International Workshop on Advances in Biofuel
27th September 2012
Kota Kinabalu
The Advent of the 2nd Generation of a
MINI BIOGAS POWER PLANT
Rural Development Concept with Biogas all Sizes … and “MINI”

1. View on Palm Oil Mills for Biogas
2. Biogas Technology
3. MBPP for Rural Development
Established Palm Oil Mill  
-> Organic Output  
Focus: CPO  
New Focus: By-Products
MAJOR CHALLENGE:

- Everything that influences the production of CPO and therefore the revenue and profitability of the core business!

- Environmental Regulation
- Cost Structure, e.g. Fertilizer
- Market Price and Behaviour
- Market Restrictions / Regulations
- Sustainability
Palm Oil Mill - Organic By-Products

Organic By-Products

- Use as fuel for boiler:
  - Low efficiency but sufficient enough

- Use for Mulching and Composting: Energy consuming, mainly for solids

OPTION: Anaerobe Process for liquid and solid, energy producing, 1st treatment Step to reach BOD 20 compliant discharge after final Waste Water Treatment Plan (WWTP).
Palm Oil Mill
-> Sober REALITY

The POM & Plantation needs …
(beside FFB’s)

- Water
- Steam
- Electricity
- Fertilizer (Plantation)
- to comply with Environmental Regulations
- Sustainability
The variation of capacity and size of the Palm Oil Mills in Malaysia have a huge variety (appr.):

- 1/3 rd are large … > 400 000 t FFB /a
- 1/3 rd are medium size … 200 000 – 400 000 t FFB /a
- 1/3 rd are considered small … < 200 000 t FFB/a

Especially 120 000 t down to 80 000 t FFB /a Mills encounter a huge challenge according to scale of economy.

-> bv-product?
Based on 100,000 t FFB processing per annum and average organic waste production, the efficiency of the anaerobe biogas process can range from:

- **0.4-0.7 MWh** … with POME only and standard 1 stage process and depending on technology
  This would create a challenge in the feasibility for small Palm Oil Mills!

- **1.8 – 2.0 MWh** … with POME, EFB and Fiber included in the anaerobe process and applying high tech 2 stage processes
  This efficiency would make BIOGAS feasible even for small Palm Oil Mills around 100 000 t FFB / a processing.
Palm Oil Mill - Organic Mass Use & Replace

Challenges in discussion with Mill Owner and Operator:

- **FIBER:** Used as FUEL, ... need to be diverted to AD Process
- **PKS:** Used as FUEL, ... NOT suitable for AD Process
- **EFB:** Used as FUEL, ... need to be diverted to AD Process
- **POME:** FREE for use and it is liquid base for the AD

AD process = Anaerobic Digester Process

... in exchange, the AD Process provides:

- FUEL (Biogas)
- FUEL (Dry Lignin Fiber / Pellets)*
- Organic Sludge
  - ... as base for Composting
  - ... and Organic Fertilizer
- Discharge for WWTP with stable COD to reach BOD 20
- CER’s (Carbon Project)

* (2 Stage AD Process)
Palm Oil Mill - Challenges

1) Get the trust needed to implement the technology and improvements

2) Get the organic by-products … offer replacement of their value

3) Deliver base for success and improvements in:
   a) Reach BOD 20 in discharge effluents
   b) Optimize Boiler Efficiency with use of PKS, Lignin and Biogas
   c) Deliver high quality Organic Sludge as base for
      ➢ Organic Fertilizer
      ➢ Local Composting Process

* … a word in favour of …
A word in favour of COMPOSTING …

COMPOSTING – YES … BUT BEST after HARVESTING GREEN ENERGY

=> There is NO competition between composting and anaerobe process – BUT it shall be complementary!
Rural Development Concept with Biogas (all Sizes ... and “MINI”)

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Palm Oil is made out of Sun-Energy, CO$_2$, Water and Fertilizing Minerals …

**Anaerobic Treatment creates “Fuel”, CO$_2$ and Organic Fertilizer. It is “harvesting” the energy of the sun, captured in the organic material.**

*The secret of sustainability: BALANCE*
Biogas Process
- Bio Chemistry in 2 Steps and 4 Reactions

