BIOGAS DEVELOPMENT IN THE MALAYSIAN PALM OIL INDUSTRY:
STATUS, POTENTIAL & FUTURE PROSPECT

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Muzammil N, Nurul Adela B & Daryl J.T

Malaysian Palm Oil Board
Outline of Presentation

• Introduction of the Malaysian Palm Oil Industry
• Palm Oil Mill Effluent (POME)
• Status and Potential of Biogas Plant Development under EPP5
• Future Prospect & Way Forward
• Issues and Challenges
• Conclusion
Overview of the Malaysian Palm Oil Industry

- World’s second largest CPO producer
- World’s second largest exporter of palm oil products.
- Crude Palm Oil production in 2013: 19.23 mil. tonnes (94.92 mill. Tonnes FFB)
- Export earnings in 2013: RM 61.36 billion

Based primarily on palm oil/palm kernel oil
### 2013 Malaysian Palm Oil Industry (Palm Oil Mills and Plantation)

<table>
<thead>
<tr>
<th>Region</th>
<th>No of Mills (Capacity, mil. tonnes)</th>
<th>Plantations (mil. hectare)</th>
<th>FFB Processed (mil. tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peninsular</td>
<td>247 (56.87)</td>
<td>2.60</td>
<td>52.00</td>
</tr>
<tr>
<td>Sabah</td>
<td>124 (32.28)</td>
<td>1.48</td>
<td>27.44</td>
</tr>
<tr>
<td>Sarawak</td>
<td>63 (14.94)</td>
<td>1.16</td>
<td>15.47</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>434 (104.09)</strong></td>
<td><strong>5.23</strong></td>
<td><strong>94.92</strong></td>
</tr>
</tbody>
</table>
## Oil Palm Biomass from Palm Oil Mills

<table>
<thead>
<tr>
<th>Biomass  (wt% to FFB)</th>
<th>Quantity, Million tonnes</th>
<th>Moisture Content, %</th>
<th>Calorific Value, MJ/kg (dry basis)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fibre (13%)</td>
<td>12.34</td>
<td>37.00</td>
<td>18.8</td>
</tr>
<tr>
<td>Shell (6%)</td>
<td>5.69</td>
<td>12.00</td>
<td>20.1</td>
</tr>
<tr>
<td>EFB (23%)</td>
<td>22.88</td>
<td>67.00</td>
<td>18.9</td>
</tr>
<tr>
<td>POME (65%) (biogas)</td>
<td>61.70 (1728 mill m³)</td>
<td>-</td>
<td>20.0 MJ/m³</td>
</tr>
</tbody>
</table>
Palm Oil Mill Effluent (POME)

- POME is a thick brownish viscous liquid colloidal suspension from palm oil milling process consisting of:
  - Water 95% - 96%
  - Oil 0.6% - 0.7%
  - Total Solid 4% – 5% (SS 2% – 4%)

- Common POME treatment employs either open ponding or open digester tank system

- About 0.65 t POME is generated for every tonne FFB processed.
Source of POME

• Separator sludge – clarification of CPO (1.5 m³ / t CPO)*
•Sterilizer condensate – fruits sterilization (0.9 m³ / t CPO)*
• Wet separation of kernel & shell (0.1 m³ / t CPO)*
• EFB Juice (mills with EFB treatment plant)
• Cleaning (machineries / factory)

