Bamboo for Bio-Energy

Presented by Engr. Dante S. Chichioco at the MAP ABCD Breakfast Forum on December 6, 2011 held at Metropolitan Club, Makati City.
National Energy Trends

**R.A. 9367: BIOFUELS ACT OF 2006**

“An Act to direct the use of biofuels, establishing for this purpose the Biofuels Program, Appropriating Funds therefor, and for other purposes.”

**R.A. 9513: RENEWABLE ENERGY ACT OF 2008**

What is Renewable Energy?

Renewable Energy is energy that can be naturally replenishable such as:

- Wind Energy
- Hydropower
- Wave Energy
- Ocean Current Energy
- Solar Energy
- Geothermal Energy
- Biofuels
Fossil or Mineral Fuels are carbons or hydrocarbons that are found in the earth’s crust, which are generally accepted to be the fossilized remains of dead animals and plants.

They are classified as non-renewable resources because they take millions of years of exposure to heat and pressure from within the earth’s crust. Reserves of fossil fuels are depleted much faster than new ones are being formed, and the burning of this produces around 21.3-B Tons of carbon dioxide per year.

It is estimated that the natural processes can only absorb about half that amount, so there is a net increase of 10.65 Billion tons of atmospheric carbon dioxide annually.
Impact of Using Fossil Coal

• Pollution
  – Particulates, mercury
• High GHG emission
  – CO2, CH4
  – NOx, SO2
• Global warming & CC
  – Natural disasters
  – Crop failures, etc
• Landscape change
• Biomass fuels – renewable, green CO2
• Fossil fuels – non-renewable, grey CO2
  – coal, natural gas, petroleum

Fossil coal
  • Dirty, even with clean coal tech
  • Mostly imported
  • Not cheap
Biomass comprises a variety of carbon-containing substances derived from living matter. Fuelwood, bamboo, twigs and leaves, agricultural residues such as husks and stalks, vegetable oils, and animal wastes are all examples of biomass. These materials can be used as fuel to obtain energy. Throughout human history, biomass has been burned to generate heat and to provide illumination.
(1) **Traditional biomass-based enterprises** - these are mainly cottage industries and small-scale enterprises in rural areas. They depend predominantly on biomass fuels such as wood, agricultural residues (stalks, husks), and saw dust. The reason is simple: biomass is cheap in rural areas compared to fossil fuels, and it is more readily available. The biomass is used for purposes such as direct heating (for instance, in firing bricks), indirect heating (e.g., for drying of tobacco or onions), boiling of water (e.g., to cook cocoons to make silk), and so on.
Two types of biomass-consuming enterprises:

(2) **New or potential biomass-based enterprises** - these are medium-sized or small-scale enterprises that currently use fossil fuels but are willing to switch over, at least partially, to biomass fuels that are available locally at lower prices. Examples of such ‘new/potential’ industries include textile dyeing units, crumb rubber units, and lime kilns.
Thermal Energy from Biomass

In general, there are two ways to use thermal energy from biomass:

- By **boilers** (where the biomass is burned to boil water and produce steam); and
- By **gasification** (where the biomass is converted into a gas that can be burned for various applications).

Biomass gasification is a process that converts solid biomass such as fuelwood, coconut shells, etc., to combustible gases with high conversion efficiency (~ 85%). The principle is simple: biomass is burned in a limited supply of air (i.e., less air than is needed for complete burning). This converts the biomass into an inflammable mixture of gases known as producer gas, comprising CO (carbon monoxide), H₂ (hydrogen), and CH₄ (methane), along with CO₂ (carbon dioxide) and N₂ (nitrogen).
The producer gas (also known as bio-gas) can be separated or contained and burned efficiently in a controlled way to produce a cleaner, steady, and high-temperature flame. The heat generated in this way can be directly used in a process—the ‘thermal’ application of biomass gasifier technology—or it can be used to drive an engine to generate electric power for lighting and other purposes.
An opportunity for reforestation and afforestation. Biofuels, as its name suggests come from hydrocarbon plants. To produce extract required from biofuels plants, feedstock must be planted first. And the propagation scale must be very extensive to warrant viability.
To achieve energy sufficiency and fuel diversification while meeting environmental challenges through the utilization of biofuels. But which feedstock is most feasible?
It’s Bamboo!

The fastest growing timber plant on Earth, with many applications as a wood substitute.
Sustainable Characteristics of Bamboo

- Bamboo grows more rapidly than trees - as much as 400 mm or 15” per day.
- Matures in 4 to 5 years.
- Multiple harvests every second year upwards.
- Lives up to 100 years.
- Bamboo produces biomass of up to 40 tons/ha per year in a well-managed bamboo stand or plantation.
Bamboo’s Advantages & Uses

- Bamboo is recognized as a substitute for lumber by the scientific community. Our shrinking timber supply hurts the furniture, handicraft, construction industry, and those who depend on forests for their living — and bamboo can augment or even replace their need. However, its development is impaired due to lack of support from many sectors.