Carbon hydrates → Sugars

Fats → Fatty Acids

Proteins → Amino Acids

Carbonic Acid and Alcohols → Hydrogen Acetic Acid

Hydrogen Carbon Dioxide Ammonia → Methane Carbon Dioxide

Hydrolysis → Acidogenesis → Acetogenesis → Methanogenesis

Process Step 1
Optimize for: Hydrolysis

Process Step 2
Optimize for: Methanogenesis

Optimised Conditions?!
<table>
<thead>
<tr>
<th>Biogas Plant 1-Stage System</th>
<th>High Performance Biogas Plant Multi-Stage System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pigs need easy digestable fodder</td>
<td>Cows are able to digest cellulosic material as fodder due to the 4 chabered stomach</td>
</tr>
<tr>
<td>All 4 steps of the methane production take place in one tank (stomach): Hydrolysis, Acidogenesis, Acetogenesis, Methanogenesis</td>
<td>Two steps in one tank, two steps in a second tank: 1st tank: Hydrolysis and Acidogenesis 2nd tank: Acetogenesis and Methanogenesis</td>
</tr>
<tr>
<td>1-Stage System: Standard yield but...</td>
<td>+ 30% higher yield from same feedstock</td>
</tr>
</tbody>
</table>

1 stage Anaerobe Process Technology 2stage Thermophyllic Process
**Process Selection: High Efficiency = High Return**  
2\(^{nd}\).. 3\(^{rd}\) Generation

### 1 stage Anaerobe Process Technology

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>1ST GENERATION (Pond with membrane)</th>
<th>2ND GENERATION (Mesophilic Process)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retention Time</td>
<td>More than 20 days</td>
<td>20 days</td>
</tr>
<tr>
<td>Digester Capacity Requirement</td>
<td>Big</td>
<td>Big</td>
</tr>
<tr>
<td>Desludging</td>
<td>Required</td>
<td>Not required (depends on process)</td>
</tr>
<tr>
<td>Homogenisation</td>
<td>None</td>
<td>By pump</td>
</tr>
<tr>
<td>Gas Production</td>
<td>Slow</td>
<td>Slow</td>
</tr>
<tr>
<td>Degradability</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Fungi &amp; Virus Contamination</td>
<td>Growth present</td>
<td>Growth present</td>
</tr>
<tr>
<td>Unwanted Microbiology</td>
<td>Present</td>
<td>Present</td>
</tr>
<tr>
<td>Alternative Organic Waste (to increase gas production)</td>
<td>Impossible</td>
<td>Troublesome</td>
</tr>
<tr>
<td>CDM Certification</td>
<td>o.k.</td>
<td>o.k.</td>
</tr>
<tr>
<td>Future CDM Certification (adjustment to stricter methodologies)</td>
<td>Doubtful</td>
<td>o.k.</td>
</tr>
<tr>
<td>Investment Cost</td>
<td>Low</td>
<td>Very high</td>
</tr>
</tbody>
</table>

### 2 stage Anaerobe Process Technology*

- Based on Thermophilic Process
- Optimizes process condition for Hydrolysis and Methanogenesis
- Add solid Feedstock, e.g. EFB, Fiber to enhance gas production
- Optimizes process automation for feeding and process control

*patented*
Due to the capability to break down Cellulose, the 2 stage process is able to use solid feedstock in addition.

By-Product:
Lignin Fiber, useful as “Wood Pellets” or direct for wood burner.
## Optimum environment for hydrolysis bacteria and methane bacteria

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Hydrolysis bacteria</th>
<th>Methane bacteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time of reproduction</td>
<td>30 minutes to three days quick biological reaction</td>
<td>5 – 14 days slow biological reaction</td>
</tr>
<tr>
<td>Optimum of temperature</td>
<td>30 to 65 °C variable</td>
<td>37 °C or 55 °C constant</td>
</tr>
<tr>
<td>Optimum of pH value</td>
<td>down to 4,5</td>
<td>7 – 8</td>
</tr>
<tr>
<td>Vitality</td>
<td>robust, can easily cope with interruptions and variations of temperature and pH, quick change of feedstock is possible</td>
<td>very sensitive to any kind of disturbance in temperature and pH, change of feedstock is critical</td>
</tr>
<tr>
<td>Aerobic sensitivity</td>
<td>oxygen improves the hydrolysis process</td>
<td>strictly no oxygen</td>
</tr>
<tr>
<td>Biogas yield</td>
<td>low, methane content 0 – 30 %</td>
<td>high</td>
</tr>
</tbody>
</table>
HIGH Performance AD-Process