*source: A.N.Ma & Augustine S.H.Ong (1988)
POME Treatment

Conventional Method of POME Treatment

- **Cooling**
- **Mixing**

Biogas (Methanogenic)
Mesophilic process - < 50ºC

- **Anaerobic**
- **Facultative**
- **Algae**
- **Final Discharge**

Total Production (@ 65% of FFB processed)
- 60.01 million m³

Biogas production (@ 28 m³/m³ POME)
- 1680 million m³

Potential energy (@ 21% thermal eff.)
- 243 MW

Potential energy (@ 35% thermal eff.)
- 454 MW

Open ponding system

Open top digester tanks
Characteristics of POME and DOE Standards

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Limit for Discharge</th>
<th>Raw POME</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Range</td>
</tr>
<tr>
<td>Biochemical oxygen demand (BOD$_3$, mg/l)</td>
<td>100*</td>
<td>25000</td>
</tr>
<tr>
<td>Chemical oxygen demand</td>
<td>-</td>
<td>51000</td>
</tr>
<tr>
<td>Suspended solids (mg/l)</td>
<td>400</td>
<td>18000</td>
</tr>
<tr>
<td>Oil &amp; grease (mg/l)</td>
<td>50</td>
<td>6000</td>
</tr>
<tr>
<td>Ammoniacal nitrogen (mg/l)</td>
<td>150</td>
<td>35</td>
</tr>
<tr>
<td>Total nitrogen (mg/l)</td>
<td>200</td>
<td>750</td>
</tr>
<tr>
<td>pH</td>
<td>5-9</td>
<td>4.2</td>
</tr>
</tbody>
</table>

* In some sensitive areas – more stringent BOD discharge limit is imposed e.g < 50 and < 20 ppm
Status & Potential of Biogas Implementation in Palm Oil Mills in Malaysia
Biogas from POME

- Anaerobic digestion of POME converts organic matters and releases biogas into the atmosphere and contributes to global warming.
- Biogas contains about 65% of CH$_4$, 35% CO$_2$ and traces of H$_2$S.
- Potentially used to generate heat and electricity for internal and external uses of palm oil mills.

Biogas Production from Anaerobic Treatment

- Converts waste organic materials to CH$_4$+CO$_2$ in the absence of molecular oxygen.
- Involves two types of bacteria: acid-producing bacteria and methane-producing bacteria.
- Occurs in 3 steps: hydrolysis, acidogenesis, and methanogenesis.
Development of Biogas Plants in Palm Oil Mills

• Identified as one of the major resources of RE in Malaysia.

• Early 1980s – the industry started in exploring / capturing of biogas & utilization, was not fully successful / implemented

• Early 2000’s due to economic and environmental factors, views on biogas from POME has been renewed as source of renewable energy to generate heat and power for internal usage and supply to the grid

• Utilization rate of biogas is still low as energy from palm biomass provides more than sufficient energy for palm oil mill’s operation
# Energy Potential of Biogas from POME

<table>
<thead>
<tr>
<th>Material</th>
<th>Production Rate</th>
<th>Quantity (based on FFB processed in 2013)</th>
<th>Quantity (based on 60 t/hr mill)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FFB</td>
<td>-</td>
<td>94.92 million tonnes</td>
<td>360,000 tonnes</td>
</tr>
<tr>
<td>Effluent</td>
<td>65% to FFB</td>
<td>61.70 million tonnes = 61.70 million m³</td>
<td>234,000 tonnes = 234,000 m³</td>
</tr>
<tr>
<td>Biogas</td>
<td>28 m³ m⁻³ of effluent</td>
<td>1728 million m³</td>
<td>6.55 million m³</td>
</tr>
<tr>
<td>Biogas at 35°C Total heat value</td>
<td>20 MJ m⁻³ 1728 X 20 million MJ = 34551 million MJ</td>
<td>34551 million MJ 1 MWhr = 1 MJ/3600</td>
<td>131 million MJ 1 MWhr = 1 MJ/3600</td>
</tr>
<tr>
<td>Power Output</td>
<td>@ 40 % of heat input</td>
<td>9.60 X 40% = 3.84 million MWhr</td>
<td>36400 X 40% = 14560 MWhr</td>
</tr>
<tr>
<td>Power plant size</td>
<td>Plant operates 300 days yr⁻¹ = 7200 hr yr⁻¹</td>
<td>3840000/7200 = 533 MW</td>
<td>14560/7200 = 2.02 MW</td>
</tr>
</tbody>
</table>
# Entry Point Projects (EPP) under NKEA of Palm Oil Sector

