BIOFUELS TECHNOLOGIES IN GHANA: CURRENT STATUS

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Variety of Feedstock – Usually Solid State

Variety of Products & Forms – Gas, Liquid & Solids

Source: Biofuels Production Routes (FAO, 2004)
**TESTED BIOENERGY TECHNOLOGIES**

1. Improved Cookstoves (Firewood & Charcoal)
2. Improved Charcoal Production Technologies
3. Briquetting – **Potential for export due to local competition with Charcoal & Woodfuel**
4. Biomass Co-generation (Sawmill / Oil Palm residues)
5. Biogas (Institutional, Municipal Waste & Farm waste)
6. Gasification (Feasibility study/research)
7. Biodiesel –
   a) **First Generation Feedstocks**: Jathropha, Castor oil, Palm Oil, Palm Kernel Oil, Soya bean oil, Coconut oil, Sunflower, etc.
   b) **Second Generation Feedstocks**: Agricultural & Municipal Wastes – Cellulosic Materials
1. Gaseous – Biogas
   Examples: Domestic waste & Sewerage

2. Liquid –
    Biodiesel – Jatropha oil, Soy diesel, Palm oil diesel, Palm kernel diesel
    Bio-ethanol – Sugarcane & Cassava based ethanol
   - Envisioned revamping of Asutsuare & Komenda Sugar Factories

3. Solid –
    Cellulosic Alcohols

Photos: Rural Energy, Ghana
Improved Wood Stoves in Selected Basic Schools in the Northern & Upper East Regions of Ghana

Traditional 3 stone stoves

Courtesy: Ahiataku-Togobo, 2009
Biomass Co-generation

- Over 6MW capacity installed based on sawmill residue and oil palm waste.
- It has been the source of electric power for the industries and surrounding communities without grid electricity.
- High potential but hindered by the following factors:
  - cheaper power supply from grid electricity.
  - no financial or fiscal incentives
  - neither are there regulatory requirements that would encourage industry to generate and sell electricity to the grid (i.e. No grid-connected tariffs).
### Biomass Co-generation

**Snapshot of Some Installed Units**

<table>
<thead>
<tr>
<th>Plant Location</th>
<th>Installed Capacity</th>
<th>Average Annual Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kwai Oil Mills</td>
<td>420 kW</td>
<td>1.50 GWh</td>
</tr>
<tr>
<td>Benso Oil Mills</td>
<td>500 kW</td>
<td>1.90 GWh</td>
</tr>
<tr>
<td>Twifo Oil Mills</td>
<td>610 kW</td>
<td>2.10 GWh</td>
</tr>
<tr>
<td>Juaben Oil Mills</td>
<td>424 kW</td>
<td>1.50 GWh</td>
</tr>
</tbody>
</table>

- SNEP, 2006

### Some Palm Kernel Shell Generation Data

<table>
<thead>
<tr>
<th>Factory</th>
<th>Location</th>
<th>Annual Shell Generation (tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benso Oil Plantation</td>
<td>Benso (Western Region)</td>
<td>4,000 – 5,000</td>
</tr>
<tr>
<td>Ghana Oil Palm Plantation Corporation (GOPDC)</td>
<td>Kade (Eastern Region)</td>
<td>5,000 – 6,000</td>
</tr>
<tr>
<td>Ghana Oil Palm Plantation Corporation (GOPDC)</td>
<td>Kwae (Eastern Region)</td>
<td>3,000</td>
</tr>
<tr>
<td>National Oil Palm Plantation</td>
<td>Ayiem (Western Region)</td>
<td>1,600</td>
</tr>
</tbody>
</table>

Adapted from Lartey, Acquah & Nketia, 1999
IMPROVED CHARCOAL PRODUCTION TECHNOLOGIES

Technology uptake failed in due to:

• operations of the producers are not regulated

• yields no significantly superior to the traditional method contrary to those reported in literature.

• improved method requires some level of initial capital investments in addition to the cost of the wood.