Example: **100 000 t FFB/a Capacity**

POME + EFB + Fiber = **2.0 MWh el. (500m3 CH4/h)**

By Product: + Organic Sludge
By Product: + Lignin Fiber / Pellets

**Benefit:**
- Fertilizer (optional)
- Sales of PKS, Fiber
- Sustainability
- BOD ...

**Revenue Streams:**
- Gas / el. Power
- Fertilizer
- Lignin Pellets
- CER’s

**SLUDGE:** Further COMPOSTING / Upgrading > Organic Fertilizer

Waste Water: With COD <500 further WWTP to reach > BOD 20
BIOGAS Opportunities & Local Solutions

FIT: 0.34 RM/kWh
= 1.36 RM / Nm$^3$ CH$_4$

0.5 – 4.0 MWh

Electricity + HEAT Recovery System

BioGas

+ Liquid CO$_2$ Gas Sales

BioGas

125 – 1000 Nm$^3$ / h CH$_4$ = 89 kg – 717 kg / h

BioMethane

BioMethane: 1.5 RM / Nm$^3$ CH$_4$

... for small Palm Oil Mills
Rural Development Concept with Biogas all Sizes ... and “MINI”

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3. MBPP for Rural Development
Sabah & Sarawak
Remote Areas Outside the Reach of the Grid

MBPP: Mini Biogas Power Plants
... small decentralized solutions?
Remote Areas e.g. in Sabah - Sarawak

- appr. 360 Rural Schools have NO grid Connection in Sarawak (MoE)

- Communities & Kampungs: Use of Generators and expensive supply of Diesel or Gasoline

- Remote areas are served by AIR or BOAT: 1 Liter Diesel = up to 6 RM

- Priorities:
  A) Reliability / Availability of Power
  B) Supply
  C) Cost Savings
  D) Carbon Footprint
Mini Biogas Plant fulfills Priorities - at a Glance:

### Farm:
- Organic Waste

### Household:
- Organic Waste

### Employment:
- Operator
- Technician
- Collector

### Community Benefits:
- Gas & El. Power
- Additional Income
- Waste Management
- Save Fossil Fuel
- Education

### General National Benefits:
- GDP: Services & Products
- Employment
- Living Quality
Feedstock: Huge Variety for the Biogas Plant

- Grass
- Maize / Sunflower
- Sorghum
- Straw
- Dry grass
- Stems (banana i.e.)
- Stems (cutted)
- Leaves
- Vegetable
- Organic waste
- Vegetable waste
- Fish waste
- Market waste
- Grass
BASIC APPLICATION CONDITIONS:

- Organic Waste: 200kg / day ... 1700kg / day ... (open)
- Organic Waste Type: ALL (except wood, bones, paper)
- Space Required: 10x10m (min 8x8m) + delivery/pick up space
- Operation: Manual by trained local staff
- El. Power demand: 5 kWh ... 35kWh ... (250kWh ... 2 MWh or bigger)
- REMOTE: – Replacement of expensive Fossil Fuel for GenSet
- Costs: 1.2-1.5 Mio. RM

TARGET APPLICATION GROUP for Rural Development:

- Communities & Wet Markets
- Farmer (small / mid size) with Live Stock and/or Plantation
- Process Industry with Organic Waste Output (e.g. FOOD, FRUITS, ...)
- Hotel & Resorts
- Islands
- Universities & Campus, Colleges
- REMOTE
  - Schools
  - Airports
  - Telecommunication
MBPP – Technology