<table>
<thead>
<tr>
<th>Value Chain</th>
<th>EPP No</th>
<th>EPP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upstream Productivity and sustainability</td>
<td>1</td>
<td>Accelerate replanting</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Improve Fresh fruit Bunch yield</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Improve worker productivity</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Increase Oil Extraction Rate</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Biogas facilities at Palm oil Mills</td>
</tr>
<tr>
<td>Downstream Expansion and Sustainability</td>
<td>6</td>
<td>Developing Oleo Derivatives</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>Commercialising 2 Generation biofuels</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>Food and Health based sectors</td>
</tr>
</tbody>
</table>

RM33.1 billion GNI

RM14 billion GNI
EPP5: Building Biogas Facilities at Palm Oil Mills

- All palm oil mills to install biogas facilities (or methane avoidance) by 2020
- To encourage use as energy source for internal use and to supply to national electricity grid
- GNI – RM2.9 billion (≈ USD 1 billion)
Why Embark on Biogas Capture

**Economic Benefits**
- Renewable Energy fuel for internal and external use
- Displacement of diesel & electricity used from national grid

**Environment**
- Reduce carbon footprint and GHG from the industry
- To comply 35% GHG saving for Biodiesel EU RED

**Governmental Support**
- Policy and programme for RE and GHG reduction
- Incentive for RE and GHG reduction based project
## Status of Biogas Projects

No of Mills : 434

<table>
<thead>
<tr>
<th>Status</th>
<th>As of May 2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Completed Biogas Plants</td>
<td>64</td>
</tr>
<tr>
<td>Under Construction</td>
<td>14</td>
</tr>
<tr>
<td>Under Planning</td>
<td>150</td>
</tr>
</tbody>
</table>
Accumulated completed biogas plants (2007 – May 2014)
Completed Biogas Plant by State (as of May 2014)
Biogas Trapping Technology Used in Palm Oil Mill

Total completed projects: 64 biogas plants

- Covered Lagoon, 23 (36%)
- Digester Tank, 41 (64%)

Covered lagoon digester

Digester tanks
Capturing Technology – Digester Tank

- Most common type of biogas digester: fixed roof & floating roof / dome type digester (for biogas storage)

- POME is uniformly mixed and constantly / periodically flowing in and out - equipped with mixer / circulation pump (POME / biogas)

- Well proven globally for high organic waste - high yield of biogas

- Shorter Hydraulic Retention Time (HRT) 10 -20 days
Reinforced concrete

Mild steel digester with double membrane storage

Biodome top mounted gas holder

Reinforced concrete
Capturing Technology – Covered Lagoon

• An anaerobic lagoon fixed with an impermeable, gas and air tight cover – synthetic HDPE

• Suitable for mills with huge land availability - low capital investment and maintenance cost

• High gas storage capacity

• Longer HRT : 20 -60 days

• Enhanced with influent feeding, mixing and sludge separator
Utilisation of biogas
Status of Biogas Utilization in the Palm Oil Mills

Total completed projects: 64 biogas plants

- Combined Heat & Power: 12
- Electricity (gas engine): 23
- Flaring only: 27
- Other: 2 (package boiler)
Biogas Utilization in Palm Oil Mills

Onsite Biogas (without H₂S removal)
- Biomass boiler
- Package boiler
- Flaring

Onsite:
- Biogas (with H₂S removal)
- Gas engine
- Micro gas engine
- Diesel substitute
- Electricity for internal or external uses

Prospect Utilization:
- Biogas upgrading system
- Membrane technology
- PSA
- Water / chemical
- Direct fuel replacement:
  - Industrial and transportation
Flaring Unit

