Anaerobic Digestion of Palm Oil Mill Effluent (POME) and Empty Fruit Bunches (EFB):

Maximized biogas production through full utilization of palm oil processing wastes and by-products
ASIA BIOGAS INTRODUCTION
Company Introduction

• Offices in Singapore, Bangkok and Jakarta
• Design/Engineering, Turn-key supply, O&M Services and Project Development
  o Industrial heat
  o Power generation
  o Compressed Biogas/Biomethane (CBG/bioCNG)
• Over 80 projects in Thailand, Philippines and Vietnam
• 6 operating projects in Thailand (BOOT)
• Under construction:
  o Krabi 2.2 MW POME, Thailand
  o Greenfields Dairy Farm Biogas, Indonesia
LARGE PLANTS?
Starch Wastewater Biogas Plant, KWTE

- 10,000 m³ WW/day
- 3 MW Power Plant and
- 22 MW(thermal)

1) Mixing Tank
2) Pump House
3) ABR
4) Control Room
5) Blower House
6) Power Plant
Cassava Pulp (garg) Biogas Plant, SWE

- 1,500 ton garg/day
- 8.4 MW Power plant and
- 15 MW(thermal)

1) Pulp Dilution
2) Mixing Tanks
3) ABRs
4) Blower/Pump House
5) Control Room
6) Power House
7) Flares
Biogas plants at SWI, Thailand

1) Starch Factory
2) Starch Wastewater Biogas Plant
3) Cassava Pulp (garg) Biogas Plant

- 11.4 MW Power Plant
- 37 MW(thermal)
WASTES FROM PALM OIL PRODUCTION – BIOGAS AND POWER POTENTIAL
Wastes from Palm Oil Production

**POME**
- 0.5–0.6 m$^3$/ton FFB
- COD: 50–100,000 mg/L

**EFB**
- 22 – 24 % of FFB
- 35 % TS
- 90 % VS of TS

**Decanter cake**
- 4 % of FFB
- 20 – 25 % TS
- 80 – 85 % VS of TS

---

Source: Adapted from (Perez, 1997)
45 TPH POM Waste $\rightarrow$ 5.3 (8.2)* MW

FFB
45 TPH

POME
540 m$^3$/day
COD: 90,000 mg/L

Methane
602 m$^3$/h
Power
2.46 MW

EFB
248 ton/day
35 % TS
90 % VS of TS

Methane
652 (1304)* m$^3$/h
Power
2.67 (5.33)* MW

Decanter cake
43 ton/day
23 % TS
83 % VS of TS

Methane
100 m$^3$/h
Power
0.4 MW

*) with pretreatment of EFB
BIOGAS PRODUCTION FROM POME
Biogas production from POME

- Technology options?

<table>
<thead>
<tr>
<th></th>
<th>IN-GROUND REACTOR</th>
<th>TANK REACTOR</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Reactor type</strong></td>
<td>Anaerobic Baffled Reactor (ABR)</td>
<td>Continuous Stirred Tank Reactor (CSTR)</td>
</tr>
<tr>
<td><strong>Area</strong></td>
<td>Large</td>
<td>Medium</td>
</tr>
<tr>
<td><strong>Technology</strong></td>
<td>Simple</td>
<td>Medium</td>
</tr>
<tr>
<td><strong>Automation</strong></td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td><strong>Investment</strong></td>
<td>Lower</td>
<td>Higher</td>
</tr>
</tbody>
</table>
**KrabiWTE POME 2.2 MW**

- Krabi Waste to Energy Co Ltd
- Host: Krabi Oil-Palm Farmers Cooperatives Federation Ltd

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>POME flow</td>
<td>m3/day</td>
<td>500</td>
</tr>
<tr>
<td>POME COD</td>
<td>mg/L</td>
<td>100,000</td>
</tr>
<tr>
<td>Methane</td>
<td>Nm3 CH4/day</td>
<td>14,875</td>
</tr>
<tr>
<td>Biogas</td>
<td>Nm3/day</td>
<td>24,792</td>
</tr>
<tr>
<td>Power equivalent</td>
<td>kWe</td>
<td>2,534</td>
</tr>
</tbody>
</table>
KrabiWTE POME 2.2 MW (May)
Biogas production from POME

• Effluent treatment?
• Zero-discharge?

