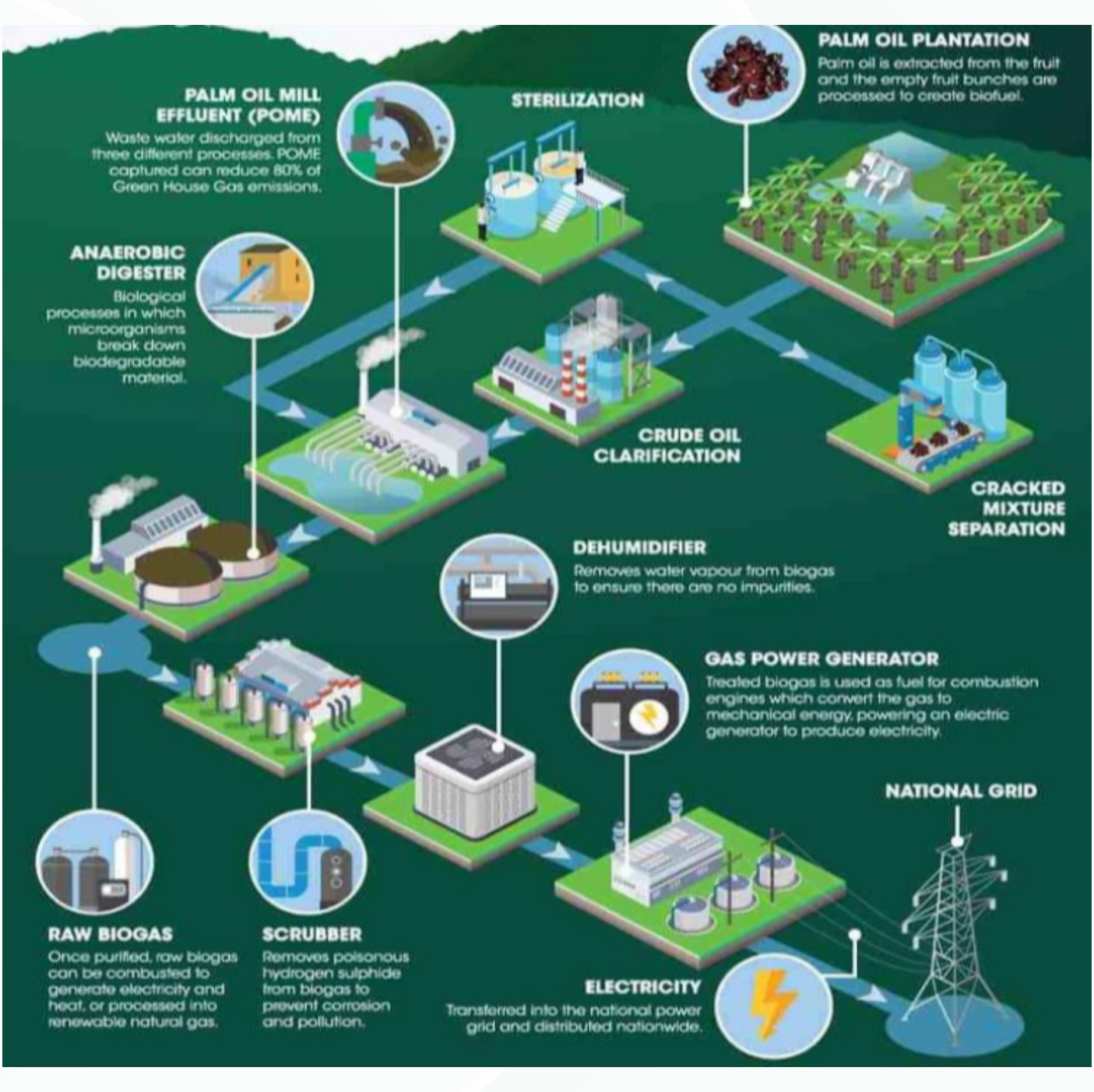
The figure shows the process flow of Palm Oil Mill Effluent (POME) is extracted and pictured of the dark brownish color of (POME). High organic content in POME made it a good source for methane (CH4) gas generation via anaerobic digestion.

