Cleaner Use and Management of Agricultural Waste for Biogas Fuelled Power Generation and Biofertilizers Production

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MORE THAN 2 BILLION PEOPLE AROUND THE WORLD LIVE WITHOUT CONNECTION TO THE GRID...

...WORLDWIDE HIGH GROWTH RATES FOR STAND-ALONE POWER GENERATION SYSTEMS...

...FOSSIL FUELS REPLACEMENT BY RENEWABLES.
Unsafe Electricity Supply

- Cripples country economics
- Causes chaos in the cities
- Affects production costs
- Poses important technical problems to key consumers
North America 2003 Blackout

- 66% lost at least 1 business day
- 24% lost > 50’000 USD/hr downtime
- 4% lost > 1 million USD/hr downtime
- 11% consider relocation
- 38% consider investment in alternate power generation systems
Choice of Power Supply

- Grid availability
- Fuel availability
- Consumers structure
- Electric power production reliability and costs
Fossil Fuel Options

MALAYSIA POWER
2004

IMTE AG

2000

2020

+9 %

-2 %

-4 %

-11 %

41 %

50 %

16 %

14 %

11 %

7 %

17 %

6 %

85 %

85 %

77 %

-8 %
Renewable
Fossil vs. Renewable

- Fossil
- Renewable

*2000 vs. *2020
Fossil vs. Renewable

*2000
- Fossil: 85%
- Renewable: 15%

*2020
- Fossil: 77%
- Renewable: 23%
- The Forest Residue ➔ Heat & Syngas
- Free Field Residue ➔ Heat & Syngas
- Wood Processing Industry ➔ Heat & Syngas
- Waste from Agricultural Products Processing Industry ➔ Biogas & Syngas
- Organic Components in Town Waste ➔ Syngas & Biogas
- Solid & Liquid Animal Manure ➔ Syngas & Biogas
- Agricultural Plant Waste ➔ Heat, Biogas, Syngas, Methanol & Ethanol
- Waste Waters ➔ Biogas
- Landfills ➔ Biogas (Landfill gas).
Conversion Technologies

- Direct Combustion → Heat

- Thermo-Chemical Conversion → Syngas & Charcoal

- Bio-Chemical Conversion → Biogas, Methanol & Ethanol
Biogas

- Anaerobic Digestion Decomposition in absence of O$_2$
  - Psychrophilic 20 - 25°C
  - Mesophilic 25 - 35°C
  - Thermophilic 50 – 60°C

- 55% - 65% CH$_4$ ** 35% - 45% CO$_2$ ** H$_2$S ** N ** H$_2$

- Hu $\rightarrow$ 20 -24 MJ/Nm$^3$ (Natural Gas ~40MJ/Nm$^3$)
① hydrolysis
② fermentation
③ acetogenesis
④ methanogenesis

complex organic matter
carbohydrates, proteins, fats

soluble organic molecules
sugars, amino acids, fatty acids

volatile fatty acids

acetic acid

H₂, CO₂

CH₄ + CO₂
Demonstration Pilot Project for Biogas Production from Sisal Waste

Sisal is long hard fiber used primarily in cordage (ropes & cords)
<table>
<thead>
<tr>
<th>Digestion Process</th>
<th>Description</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry</td>
<td>Dry solids content of &gt; 25-30%</td>
<td>Compact, lower energy input, better biogas quality (&lt;80% CH₄), maintenance friendly</td>
<td>Restricted mixing possibilities</td>
</tr>
<tr>
<td>Wet</td>
<td>Dry solids content of &lt; 15%</td>
<td>Better mixing possibilities</td>
<td>Higher energy input, lager reactor</td>
</tr>
<tr>
<td>Psychrophilic</td>
<td>Digestion temperature around 20°C</td>
<td>Long process time, very slow rate</td>
<td>Minimal energy input</td>
</tr>
<tr>
<td>Mesophilic</td>
<td>Digestion temperature between 25°C and 35°C</td>
<td>Longer process time, slower rate</td>
<td>Low energy input</td>
</tr>
<tr>
<td>Thermophilic</td>
<td>Digestion temperature between 50°C and 60°C</td>
<td>Shorter process time, higher degradation, faster rate</td>
<td>Higher energy input</td>
</tr>
<tr>
<td>Batch</td>
<td>Substrate in closed reactor during whole degradation period</td>
<td>Suitable for small plants with seasonal substrate supply</td>
<td>Unstable biogas production</td>
</tr>
<tr>
<td>Continuous</td>
<td>Reactor is filled continuously with fresh material</td>
<td>Constant biomass production through continuous feeding</td>
<td></td>
</tr>
</tbody>
</table>
Upflow Anaerobic Sludge Blanket (UASB) type digestion

- More efficient treatment of warm & high strength waste liquids
- Minimal electrical power usage
- High organic loading rates
- Suitable for tropical climate
- Longer digester shutdown possible
## Process Parameters