• management of the carbonisation process requires continuous surveillance.
Biogas

- Potential not fully exploited since 1960s
- Over 240 digesters with total capacity of about 3,680 m$^3$ installed
- Size range = 4 – 800 m$^3$ (*Biggest @ GGBL, Kumasi using UASB*)
- Current implementations by private companies
- **Areas of Applications** include:
  1. Bio-sanitation (Domestic & Institutional)
  2. Households cooking,
  3. Direct lighting and
  4. Small power generation (e.g. 12.5 kVa genset @ Appolonia)

**Feedstock** have been:

a) animal dung,
b) human excreta and
c) industrial organic waste.
CASE STUDY - BIOGAS SURVEY

Total Population = 50 (50% of known plants in Ghana)

- Domestic, 14
- Institutions, 29
- Community, 7

- Before 1981: 0
- 1981 - 1990: 12
- 1991 - 2000: 3
- 2001 to date: 14

Graph showing the distribution of biogas survey populations by time period and type.

Bar chart showing the population by sector:
- Education: 9
- Health: 7
- Estates: 4
- Slaughterhouses: 3
- Prisons: 1
- Chemical Industries: 1
- Hotels: 1
- Others: 3

Graph showing the population by sector:
- Operating: 22
- Partially operating: 10
- Not operating: 14

Courtesy: Bensah, 2009
KNUST BIOMASS PROJECT STATUS

System Characteristics
- Fraction of Campus Student Population ~ 7,000
- 200 m³/day of biogas
- Power Output ~100kW

Power Generation Options
- Microturbine (~US$3,000/kW)
- Fuel Cell (US$ 10 – 12,000/kW)

Pre-Feasibility Studies (Completed)
- MSc Student Mini-Project
- MSc Thesis Research
- National Servicemen/TA’s Project

More Feasibility Studies (On-Going)
- Project Implementation Partner Search
Feedstock: Municipal Solid Waste
Environment: Engineered Landfill
Interests: At least German delegations for Dompoase site near Kumasi
Technology transfer is needed to back the known principles
Potential: 1 MW energy per site
Sites: Four more other sites in Ghana
BIODIESEL FEEDSTOCKS & PRODUCTION

- STRAIGHT VEGETABLE OIL (SVO) / PURE PLANT OIL (PPO):
  - Jatropha Oil
  - Castor Oil
  - Allan Blackia

- (TRANS)ESTERIFICATION:
  - Sunflower oil
  - Soyabean Oil
  - Jatropha Oil
  - Other Vegetable Oils (Palm, Palm Kernel & Copra Oils)
  - Waste Vegetable Oils
LOCALLY AVAILABLE BIODIESEL FEEDSTOCK

A. Virgin Oils:

α) Plant Sources:

1. Palm Fruit
2. Palm Kernel
3. Copra/Coconut Oil
4. Soyabean – Caltech Ventures, Accra (450 l/day processor)
5. Sunflower
6. Jatropha
β) Animal Sources:

No capacity in Ghana yet

B. Waste Vegetable Oils (WVO)

- Hotels, Restaurants & Fast food joints (Steers, Mr. Biggs, Ebusua Restaurants, etc.)
- Institutions (Boarding Houses, Hospitals, Prisons, etc.)
- Potential Assessment – Energy Commission Sponsored & TEC Fellows – KNUST
  1. Survey - Completed
  2. Transesterification of Samples – Completed
  3. Biodiesel Tested
  4. Engine Testing – On-going for Performance & Emissions

Independent Private Company at the Implementation Stage in Accra
**BIO-ETHANOL PRODUCTION**

- **Competition for end-usage:** Beverage vrs Fuel???
- **Feedstocks:**
- **Sugar Crops:**
  - Sugarcane - Proposals for Asutuare & Komenda Sugar Factories Revamping
  - Sweet sorghum – Potential yet to be tested fully
- **Starch Crops:**
  - Corn and
  - **Cassava:** 1. Laboratory tests – Completed & Ongoing
    - KNUST
    - Notre Dame Industries near Kumasi
- **Laboratory Pilot Plant** – Yet to proceed
  2. Caltech Ventures – Target = 30% Ethanol local market;

Currently, 1, 250 acres plantation for gari; flour & dough awaiting plant construction
# Bio-Ethanol Production