Outline in Detail

- **Mini Biogas Power Plant - Life Time: 20+ Years**  (references in operation for appr. 10 years already !)
  - Product Quality is similar to Industrial Biogas Plants
  - Monitoring (local & remote) ensure trend analysis and continuous maintenance and repair to keep the system high performing operational

- **Process**
  - Anaerobe Process – high efficient (patented), therefore space and cost optimized
  - **Multivariable** feedstock for organic waste, mix and changes easy possible
  - Semi automated and remote monitored process
  - State of the art small Generator with Battery Buffer to produce el. Power

- **Safety**
  - Safety and security provided due to fenced area
  - Germany Safety Standards applied for the process

- **Mini Biogas Power Plant** (capacity with food waste & green cuts)
  - min 200 kg/d = 5 kWh el. power possible (12%)
  - … 1000 kg/d = 25 kWh el. power possible (60%)
  - max 1700 kg/d = 45 kWh el. power possible (100%)
  - Substrate: Food Waste and/or Green Cuts

- **Operation Plan** : Target continuously 24h-360d, 5 days service / a
  - Operation depends mainly on delivery of organic feedstock

- **Local Partner:** provide Site Area, Civil Works, Organic Waste and Utilities *
- **MBPP:** provide Operation**, Gas, El. Power and Fertilizer *

* Depending on each location and possibilities
** by German Main Contractor based in Malaysia or locals with training
**Mini Biogas Power Plant … OUTPUT**

SIMPLIFIED as a rule of the thumb for **Food Waste** and **Green Cuts**:

*(ATTENTION: Feeding per day – el. Power per hour!)*

- **200 kg** = 5 kWh el. Power … this 200kg are equivalent to green cut = 40 kg = 1 kWh el. Power
- **1000 kg** = 25 kWh el. Power or 20g / m² on 1 hectare = 50g / m² on 1 acre

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**Feedstock - Organic Active**

<table>
<thead>
<tr>
<th>Substrate</th>
<th>Dry Matter</th>
<th>Volatile Solids</th>
<th>Ratio to Feed</th>
<th>CH4 / VS and / Feedstock</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>%</td>
<td>kg VS / 1kg FS</td>
<td>m3CH4/kg VS</td>
</tr>
<tr>
<td>Cattle Manure (Liquid)</td>
<td>8%</td>
<td>80%</td>
<td>0.064</td>
<td>0.55</td>
</tr>
<tr>
<td>Cattle Manure (solid)</td>
<td>25%</td>
<td>80%</td>
<td>0.200</td>
<td>0.55</td>
</tr>
<tr>
<td>Grass (fresh)</td>
<td>21%</td>
<td>91%</td>
<td>0.192</td>
<td>0.40</td>
</tr>
<tr>
<td>Market Waste (mixed)</td>
<td>25%</td>
<td>90%</td>
<td>0.225</td>
<td>0.40</td>
</tr>
<tr>
<td>Vegetable Waste</td>
<td>25%</td>
<td>90%</td>
<td>0.225</td>
<td>0.40</td>
</tr>
<tr>
<td>Fish Processing Waste</td>
<td>30%</td>
<td>90%</td>
<td>0.270</td>
<td>0.50</td>
</tr>
<tr>
<td>Food Waste (Canteen/Kitchen)</td>
<td>40%</td>
<td>98%</td>
<td>0.392</td>
<td>0.50</td>
</tr>
<tr>
<td>Park &amp; Garden Waste (fresh)</td>
<td>42%</td>
<td>97%</td>
<td>0.407</td>
<td>0.50</td>
</tr>
<tr>
<td>Organic Waste (municipal)</td>
<td>75%</td>
<td>90%</td>
<td>0.675</td>
<td>0.60</td>
</tr>
<tr>
<td>Oil Seed Residue (pressed)</td>
<td>92%</td>
<td>97%</td>
<td>0.892</td>
<td>0.62</td>
</tr>
</tbody>
</table>

Feedstock - Organic Active - conservative rounded down = 180m³ / 1000kg per day
## Costs of Electricity

<table>
<thead>
<tr>
<th>Source</th>
<th>Price KWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grid</td>
<td>0.30 RM (WM)</td>
</tr>
<tr>
<td>Gen Set (boat, air)</td>
<td>&lt; 6 RM</td>
</tr>
<tr>
<td>MBPP</td>
<td>1.30 RM</td>
</tr>
</tbody>
</table>

1 km powerline will cost RM 23 Mio
Case Study
San Andres Islands

45 km²
Population 75,000
Tourism
Main Income Source

Fully dependent on GenSets
The MBPP will be produced in Malaysia according to GERMAN Engineering, Design & Know-How, Standards and Quality (ISO 9001, 14001, 18001).