• To safely burn surplus biogas or when the recovery plant fails / not operated

• 2 types: open and enclosed flares

• Combustion temp: 550 – 900°C

• Vital equipment during the commissioning / early stage of biogas operation

Open flare

Enclosed flare
Direct Fuel Displacement

- **Biomass Boiler**
  - Cofiring with biomass for steam and power

- **Package Boiler**
  - Fuel replacement (diesel/ MFO/ NG) for steam

- **Kiln / dryer**
  - Fuel replacement for heat / drying purpose
Biogas for Biomass based Boiler (Co-Firing)

- Biogas can be co-fired directly into existing biomass boiler
- Provides a safer, cheaper and faster way of biogas utilization (no gas pretreatment required)
- Potential for reduction of dust particulate, slagging/fouling of the boiler tube
- Displacement of palm shell (2 - 5% of shell saving / t FFB) – additional income for the millers (less crinkle formation)
Biogas Utilization for Steam & Chilled Water Generation

- Applicable for integrated palm oil complex with refinery

- Suitable for low and high pressure package boiler / absorption chiller (use the heat for compressing refrigerant vapors to a high-pressure)

- Direct fuel displacement – Medium fuel oil (MFO) & diesel (for package boiler)

- Saving of electricity – replacement of electrical chiller
Biogas for Electricity Generation (with H₂S removal)

- **Internal Use**
  - Downstream activity & reduce dependency on diesel and electricity from TNB

- **Grid Connection**
  - Additional income for the millers

- **Rural Electrification**
  - CSR or to provide low cost electricity for rural area
Biogas Utilization for Electricity in Palm Oil Mills

- Suitable for the mills that require additional electricity for on-site downstream activities / value added products such as EFB treatment plant, Kernel Crushing Plant (KCP), briquetting/pelletizing plant, composting etc.

- Diesel saving / replacement for mills during start up/ non processing hrs /quarters uses.

- Electricity generation via gas engine, micro turbine or co-firing in diesel genset (diesel displacement).
Gas Engine Used in Biogas Plant

- 500 kW Shendong – Shengli Gas Engine
- 600 kW MWM Gas Engine
- 500 kW Guascor Engine in engine room
- 1.2 MW Guascor Engine in containerized type
- 1.0 MW GE Jenbacher
Downstream Activities in POM using Electricity generated from the Biogas Plant

- Kernel Crushing Plant integrated with POM
- Tertiary plant of POME
- Solvent Extraction Plant
- EFB Treatment Plant for Fibre and Solid Fuel
- POM staff quarters
Biogas Utilization for Grid Connected Electricity

- Electricity generated from biogas can be sold and connected to the national grid.
- Economically attractive with the recently announced Feed-in tariff (FiT) for RE power
- Total installed capacity under FiT : 5.75 MW (4 Plants)
- Issue on grid connection – costly if grid connection too far.
- Suitable for rural electrification project – saving in diesel cost
Feed-in Tariff and Current Status

- Electricity can be sold to power utilities at a fixed premium price and for specific duration.

- Fit rates for biogas (RM0.397 – 0.0.4169/kwh) for 16 years without annual degression rate.

**Status of Installed Capacity (kW) of Biogas Plants under FIT**

<table>
<thead>
<tr>
<th>Biogas Developer</th>
<th>Installed Capacity, kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bell Thermal Power (Batu Pahat, Johor)</td>
<td>2000</td>
</tr>
<tr>
<td>Achi Jaya Plantation Sdn. Bhd. (Segamat Johor)</td>
<td>1250</td>
</tr>
<tr>
<td>Felda Palm Industries Sdn. Bhd. (Serting, Negri Sembilan)</td>
<td>500</td>
</tr>
<tr>
<td>Havys POM, Keratong Pahang (Camco)</td>
<td>2000</td>
</tr>
</tbody>
</table>
Grid Connected Biogas Plants