- It is very effective for erosion control, watershed protection, soil remediation, carbon sequestration, environmental greening, & for food.
SUSTAINABLE VILLAGE-LEVEL BIOFUEL PROGRAM USING BAMBOO AS FEEDSTOCK: A 2,000-HECTARE PROJECT MODULE
“BIO-OIL” is an organic, liquid fuel produced through a process known as fast pyrolysis, which is the rapid thermal decomposition of organic materials in the absence of oxygen.

Bio-Oil with Bamboo as Feedstock
# Bamboo as Feedstock of BioOil & BioGas for Power Production

## Heating Values of Fuels & Various Solid Wastes

<table>
<thead>
<tr>
<th>ITEM</th>
<th>BTU/lb</th>
<th>Kcal/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coconut Shell</td>
<td>7,740</td>
<td>4,300</td>
</tr>
<tr>
<td>Coconut Coir</td>
<td>5,458</td>
<td>3,032</td>
</tr>
<tr>
<td>Coconut Shell Charcoal</td>
<td>9,991</td>
<td>5,550</td>
</tr>
<tr>
<td>Coffee Hull</td>
<td>7,006</td>
<td>3,892</td>
</tr>
<tr>
<td>Corn Cob</td>
<td>7,175</td>
<td>3,986</td>
</tr>
<tr>
<td>Saw Dust</td>
<td>4,860</td>
<td>2,700</td>
</tr>
<tr>
<td>Coal</td>
<td>11,701</td>
<td>6,500</td>
</tr>
<tr>
<td>Wood</td>
<td>5,040</td>
<td>2,800</td>
</tr>
<tr>
<td>Wood Charcoal</td>
<td>9,631</td>
<td>5,350</td>
</tr>
<tr>
<td>Bamboo</td>
<td>7,100</td>
<td>3,944</td>
</tr>
<tr>
<td>Bagasse</td>
<td>7,164</td>
<td>3,980</td>
</tr>
<tr>
<td>Rice Hull</td>
<td>5,400</td>
<td>3,000</td>
</tr>
<tr>
<td>Rice Straw</td>
<td>5,040</td>
<td>2,800</td>
</tr>
<tr>
<td>Used Tires</td>
<td>12,745</td>
<td>7,080</td>
</tr>
</tbody>
</table>
### Bamboo as Feedstock of BioOil & BioGas for Power Production

#### BIOFUELS: Feedstock Production Compared

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Bio-oil</th>
<th>Bioethanol</th>
<th>Biodiesel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant Capacity</td>
<td>200TPD</td>
<td>100KLPD</td>
<td>70KLPD</td>
</tr>
<tr>
<td>• Est. total dev cost, US$</td>
<td>17M-20M</td>
<td>25M-30M?</td>
<td>20M-25M?</td>
</tr>
<tr>
<td>Feedstock</td>
<td>Bamboo*</td>
<td>Sorghum***</td>
<td>Oil Palm***</td>
</tr>
<tr>
<td>• Min daily feedstock, mt</td>
<td>400</td>
<td>1,800</td>
<td>257</td>
</tr>
<tr>
<td>• Daily land equiv, Ha</td>
<td>&lt;6</td>
<td>37</td>
<td>12</td>
</tr>
<tr>
<td>• Annual land equiv, Ha</td>
<td>1,900</td>
<td>3,960</td>
<td>3,960</td>
</tr>
<tr>
<td>Water &amp; Energy Usage</td>
<td>nil</td>
<td>12-18</td>
<td>9-15</td>
</tr>
<tr>
<td>• Water per liter biofuel, Li</td>
<td>25</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>• Supplied energy, %</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output per Day, Li</td>
<td>116,578</td>
<td>100,000</td>
<td>70,000</td>
</tr>
<tr>
<td>• Barrel of oil equiv, BOE</td>
<td>396</td>
<td>380</td>
<td>400</td>
</tr>
</tbody>
</table>

**Legend:**
- *Indigenous kawayan-tinik
- **Assumed 3-cropping per year
- *** Hybrid passing SIRIM Standards
Bamboo as Feedstock of BioOil & BioGas for Power Production

BioGas Production:

The fast pyrolysis process can also result in direct gas production...

Which is also known as gasification.
Bamboo as Feedstock of BioOil & BioGas for Power Production

The RGV2000M Gasification Equipment:

Thru gasification, this facility can convert almost any biomass into what we can call “BioGas”.