Application Engineering will be done in MALAYSIA.

PROJECT EXAMPLE: SCHEDULE

Time of Delivery:
3-6 Months

* for the first ordered units, the delivery time can be longer – please contact us.
Partner companies from Germany are experienced in High Efficient Mini Biogas Power Plants – with 12 References in tropical AFRICA!
Example / References
In a Nutshell: Benefits of a Mini Biogas Plant

 Benefits and ADDED Value out of using Mini Biogas Power Plants

- Feasibility
  - Depending on Diesel Gasoline Price …
  - Pay Back: 4-7 years – BEST case 3 years, WORST case 8 years!
- Substantial Cost Savings:
  - Reduced Gasoline & Electricity Cost
  - Reduced Disposal Cost for Canteen and Green Cut Waste
- Organic Waste Management for Rural Communities

Benefits and ADDED Value out of using Mini Biogas Power Plants

- Reduction / Replacement of Fossil Fuel
- Reduction of Organic Waste
- Creation of new Jobs
  - Production of Organic Fertilizer
  - Education in Environmental Aspects

- COST Savings
- WEALTH/SKILLS
- INCOME
- INTELLIGENCE
- GREEN

… all in all … everybody will benefit from these added values !!!
Vision 2030

FUEL… -> · BIOFUEL ➔ ELECTRICAL
Thank you ...

Malaysia is rich in organic mass, a big value and a great asset for a bright future

... with decentralized Mini-Small-Medium and Large Size Biogas Power Plants

YOU are WELCOME to VISIT the first Mini-Biogas Plant at USM:
Launch November / December 2012
MBPP Demonstrator Operation Opening

PROFESSOR DR. KARL WAGNER
Email: profwagnerkarl@gmail.com
National Biomass Strategy 2020

Task force under the Government

Objectives:
Align stakeholders
Attract downstream companies
Keep value creation in Malaysia -> create jobs

Right now, only chapter 1 of biomass strategy Malaysia is being written
Must be interesting for industry!
Policy can then facilitate
Look at the innovation side rather than at the technological side.

If we work together, 20 bio. Turnover from biomass and creation of 66,000 jobs
3. Choo Yuen Ney

Bio-Diesel

• Go into biodiesel
• Macro-view
• Govt.
• Problem: petrol prices cheaper than biodiesel
• 4 tons per ha/a
• Already 2006 Policy: 5 strategic thrusts:
• Not as rosy as we had planned earlier on.
• 1985: first biodiesel plant in the world
• Germany: tests. 3 plants in MY, biggest in Johor.
• Programme NOT SO ENCOURAGING, esp. For exports. Dropped to 50,000 t.
LOCAL B5 programme (Feb 2009)
5% biodiesel, 95% petrol.
1100 stations in central peninsula have to supply the hybrid
By 2014 nation-wide B5 => 500,000 t /a
1.5 billion tons less CO2

Issues/ challenges:
High costs of feedstock (unlike Indonesia, taxation different, can export 1 mio tons incl. EU
Biodiesel price higher, subsidies required.

Move from B5 – B10?
• Shell and fibre already used
• EFB to produce electricity supply grids
• Solid: pelletising brickets
• Liquids: bio oil
• No theme, no storyline
4. Choo Yuen May

- Feedstock is an issue (Sabah is the place to be)
- EU 6 presenters
- Technology is not the constraint: Problem is lack of interest of buyers
- Focus on commercial applicability
- Tremendous potential in Sabah – not enough electricity. Still power shortage when power plants are completed
- 80%
- Focus on small power plants in rural areas
- Without need of policy making
- 1/3 of el could come from RE.