1.25 MW Biogas Plant at Achi Jaya POM, Segamat
COD: December 2012

2.0 MW Biogas Plant at Batu Pahat POM (BELL Group)
COD: January 2010

500 kW Biogas Plant at Serting Hilir POM
COD: December 2012

2.0 MW Biogas Plant at Havys POM (Camco) – COD August 2013
Biogas Plant for Rural Electrification

1.2 MW biogas plant (covered lagoon) installed in a 54 t/hr palm oil mill in Felda Umas, Tawau, Sabah

0.6 - 1.2 MW electricity generated from biogas plant supplied to Felda Umas settlers (replacing/reducing diesel for electricity generation)
Way Forward – Future Prospect

To increase the no of biogas plants in palm oil mills

To diversify and expand the use of biogas

Governmental Support – regulation and policy
Diversify and Expand the Use of Biogas

Grid Connection
Attractive FiT and incentives to attract more grid connected biogas plants

Biogas Upgrading Plant
Bio-CNG for transportation (NGV) or industrial fuel

Direct Sell
CSR or to provide low cost electricity/energy for rural area / industrial area
## Description of Qualifying Renewable Energy Installation

(a) Basic FiT rates having installed capacity of:

<table>
<thead>
<tr>
<th>Description</th>
<th>FiT Rates (RM per kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) up to and including 4MW</td>
<td>0.3184</td>
</tr>
<tr>
<td>(ii) above 4MW and up to and including 10MW</td>
<td>0.2985</td>
</tr>
<tr>
<td>(iii) above 10MW and up to and including 30MW</td>
<td>0.2786</td>
</tr>
</tbody>
</table>

(b) Bonus FiT rates having the following criteria (one or more):

<table>
<thead>
<tr>
<th>Description</th>
<th>Bonus FiT (RM per kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) use of gas engine technology with electrical efficiency of above 40%</td>
<td>+0.0199</td>
</tr>
<tr>
<td>(ii) use of locally manufactured or assembled gas engine technology</td>
<td>+0.0500</td>
</tr>
<tr>
<td>(iii) use of landfill, sewage gas or agricultural waste including animal waste as fuel source</td>
<td>+0.0786</td>
</tr>
</tbody>
</table>
Prospect Off-Site Utilization of (Biogas Upgrading for Biomethane)

- Potential biogas utilization in future
- Upgrading 60-65% of CH₄ in biogas to >94% of CH₄
- Commercial technologies for upgrading is available
- Potential utilization includes as transportation fuel, distribution via gas grid connection for household/industrial application
Proposed Collaboration Approach

To provide grant (mainly for the plant) and R&D expertise for the development of Bio-CNG Plant

Turnkey Contractor / Technology provider & Product Distributor

To provide fund, space, manpower, utilities and biogas facilities for the development and operation of Bio-CNG plant

Commissioning and performance assessment of the plant
Field trial / Utilization trial of the product

Commercial operation of the plant and commercialization of the Bio-CNG by Felda / Sime Darby

Profit sharing on selling of bio CNG + Technology transfer

Lembaga Minyak Sawit Malaysia • Malaysian Palm Oil Board
Scope of the Project

FELDA, MPOB, & SIME DARBY - upgrading and compression
SIME DARBY & MISC - Distribution and marketing
- Trailer / prime mover
Industrial customer - Piping / boiler

MPOB to monitor the project progress - R&D and commercial basis & Bio-CNG value/supply chain
Marketing the produce from the project will not be an issue as there is already an existing market for CNG.

Large existing consumption of 795,104 mmscf in Malaysia

<table>
<thead>
<tr>
<th>Category</th>
<th>Demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>246</td>
</tr>
<tr>
<td>Comm</td>
<td>1,190</td>
</tr>
<tr>
<td>Industry</td>
<td>163,970</td>
</tr>
<tr>
<td>Non-Energy</td>
<td>148,966</td>
</tr>
<tr>
<td>Transport</td>
<td>10,371</td>
</tr>
<tr>
<td>Power Stations</td>
<td>470,361</td>
</tr>
<tr>
<td>Total Demand</td>
<td>795,104</td>
</tr>
</tbody>
</table>