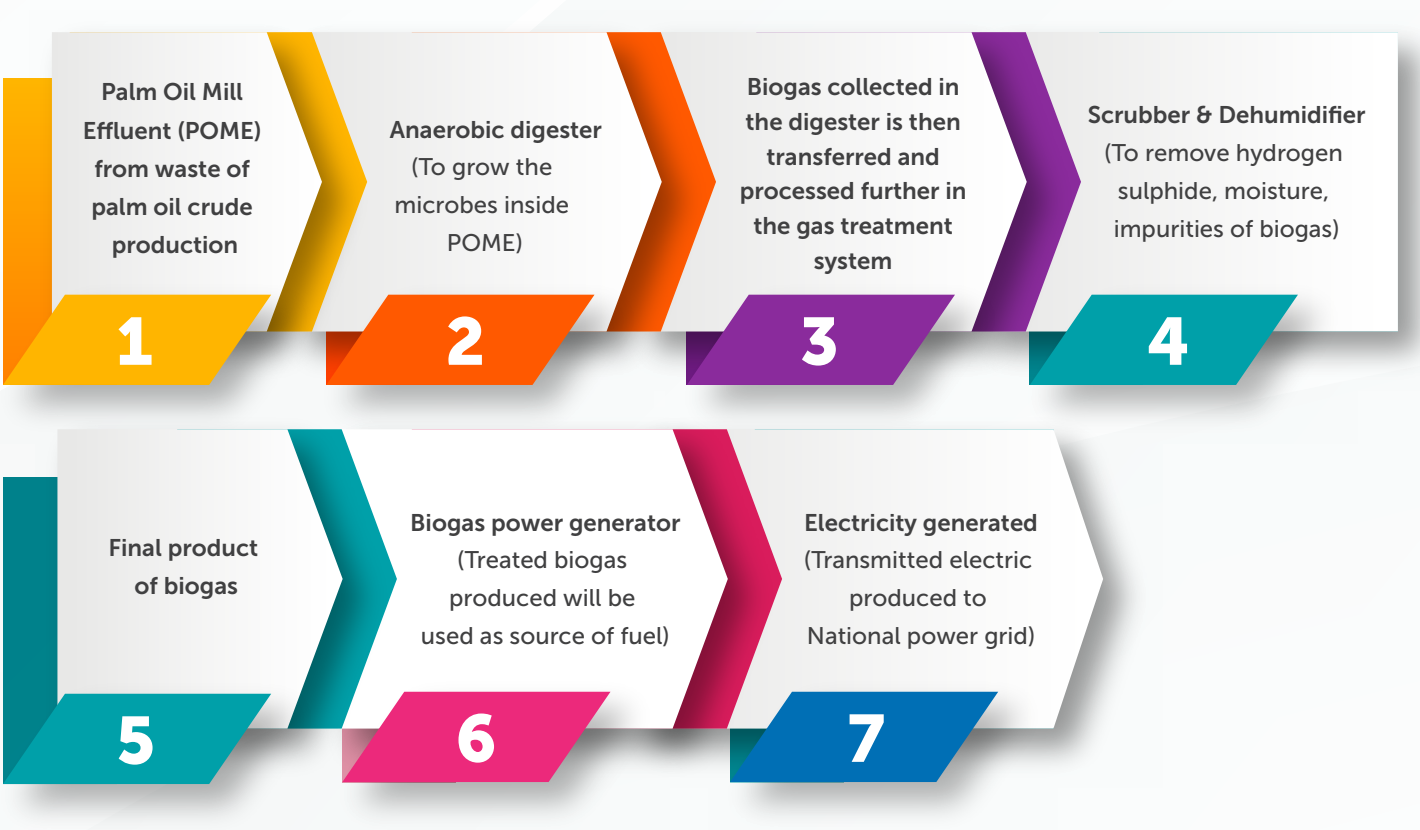
Anaerobic — Types of Digestion — Aerobic