## Ethanol Production Steps by Feedstock and Conversion Techniques

<table>
<thead>
<tr>
<th>Feedstock type</th>
<th>Feedstock</th>
<th>Harvest technique</th>
<th>Feedstock conversion to sugar</th>
<th>Process heat</th>
<th>Sugar conversion to alcohol</th>
<th>Co-products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sugar crops</td>
<td>Sugarcane and sweet sorghum</td>
<td>Cane stalk cut, mostly taken from field</td>
<td>Sugars extracted through bagasse crushing, soaking, chemical treatment</td>
<td>Primarily bagasse</td>
<td>Fermentation and distillation of alcohol</td>
<td>Heat, electricity and molasses</td>
</tr>
<tr>
<td>Starch crops</td>
<td>Corn</td>
<td>Starchy parts of plants harvested, stalks mostly left on the field</td>
<td>Starch separation, milling, conversion to sugars via enzyme application</td>
<td>Typically from fossil fuel</td>
<td>Fermentation and distillation of alcohol</td>
<td>Animal feed and sweetener</td>
</tr>
<tr>
<td></td>
<td>cassava</td>
<td>Starchy root tuber harvested. Sticks serve as planting material</td>
<td>Peeling, drying, milling, conversion of sugars via enzyme application</td>
<td>Typically from fossil fuel</td>
<td>Fermentation and distillation of alcohol</td>
<td>Animal feed, manure or raw material for biogas plant</td>
</tr>
</tbody>
</table>

Adapted and modified from Rutz and Janssen, 2008
BIODIESEL PRODUCTION

Anuanom Ventures -
- Should be credited with popularizing Jatropha and Biodiesel in Ghana.
  - Worked on Biodiesel ≥ 5 years
  - Jatropha seeds from outgrower farmers

1. TRAGRIMACS: 200 l/day batch process unit
   - Imported System
   - Feedstock: Sunflower Seeds

2. DUMPONG Farms (near Aburi): 190 l/day biodiesel process unit.
   - Locally Assembled System
   - Feedstock: Crude Palm Kernel Oil
   - End Usage: Electricity generation & Transportation (Sales)
INTEGRATED RENEWABLE CASE STUDY

Busunu Project:

150 houses are connected to the electricity supply system. Each house is entitled to 2 CFL lamps at 11W each. Generator can run on 5 gallons of jatropha oil for up to 5 hours.

Catholic chaplaincy in Busunu enjoys 24 hour electricity. Villagers to enjoy 4 hour (6 – 10 pm) access each day.
**RESEARCH SUPPORT**

- KNUST through Departments & Research Institutes such as TCC and TEC offers high quality research, support services & consultancies in agricultural and energy research at National, Regional & Continental levels

- UG – Similar Role as KNUST

- Other Research organizations on biodiesel feedstocks (including Jatropha) to biogas plants include but not restricted to:
  - Biotechnology and Nuclear Agricultural Research Institute (BINARI) under Ghana Atomic Energy Commission (GAEC)
  - IIR, FORIG, Soil & Crop Research institutes under the Council for Scientific and Industrial Research (CSRI).
OTHER SUPPORT SYSTEMS

Engineering Firms:

Many firms have been meeting the energy project machinery requirements, namely:

- Machinery designs: TCC and Mechanical & Agricultural Engineering Departments (KNUST)

- Fabrication: GRATIS and various engineering firms like FATECO in Accra, RP Engineering in Cape Coast & SIS Engineering in Kumasi
CONCLUSION

- Woodfuel – Still Vital and important energy resource.
  - Main source of cooking fuel for many households
  - Contributes significantly to process heat delivery for commercial and medium scale industrial activities.

- Other bioenergy forms - High potential for heat and electricity on large scale or demonstration plants.

- Biogas development focusing on sanitation improvement with energy as a by-product is gaining grounds.

- Biofuel development as substitute for diesel, kerosene and gasoline is a recent phenomenon in Ghana.

- Biomass gasification and waste to energy - Yet to be demonstrated.

- Second generation biofuels technologies at R,D&D stage

- Research & Support Systems are available but needs to be utilised and strengthened via partnerships & collaborations.
Thank You