Bamboo and Energy
Bamboo: Its suitability as energy crop

- Bamboo is fastest growing plant on earth.
- Perennial “Woody Grass”, rapid growth: annual selective harvesting possible (no clear felling) for 50 years.
- Environmental protection: Soil erosion, water recharge, reclaiming degraded lands, etc.
- Additional benefits: Bamboo shoots (food security), fodder, multiple uses, etc.
- Yield: 5 to 47 metric tons per hectare (Priority species: > 10 MT per annum).
Energy or Calorific values comparison (Bamboo Vs Wood)

- Calorific value of dry bamboo: ~ 19 MJ/kg or 4500 Kcal/Kg (Scurlock, 2000)

- Low ash and alkali content; C and H similar to wood.

- Calorific value of bamboo charcoal: 26 - 29 MJ/Kg or ~ 6600 Kcal/Kg

<table>
<thead>
<tr>
<th>Biomass</th>
<th>HHV</th>
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<tbody>
<tr>
<td></td>
<td>MJ / Kg</td>
</tr>
<tr>
<td>Bamboo</td>
<td>19.8</td>
</tr>
<tr>
<td>Eucalyptus</td>
<td>19.6</td>
</tr>
<tr>
<td>Hybrid popular</td>
<td>19.7</td>
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<tr>
<td>Willow</td>
<td>19.7</td>
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Botanically, bamboo is a grass

.......... And not a tree
Modeling biomass / carbon dynamics of bamboo forest

- Rapid growth and regrowth.
- Reach stable carbon in a period of 6 -10 years (beyond that, bamboo forests are carbon neutral (Liese, 2009)
- Above ground and high underground biomass ratio: 66: 34 percent
- Leaf litter: 6 – 8 percent of total biomass (1 to 37 MT per annum) (Kleinhenz and Midmore, 2001).
- Soil carbon: 15 – 17 percent of leaf litter and underground biomass.
- Gregarious bamboo flowering at end of life cycle.
- Active management necessary for improving carbon sequestration.
Modeling carbon sequestration of Moso bamboo (INBAR, 2010)

- Fast growing, annual yielding crop
- When managed, bamboo can outperform fast-growing species in terms of carbon sequestration
Bamboo and Energy: Fuel wood and Charcoal Production Technologies
What is Bamboo Charcoal?

Bamboo charcoal is a product from bamboo materials in high temperature pyrolysis with no air or by controlling or limiting the airflow, i.e. oxygen.
How to obtain bamboo charcoal?
Drum Charcoal

- Portable
- Low investment
- Charcoal Yield: 22 – 25 percent
Drum Charcoal - Model 2
Drum Charcoal - Model 3
Drum Charcoal - Model 4
Dome Charcoal
Large Kilns for high quality charcoal production
Traditional kilns in China (vertical and horizontal)
Traditional kilns in Ghana
Mechanical kilns in China (Continuous (Left) and Periodic Types (Right))
Successional mechanical (vertical)

Furnace
Mechanical and Traditional kilns in Taiwan, China
Traditional kilns in Korea
Briquetting Enterprises
Ram-type and screw-type biomass briquettes from farming households

Currently, four processing units are operational with a combined capacity of 12,000 tons/annum, which is $500,000 new income to the farming households who would have otherwise just burned the residue in the fields.
Manual Briquetting Enterprises
Semi-mechanized pelleting enterprises (Alaknanda, Uttarakhand, India)
Mechanized briquetting units (Mbeya, Tanzania & Uttarakhand, India)
Mechanized Honey-Comb Briquetting (Coal dust, Vietnam)
Mechanized honey-comb
Bamboo and Electricity

• 1.2 Kg biomass produces 1 unit of electricity.
• Bamboo biomass is a suitable feed stock for electricity generation.
• Wastes arising out of industrial processes could be used for electricity generation.
• 100 per cent producer gas engine
• Combined diesel and producer engine
• Combined charcoal and electricity generation units
Combined gasifier and charcoal production units
Gasifier system for electricity generation (Uttarakhand, India)
Technology: Bio-ethanol

- **Bio-chemical process:** The recalcitrant cellulose and hemi-cellulose in the biomass is converted into digestible glucose or sugars using pre-treatment methods and the resulting glucose is further converted into alcohol though the process of fermentation (Zhu et al., 2008; Zang et al., 2009; Leenakul and Tippayawong, 2010).

**Main Process:**
- Size reduction
- Pre-treatment
- Enzyme hydrolysis
- Fermentation
- Distillation

Source: www.abengoabioenergy.com
Scope: Ethanol Production

Model: 1000 Lts production capacity

Input:
Bamboo: 3000 Kg
Energy, Water, H₂SO₄, Lime

Data:

Ethanol Calculation: Theoretical ethanol Calculator (DOE, 2012)
Energy / GHG CO₂ EQ. data: Literature review

Output:
Bioethanol: 1000 Lts
Electricity: 666 kWh

Functional Unit: 1 MJ of energy.
Why is the application of bamboo charcoal?

- Porous material, large holes, small porous, microporous
What is the application of bamboo charcoal?

- Daily Use
- Interior Decoration
- Environmental Protection
- Forestry and Horticulture
- Other Uses
Necessity

Daily Use

Health care  Skin protection  Fresh keeping  Electromagnetic shield  Fuel
Necessity

Interior Decoration

Dehumidification

Art work

Building materials
Necessity

Environmental Protection

Wastewater treatment
Air purification
Drinking water purification
Necessity

Forestry and Horticulture

Feed additive
Soil improvement
Flowers and plants
Necessity

Other Uses

Activated charcoal  Capacitor  Cooking  Food
potassium(K), and sodium(Na), Calcium(Ca), Magnesium(Mg), Phosphorus(P), iron, Zink,
抗菌竹炭陶内胆
功能性聚氨酯炭基复合材料生产线
Charcoal root crafts

Bamboo Charcoal  Ceramic
Beijing opera
Bamboo charcoal air purifier products
bamboo processing

Carbonization

blending

textiles

grinding

spin thread

drawnwork
purification air pulltion
Bamboo charcoal environmental protection decorates a wall
In addition to smell, toilet decorates
Bathroom decoration with charcoal composite material
TV setting wall
Bamboo vinegar

• Bamboo vinegar is a liquid produced during the pyrogenic decomposition of bamboo. Its color is puce, the smell is strong and irritant. The composition of the bamboo vinegar is very complicated, mainly include: water, organic acids, phenols, ketones, alcohols, etc., there are in total more than 200 components.

• The formation of bamboo vinegar is also a complicated process. The yield is largely depending on the specie of the bamboo, the moisture content of the material as well as the pyrolysis techniques. The components of the vinegar also changes, it depends on the method of collection, the pyrogenic temperature, and the storage method, etc..
Bamboo vinegar

water, organic acids, phenols, ketones, alcohols, etc.
Bamboo vinegar

- Agroforestry
  - Soil improvement
  - Pesticide additives
  - Plant growth promoter
  - Feed additives
  - Deodorizer
  - Fresh keeper
  - Antiseptics
  - Beverage additives
  - Curing of dermatophytosis
  - Antiseptic and sterilization
  - Beautify and skin care
  - Curing of skin diseases
  - Curing of dermatitis
  - Showering cream
  - Pesticide
  - Food fresh keeping

- Medicine and health keeping
Athlete's foot
/beriberi
Anti-bacteria lotion

Body soap
Perfumed soap
Shampoo
Bamboo vinegar skincare
Bamboo vinegar series
made in China
Plant growth agent and foliar fertilizer
Thank You