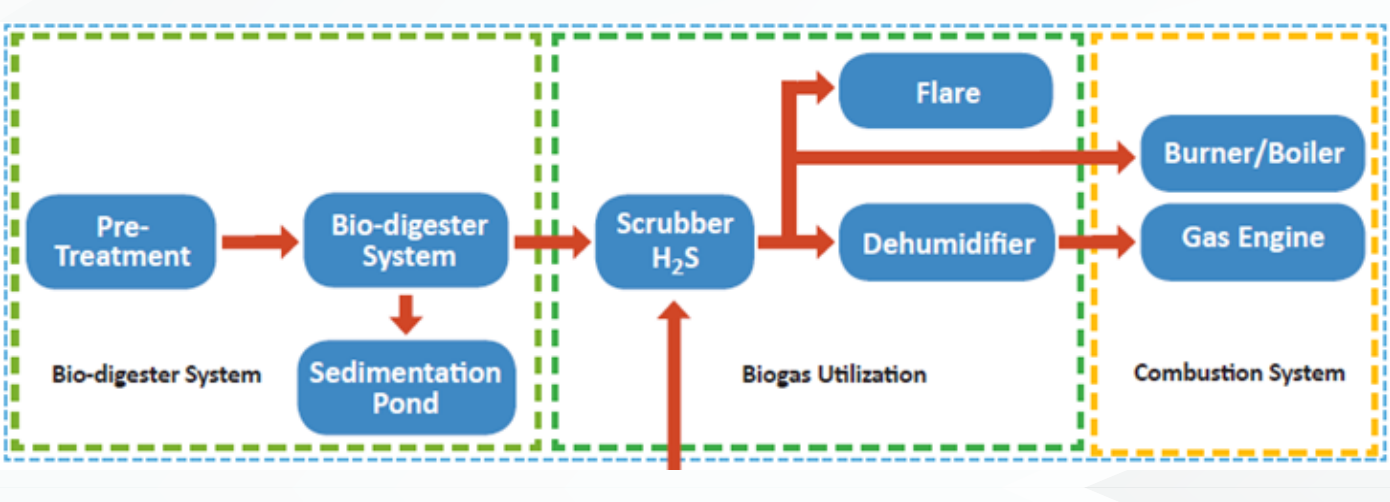
1. An anaerobic process occurs in the absence of oxygen
2. The aerobic process takes place in the presence of oxygen.

POME typically uses the anaerobic process. The main reason for choosing the anaerobic process is its high yield of biogas. Rather than converting materials to methane (CH4), the aerobic process produces large amounts of sludge along with fully treated wastewater. The anaerobic process, on the other hand, produces methane (CH4) and pre-treated water rich in nutrients such as nitrogen and phosphorus.

Biogas Plant


PALM OIL PLANTATION
Palm oil is extracted from the fruit and the empty fruit bunches are processed to create biofuel.
PALM OIL MILL EFFLUENT (POME)
Waste water discharged from three different processes. POME captured can reduce 80% of Green House Gas emissions.
STERILIZATION
ANAEROBIC DIGESTER
Biological processes in which microorganisms break down biodegradable material.
CRUDE OIL CLARIFICATION
CRACKED MIXTURE SEPARATION
DEHUMIDIFIER
Removes water vapour from biogas to ensure there are no impurities.
GAS POWER GENERATOR
Treated biogas is used as fuel for combustion engines which convert the gas to mechanical energy, powering an electric generator to produce electricity.
NATIONAL GRID
RAW BIOGAS
Once purified, raw biogas can be combusted to generate electricity and heat, or processed into renewable natural gas.
SCRUBBER
Removes poisonous hydrogen sulphide from biogas to prevent corrosion and pollution.
ELECTRICITY
Transferred into the national power grid and distributed nationwide.