Image of gasification equipment.
Bamboo as Feedstock of BioOil & BioGas for Power Production

The Gasification Process
## Bamboo as Feedstock of BioOil & BioGas for Power Production

### Bio-Oil Facilities Operating Abroad

<table>
<thead>
<tr>
<th>Name &amp; Location</th>
<th>Capacity (TPD)</th>
<th>Installation Developer</th>
<th>Feedstock Type</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ensyn Technologies, Renfrew, Ontario, Canada</strong></td>
<td>100</td>
<td>Ensyn</td>
<td>Residual wood</td>
</tr>
<tr>
<td><strong>Red Arrow Products Co., Red Arrow, Wisconsin, USA</strong></td>
<td>min 40 (6 Units)</td>
<td>Ensyn – 1989</td>
<td>Residual wood</td>
</tr>
<tr>
<td><strong>Genting Bio-Oil SDN, BHD, Malaysia</strong></td>
<td>50</td>
<td>BTG – 2005</td>
<td>Empty fruit bunches</td>
</tr>
<tr>
<td><strong>Dynamotive Energy Systems, West Lorne, Ontario, Canada</strong></td>
<td>130</td>
<td>Dynamotive – 2007</td>
<td>Waste wood</td>
</tr>
<tr>
<td><strong>Evolution Biofuels, Guelph, Ontario, Canada</strong></td>
<td>200</td>
<td>Dynamotive - 2007</td>
<td>Waste wood</td>
</tr>
</tbody>
</table>
Potential Local Coal-Fired Power Plants That Can Use Bamboo as Biomass Feedstock

- CLENERGEN proposal to establish a 34 MW biomass powerplant for the Nickle Asia Mining Corporation in Rio Tuba, Palawan Island
- CLENERGEN proposals in Kalinga & Romblon Island
- Other potential local coal-fired power plants that can use torrefied biomass feedstock as alternative fuel are those operating in Sual, Pangasinan and Bauang, La Union which can be supported by bamboo plantations in the provinces of Tarlac, Pangasinan, Zambales, La Union, Ilocos Sur, Abra and Benguet.
What is Biocoal?

- Torrefied biomass
- aka: e-coal, green coal
- No smoke/odor, clean
  - SO2 nil
  - NOx sharply reduced
  - Mercury zero
- Hydrophobic, MC~1%
- Easy to mill, friable
- Decay resistant
Torrefaction vs Charcoaling
Fossil Coal vs Biocoal

- Final Cost of Coal is $150 and above
  - Pollution Control Costs, Emissions Costs, etc.
  - Disposal Fees
  - Fuel Costs

- Final Cost of E-Coal is $60 and below
  - $90 E-Coal
  - $15-30 Carbon Credits
  - Other Offsets

References

• “Alternative Sources of Energy” – presented by Felix A. Velasquez, of PCCI at the Phil-Taiwan Investment Seminar on Feb. 11, 2009 at the Far Eastern Hotel in Taipei, Taiwan.

• “Biocoal, the Alternative to Fossil Coal” – presented by Dr. Segundino U. Foronda of APRRRDC at 1st Benguet Bamboo Techno-Forum held on June 22-24,2010 at the Benguet State University in La Trinidad, Benguet.


• “First Bamboo Biomass Plant in the Philippines” – by Melody M. Aguiba, Manila Bulletin (June 14, 2010).

• [http://www.clenergen.com/philippines/project](http://www.clenergen.com/philippines/project)
Thank you very much to the following:

- Col. Felix Velasquez, Committee Chair for Alternative Sources of Energy, Philippine Chamber of Commerce and Industry (PCCI)
- Dr. Segundino Foronda, Technical Consultant of Asian Pacific Resource Recovery Reuse & Development Corporation (APRRRDC)
- SIMBA Asia Power Corporation
- Cordillera Bamboo Development Council
- Bamboo Network of the Philippines
- Benguet State University
- Management Association of the Philippines
- Agribusiness & Countryside Development Foundation
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CLENERGEN PHILIPPINES
PROJECT SITES

Supplemental presentation to “Bamboo for Bio-Energy.”
Reference: www.clenergen.com
First bamboo biomass power plant piloted in Romblon
By MELODY M. AGUIBA

A modular type of power plant that can be ideally put up in any bamboo-growing island in the Philippines, the biomass-run power generation technology will also prompt the development of some three million hectares of coconut plantation all over the country. Bamboo can ideally be inter-cropped with coconut.

"This Beema bamboo (an Indian variety) can yield 100 tons per hectare after the third year from which we will produce wood chips as feed for a gasifier that will run engines for the power plant," said Clenergen Philippines President Antonio Aguilar-Gimenez in an interview.

A biomass-run power plant that uses bamboo wood chips as feedstock for gassification is now being piloted for the first time in Romblon as a United States-based company is pouring in $5 million for the highly cost-efficient renewable energy project.