• Technology no issue – produce drinking water if you want! (RO, Vibrating Membrane Filtration, etc)

• Cost/profitability is the issue!
Biogas production from POME

• Aerobic lagoons/irrigation – low cost
• Aerated treatment OK – but consider OPEX!

• Solids capture with geo-membranes

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Before</th>
<th>After</th>
<th>% Removal</th>
</tr>
</thead>
<tbody>
<tr>
<td>COD (mg/L)</td>
<td>44,000</td>
<td>221</td>
<td>99.5 %</td>
</tr>
<tr>
<td>TSS (mg/L)</td>
<td>44,500</td>
<td>400</td>
<td>99.1 %</td>
</tr>
</tbody>
</table>

No polymer added!
BIOGAS PRODUCTION FROM EFB
## Energy production from EFB

- **Sustainable?**

<table>
<thead>
<tr>
<th></th>
<th>Energy</th>
<th>Nutrients</th>
<th>Structure material to soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Return to plantation</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Composting</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Incineration</td>
<td>Yes</td>
<td>No?</td>
<td>No</td>
</tr>
<tr>
<td>Pellet production</td>
<td>Yes, indirect</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Biogas</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Empty Fruit Bunches

- 35% TS
- 90% VS of TS
- Cellulose: 29–39% (d.b.) (cassava pulp: 13%)
- Hemicellulose: 22% (d.b.)
- Lignin 23% (d.b.) (cassava pulp: < 2%)
EFB – Structure?

(Doherty et al., 2010)  (Mosier et al., 2004)
Biogas production from EFB

- Challenges?

- Low Nitrogen
- Oil-recovery yes/no $\Rightarrow$ Methane yields
- High TS $\Rightarrow$ High-solids digestion
- Ligno-cellulosic $\Rightarrow$ Pre-treatment economic?
Extruded EFB?

5 mm
Biogas production from EFB

- EFB
- PRESS (OPTIONAL)
- SIZE-REDUCTION
- PRETREATMENT (OPTIONAL)
- OIL-RECOVERY
- OIL
- GAS PROCESSING
- POWER
- CBG
- SOLID FERTILIZER
- LIQUID FOR IRRIGATION
- DIGESTION
- DIGESTATE DEWATERING
- POME AFTER AD
SYNERGIES / CONCLUSIONS
Synergies POME/EFB

• C/N ratio EFB not optimal
  – N from POME AD effluent

• Common gas train
  – H2S scrubber
  – Dehumidifying
  – Gensets
  – CAPEX/OPEX reductions
Biogas from POME & EFB

• Conclusions?
  – Energy + Nutrients + Structure material to soil

• Power output POME & EFB to biogas @ 90,000 mg COD/L

<table>
<thead>
<tr>
<th>Mill size ton FFB/hour</th>
<th>Power @ Different pre-treatment Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>45</td>
<td>5.5 MW</td>
<td>8.2 MW</td>
</tr>
<tr>
<td>60</td>
<td>7.4 MW</td>
<td>11 MW</td>
</tr>
<tr>
<td>90</td>
<td>11 MW</td>
<td>16 MW</td>
</tr>
<tr>
<td>120</td>
<td>15 MW</td>
<td>22 MW</td>
</tr>
</tbody>
</table>
Biogas Design Engineering Services

EPC and Turnkey Project Construction

Project Financing Solutions

Biogas solutions for:

- Cassava Starch
- Palm Oil
- Manure
- Energy Crops
- Agro-industrial Wastes
- Food/Beverage
- Ethanol

Anders Ek, Chief Scientist

asiaBIOGAS

Bangkok – Singapore – Jakarta

www.asiabiogas.com

anders.ek@asiabiogas.com