Palm Oil Mill Effluent (POME) from waste of palm oil crude production
1
Anaerobic digester (To grow the microbes inside POME)
2
Biogas collected in the digester is then transferred and processed further in the gas treatment system
3
Scrubber & Dehumidifier (To remove hydrogen sulphide, moisture, impurities of biogas)
4
Final product of biogas
5
Biogas power generator (Treated biogas produced will be used as source of fuel)
6
Electricity generated (Transmitted electric produced to National power grid)
7



Bio-digester system (Anaerobic Digester)

The figure shows an anaerobic pond in which effluent from palm oil mill plant drained to open pond system. This process called pre-treatment before drained to the covered lagoon. The open pond will reduce the hot temperature of POME, creating optimal conditions for the decomposition of organic material in the anaerobic ponds.

In the pre-treatment component, POME conditioned to achieve the parameter values needed to enter the digester. There, a screening process removes more significant objects such as dirt or fibers. Mixing and pH neutralization reaches an optimal pH of 6.5–7.5.

A cooling system (can be a cooling tower or heat exchanger) reduces the temperature of POME to about 40°–50°C. The temperature of the digester should keep below 40°C for the optimum mesophilic condition. Therefore, the POME temperature further cooled by recycling the digester effluent water. Pre-treated effluent pumped to the bio-digester, a covered lagoon (pictured below). The digestion process produces biogas and a by-product residue

The digester should be air and watertight. It can be constructed of various materials and in multiple shapes and sizes. The size of the digester depends on the flow rate of the POME for optimal digestion.

The anaerobic effluent water from the digester flows to a sedimentation pond where the digested POME separates further from the sludge and solids. Plantations can use liquid waste from the sedimentation as a fertilizer. A solids removal system extracts the sludge and solids accumulated in both the digester and sedimentation pond. Biogas covered at the digester that included the lagoon or the roof of the tank system. A covered pond maintains a low pressure of 0–2 mbarg while a tank system stores biogas at a higher pressure of 8-30 mbarg.

Palm oil mills do not generally use separate biogas storage tanks due to their high costs. Tank systems have biogas storage capacities of between 30 minutes and 3 hours, while covered lagoons have abilities of 1–2 days. Biogas collected in the digester is then transferred and processed further in the gas treatment system or flared.

Biogas utilization

Then, before biogas can generate power, hydrogen sulfide scrubber (Figure below) must reduce the H2S concentration to permissible levels by a gas engine, typically below 200 ppm. The process avoids corrosion, optimizes operation, and lengthens the lifetime of biogas engines. H2S in biogas comes from sulfur components in the wastewater. In the anaerobic digester, where there is no oxygen, the sulfur converts to H2S. A biological, chemical, or water scrubber used to reduce the H2S content. A biological scrubber uses particular sulfur-oxidizing bacteria to convert H2S to SO4, while a chemical scrubber uses a chemical such as NaOH to convert H2S to SO4. Water scrubbers, working based on the physical absorption of dissolved gases in a liquid, use high-pressure water. POME applications usually use biological scrubbers due to their low operating costs

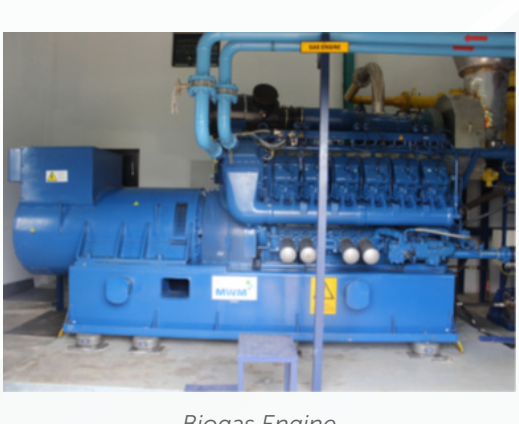
Hydrogen sulfide scrubber

Gas Dehumidifier

A gas dehumidifier (Figure below) can be dryer, chiller, or cyclone; it reduces moisture content in biogas to prepare it for use in a gas engine. The dehumidifier extracts water from the biogas. The process helps optimize the combustion process in the engine, prevent condensation, and protect the engine from the acid formation—the acid formed when water reacts with H2S and oxygen. High-quality, low-moisture biogas with relative humidity below 80% promotes engine efficiency and reduces fuel gas consumption

Combustion

Biogas engine (figure below) is part of an internal combustion engine that runs on a gas fuel such as natural gas or biogas. After the production process reduces impurities in biogas to specified levels, the biogas feeds into a gas engine to generate electricity.