A memorandum of agreement (MOA) was earlier entered by US-based Clenergen Philippines, the Romblon State University (RSU), committed to supply the high-yielding bamboo, and the National Power Corp. which will purchase electricity for off-grid areas.
Tissue cultured bamboo (Bambusa balcoa) on-field test at Romblon Island in cooperation with Romblon State University (Photo from www.clenergen.com)
Clenergen is eyeing to become a major fuel supplier in South East Asia through the Philippines' bamboo wood chip supply from coconut-bamboo inter-cropped farms.

"Energy crops offer coconut farmers a means of earning a value-added income from unused land. As the global demand for wood pellets escalates due to coal power plants being required co-fire with pellets in order to lower emissions, the Philippines is ideally positioned both geographically, climatically and structurally, to penetrate this marketplace," according to a Clenergen statement.

RSU President Jeter S. Sespene said RSU has conducted a feasibility study on the Beema bamboo for the biomass power plant technology. This bamboo variety has been developed through extensive breeding and microbiology applications. Its density is almost five times that of the ordinary Philippine bamboo, and cost is thus substantially cheaper, cutting feedstock cost by at least 50 percent.

The variety is also easy to grow in the Philippines and can be planted in marginal sites as bamboo is also indigenous to the Philippines.
Bamboo wood chips are suitable for use as feedstock for a biomass power plant since bamboos have high calorific value. These bamboo wood chips have also undergone extensive testing for gassification, combustion steam, pelletization, and pyrolysis process.
"It has passed ASTM (American Society for Testing and Materials) standard for pyrolysis oil used as fuel for mechanical equipment, for elevators, and in the future, as fuel for any engine," according to Clenergen Corp. Chief Executive Officer Mark Quinn in a separate interview.

Clenergen is also eyeing the construction of bigger capacity, 40 MW, biomass combustion-to-steam power plant in the Philippines.
Additional Information from the Clenergen website

- Clenergen and National Power Corporation (NPC) have signed a Memorandum of Agreement (MOA) to conduct feasibility studies in five different of-grid/”missionary” areas in the Philippines. The MOA makes provision for the installation of 1-2 MW/h pilot biomass power-plants in these off-grid areas (islands), using gasification technology.
• The first study was Romblon Islands (a province 370km south of Manila) was completed at the end of May 2010 and a decision by NPC is pending. The objective is to provide off grid electricity to many of the 7000 Philippine islands that suffer from acute electricity shortages.

• Another study is being undertaken in Kalinga-Apayao in collaboration with Kalinga-Apayao State College (KASC) and the Provincial LGUs of both provinces of Apayao and Kalinga. (Personal information from Dr. Emerson Barcellano of KASC-Forestry Department)
Nickel Asia Mines

- Nickel Asia has mining-rights on more than 5,000 hectares of land and is committed to engage in renewable energy projects which will have positive impacts on the environment and surrounding communities and that will remediate lands that have been mined. The company has 6 mining sites already in operation in Philippines and is expected to increase their Nickel extraction capacity by 30% over the next 24 months.
Clenergen bamboo project in Rio Tuba Nickle mining site in Palawan
Nickel Asia Mines

• Clenergen and Nickel Asia Mining Corporation (RTNMC) have signed a Memorandum of Agreement (MOA) to do feasibility studies for installing biomass power plants up to 34MW electricity generation capacity to service the Nickel Asia mining operations in the Philippines. It is proposed that the project will start with the installation of a demonstration 2 MW biomass gasification power plant in Palawan.

(Reference: http://www.clenergen.com/philippines/project/rio-tuba-nickel-mines)
Phytoremediation of mining site in Palawan using bamboo species (Photos from www.clenergen.com)
CLENERGEN Case Study

- Rio Tuba is the oldest operating nickel mine in the Philippines. It has shipped out a total 15.60 Million WMT of saprolite nickel ore containing 242,920MT of nickel, to JAPAN, AUSTRALIA, and CHINA (as of end of 2009) and delivered 4.76 Million DMT limonite ore containing 58,261 MT and 4,184 MT of nickel and cobalt metal, respectively to Coral Bay HPAL facility. The company controls 6,313 hectares (15151 acres) of mining claims.
CLENERGEN Case Study

• The company has a coal fired power plant with a 27 MW capacity and will need additional 4 mega watts for its expansion in the Slaked Lime Plant, RTN Crushing Plant and for neighboring barangays and towns. Rio tuba has been awarded Presidential Mineral Industry Environmental Award for its mine remediation practices.
CLENERGEN Case Study

• In line with their environmental conservation efforts, they have entered into a Memorandum of Agreement with Rio Tuba Nickel Mining Corporation to design and install up to 34MW/h of biomass power plants at the Rio Tuba’s mining operation sites in the Philippines. Rio Tuba’s primary area of operations is in the Palawan a southern province of the Philippines.

(Reference: http://www.clenergen.com/philippines/project/rio-tuba-nickel-mines)