<table>
<thead>
<tr>
<th>Input/Output</th>
<th>Unit</th>
<th>Quantity</th>
<th>TS (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh Sisal Leaves</td>
<td>Tons/day</td>
<td>34</td>
<td>18</td>
</tr>
<tr>
<td>Process Water</td>
<td>Tons/day</td>
<td>150</td>
<td>0</td>
</tr>
<tr>
<td>Long Fibers Dry</td>
<td>Tons/day</td>
<td>1.3</td>
<td>89</td>
</tr>
<tr>
<td>Solid Fertilizer</td>
<td>Tons/day</td>
<td>6</td>
<td>24.6</td>
</tr>
<tr>
<td>Liquid Fertilizer</td>
<td>Tons/day</td>
<td>170</td>
<td>0.4</td>
</tr>
<tr>
<td>Biogas</td>
<td>Nm³/day</td>
<td>1’470</td>
<td>-</td>
</tr>
<tr>
<td>Net Electric Power</td>
<td>kWₘₑ</td>
<td>142</td>
<td>-</td>
</tr>
<tr>
<td>Heat Energy</td>
<td>kWₘₜh</td>
<td>172</td>
<td>-</td>
</tr>
</tbody>
</table>
Hydraulic Retention Time

HRT

5 - 10 Days
Project Economics

- Project Cost → 440’000 USD
- Electricity Production → 1’050 MWh/year
- Specific Investment → 0.042 USD/kWh/year (12 years period)
- Solid Fertilizer Production → 6 ton/day
- Liquid Fertilizer → 170 ton/day
PROJECT CASHFLOW

Only power generation revenue
Net Present Value / IRR

IRR = 0%

Only power generation revenue
Anticipated Time Schedule

- Project Development & Tendering → 3 Months
- Design, Procurement & Delivery → 5 Months
- Construction & Erection → 5 Months
- Commissioning & Trial Run → 2 Months
- Total → 15 Months
Application in Malaysia?

Example: Palm Oil Mill POME

33 – 38 Millions of POME per year
CHARACTERISTICS OF POME

- **pH**: 3.4 - 5.2
- **BOD**: 10,250 - 43,750 mg/L
- **COD**: 16,000 - 100,000 mg/L
- **TS**: 11,500 - 75,000 mg/L
- **SS**: 5000 - 54,000 mg/L
# POME Characteristics vs. DOE Standards

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Unit</th>
<th>POME (Average)</th>
<th>DOE Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>-</td>
<td>4.3</td>
<td>5 - 9</td>
</tr>
<tr>
<td>BOD</td>
<td>mg/L</td>
<td>27'000</td>
<td>100</td>
</tr>
<tr>
<td>Suspended Solids</td>
<td>mg/L</td>
<td>29'500</td>
<td>400</td>
</tr>
<tr>
<td>Total Nitrogen (N)</td>
<td>mg/L</td>
<td>707</td>
<td>200</td>
</tr>
<tr>
<td>Ammonia Nitrogen (NH₃-N)</td>
<td>mg/L</td>
<td>35</td>
<td>100</td>
</tr>
<tr>
<td>Oil and Grease</td>
<td>mg/L</td>
<td>8,000</td>
<td>50</td>
</tr>
<tr>
<td>Temperature</td>
<td>°C</td>
<td>80-90</td>
<td>45</td>
</tr>
</tbody>
</table>

MALAYSIA POWER 2004
POME a Fuel for small Power Generators?
Malaysian Potential
(Based on Yearly Average FFB Production)

- FFB ➔ 43 Mio tones
- Crude Oil ➔ 13 Mio tones
- POME ➔ 36 Mio tones
- Biogas ➔ 860 Mio Nm³
- El. Power ➔ 200 MW
- El. Energy ➔ 1’400 GWh
- Usable Heat ➔ 240 MW
- Fertilizer ➔ 40 Mio tones

Utilization of EFB is not considered in above figures.
Beneficial Factors

✓ No additional pollution from renewable energy;
✓ Locally available and sustainable energy source;
✓ Fossil fuels are deplorable, biomass is renewable;
✓ Increase of importance as major energy carrier;
✓ Growing recognition among international institutions resulting in stronger support.
Constraints

- Funding limitations;
- Lack of statutory framework;
- Competitiveness under current energy market conditions;
- Lack of biomass technology dissemination;
- Lack of feedstock delivery infrastructure;
- Lack of reliable data on lifecycle benefits and emissions, technology performance and feedstock availability.
What has to be done?

- Accelerate the transition to biomass waste energy resources;
- Encourage and reward use of biomass waste energy by utilities and all power consumers;
- Stop substitution of outdated energy sources and support use of biomass waste based renewable energy;
- Promote implementation of biomass waste based energy for “green” energy generation;
- Make all efforts to reduce the pollution that causes global warming.
Summary - Conclusions

- 15% saving in fossil fuel consumption means 15% less emissions;
- Small biomass waste plants → “green”, decentralized, electricity generators;
- Biomass conversion technology is evolving rapidly and the time-span is being reduced;
- Significant advances have been made in gasification, co-firing, biogas and bio-fuels production;
- Fossil fuels price increase will put biomass based renewable energy onto a more equal footing with fossil fuels.
There is only one planet names EARTH in the Universe.

This is a place where we are living and where the following generations supposed to live..

..there is no escape if we irreversibly damage it.

Transition of fossil fuels to renewable energy is one of the most important steps to preserve life on our precious blue planet EARTH.
Thank you
QUESTIONS

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