Biogas Engine

Gas engines that run on biogas require a moisture content less than 80% and an H2S concentration less than 200 ppm; these parameters depend on the specification of the gas engines. Gas engines convert the energy contained in the biogas into mechanical energy to drive the generator, which produces electricity. Typically, gas engines have an electrical efficiency between 36–42%.

Biogas Engine Industry

Palm Oil Mill Effluent (POME) produced during crude palm oil extraction from a fresh fruit bunch (FFB) from the palm tree. The biogas mainly contains 56 % to 60 % of methane (CH4) gas will be used as fuel in the biogas engine to convert Palm Oil Mill Effluent (POME) into electrical energy to the state grid. The biogas technology will help to protect the environment and generate stable electricity energy.

Typical OEM of Biogas Engine

Biogas Engine Manufacturer	Power Capacity
Cummins	20 kW- 2000 kW
MWM	400 kW- 2000 kW
GE Jenbacher	300 kW -900 kW
MAN	60 kW- 560 kW
CNPC	400 kW- 1200 kW

Challenges in Biogas Engine

Biogas contains methane (CH4), carbon dioxide (CO2), moisture, and H2S (hydrogen sulfide), and some of the gas impurities may carry over, which potentially cause corrosion on metal components of engines, hence reduce its reliability.

A solution to challenges in Biogas Engine

Realizing that challenges, PETRONAS Lubricant come out with PETRONAS Geo BLG Series is a premium performance bio and landfill gas engine oil specially developed for bio and landfill applications.

PETRONAS Geo BLG gas engine oil developed with the quality mineral base oils, formulated with anti-wear, anti-oxidant, detergent, dispersant, anti-rust, and anti-foam additives technology.

The formulation enhanced anti-wear protection, provides excellent TBN retention, reduced combustion chamber deposits, low oil consumption, and extra protection against landfill gas.

Apart from that, PETRONAS Geo BLG Series meet or exceed vital OEM requirements and officially approved by major OEM such as GE Jenbacher and Caterpillar GmbH (formerly MWM) engines.

Track record of PETRONAS GEO BLG 40

PETRONAS GEO BLG 40 also having a testimonial track record successfully from PITAS Palm oil in Sabah for their Jinnan Biogas Engine application and VG Energy Company in Thailand, which used PETRONAS GEO BLG 40 at GE Jenbacher biogas engine.

Case study of PETRONAS GEO BLG 40 supply in FGV Triang & FGV Keratong

PETRONAS has supplied PETRONAS GEO BLG 40 to Felda Global Venture (FGV) for newly installed biogas engine model GE Jenbacher J 416 GS-B25 at FGV Triang and FGV Keratong, Pahang. Oil monitoring program used to monitor the oil performance from 0 hours to 2000 hours, which oil will analyze at an independent accredited lab every 250 hours.

OEM	GE Jenbacher
Model	J 416 GS-B25 (type 4)
Units	4
Engine speed	1500 rpm
Power generated	1202 kW
Lube oil reservoir capacity	400 Liters for each unit
Oil drain interval	Depends on lube oil analysis report (approx 2000 hours)
Fuel	Biogas from palm oil wastewater (POME)
Lube oil temperature	90 deg (max)
Lube oil pressure	4.8 bar
CH4content:	56-60%

GE Jenbacher biogas engine in FGV Triang and FGV Keratong

Product loading and inspection at FGV site

PETRONAS GEO BLG 40 sampling before oil filling activity