Bio-CNG may be able to constitute up to 4.48% of existing CNG market

- FFB (92.33 mil t)
- POME (60.01 mil m³)
- Biogas (1680 mil)
- Methane (1008 mil m³)
- Methane (35,596 mmscf)

Total Demand: 795,104
Bio-CNG from POME: 35,596 (4.48%)
Direct sale for biogas plant energy producers

**INITIAL CONCEPT PROPOSED**

1. Allow direct sale of energy in Sabah and Sarawak to willing buyers (commercial/residential)

2. Tariff to be fixed at regional SESB / SESCO rates

**CONFIRMED BY ENERGY COMMISSION**

1. Under the Electricity Supply Act 1990, Energy Commission confirmed that there are two sets of licenses:
   a) Private license for
      • Generation
      • Transmission
      • Distribution
   b) Public license for
      • Generation
      • Transmission
      • Distribution

2. Millers with biogas plants who intend to generate electricity for own use -> private license on Generation (URGENT: NEED TO INFORM ALL BIOGAS PLANT OWNERS CURRENTLY IN OPERATION)

3. Millers with biogas plants who intend to distribute electricity to residential/commercial areas -> public license

4. Under the law, biogas plant operators that sell electricity to residential or commercial areas may charge:
   a) The gazetted tariff by region (TNB / SESB)
   b) The agreed upon tariff on a willing buyer – willing seller basis

5. For all energy generation above 5MW -> may download form from Energy Commission website and submit application to HQ

6. For all energy generation below 5MW -> may download form from Energy Commission website and submit application to Regional office
New Regulation for Biogas Development

• With effect from January 1st 2014, new mills and all existing mills which apply for throughput expansion will be mandated to install full biogas trapping or methane avoidance facilities;

• For mandatory implementation in all existing palm oil mills by 2020, based on current feedback and assessment, there are many concerns raised. More dialogues with the industry will be carried out before any decision is made, probably by July 2014.
Challenge

- Even, with mandate, availability of sufficient number of contractors / technology providers is a potential problem.
- About 60 new biogas plants need to be built each year.
- Need to look into this.
Issues & Challenges of Using Oil Palm Biogas as Fuel

- Sufficient energy from biomass in POM – expanding / diversify the use of biogas esp. external purpose

- Interconnection issue / load demand – location of the power plants (for grid connected power plant)

- Need for more financial support / incentives

- Inconsistency of biogas yield – due to low crop season and weather that may affect the microbes activity

- Lack of credible contractor for biogas development

- High capital investment - digester tank technology/grid connection

- High $\text{H}_2\text{S}$ content - requires costly gas pretreatment / cleaning system
Conclusion

• Support Government’s Initiatives, EPP5
• Make biogas energy plant (or avoidance) an integral part of the milling process.
• Benefit from additional revenue from power generated, saving on the operational cost, Bio-CNG, etc
• Benefit from lower carbon footprint and better market access to competitive markets.
Thank You
International Policy/ Regulation on Palm Oil Product / palm based RE

- Palm Oil is facing challenges in the developed markets such as the EU and US which demand low –carbon footprint products

- EU RE Directive & the US Renewable Fuels Standard 2, biofuels from renewable sources like palm oil must demonstrate low GHG, otherwise they will not be eligible for the programme

- Biogas plant is among the best options to address this issue.

**EU Directive Requirements :**

Currently : 35% GHG savings as compared fossil equivalent

By 1 Jan 2017 : 50%

By 1 Jan 2018 (Plants constructed on or after Jan 2017) : 60%

<table>
<thead>
<tr>
<th>Biofuel</th>
<th>Typical GHG Emission Saving</th>
<th>Default GHG Emission Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Palm biodiesel (Process not specified)</td>
<td>36</td>
<td>19</td>
</tr>
<tr>
<td>Palm biodiesel (with methane capture)</td>
<td>62</td>
<td>56</td>
</tr>
<tr>
<td>Rapeseed biodiesel</td>
<td>45</td>
<td>38</td>
</tr>
</tbody>
</table>