Biomass Briquette/Pellet Production, Handling and Utilization in China

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Outline

• Background
• Biomass densified fuel industry growing in China
• Biomass densified fuel production in China
• Biomass densified fuel related standards in China
• Biomass densified fuel application and emission
• Summary
1 Background

Sustainability

- Conventional energy resources and consumption (energy crisis and safety)
- Environmental pollution
- Rural development

Biomass densified fuel industry
1 Background

- Unlike fossil fuels, biomass crops are CO\(_2\) neutral, in other words, they don’t add extra CO\(_2\) back in the atmosphere when they burned.

- Many scientists believe too much CO\(_2\) is bad for the environment.

- Instead, they emit only the same amounts of CO\(_2\) as they took in when they grew.
1 Background

Advantages of biomass densified fuel:

- Easy for storage and transportation
- Easy to use and sanitary
- High combustion efficiency
- Environmental friendly

Biomass densified fuel is a relatively clean burning process and as power producers move towards new technologies and leave their old boilers behind.
2 Biomass Densified Fuel Industry Growing in China

Every year, there are more than 700 million tons of crop straw in rural area of China, equivalent to 408 million tons of standard coal; 200 million tons of forestry processing residues which is equal to about 100 million tons of standard coal.

Every year, there are more than 2.5 billion tons of livestock and poultry feces and large amounts of organic wastes, equivalent to 300 million tons of standard coal.
Major Energy Crops

• **Starch and Sugar:**
  Corn, wheat, cassava, sweet potato, etc.;
  Sugar: sugarcane, sugar beet, sweet sorghum, etc.

• **Lipids:**
  Rape seed, sunflower, castor-oil plant, soybeans;
  Jatropha, palm, coconut tree, olive tree, tea tree.

• **Lignocellulose:**
  Eucalyptus, poplar, willow;
  Switchgrass, reed, bamboo reed, silvergrass, etc.

Taking advantage of barren, marginal and polluted land to cultivate energy crops.
Energy Crops

Bushy cellulose grass family which is rich in hydrocarbon compound.

- High yield of dry matter, it is perennial which benefits for long period after cultivation.
- Energy crops have strong stress resistance and are with good adaptability, low environmental requirements and low cost of production.
- Good ecological benefits, appropriate use of marginal land, can not only improve the ecological environment but also require no farmland.
- Renewable and clean energy, absorb CO$_2$ and little SO$_2$ emissions.
- Broad usage: cellulose ethanol, biomass briquette or pellet, bio-oils (pyrolysis), syngas (gasification), direct combustion for power generation.
Switchgrass

Bamboo Reed

Silvergrass

Hybrid Chinese Pennisetum

Source: Beijing Prataculture and Environmental R & D Center
## Components of Energy Crops

<table>
<thead>
<tr>
<th>Grass Species</th>
<th>Hemi-cellulose (%)</th>
<th>Cellulose (%)</th>
<th>Lignin (%)</th>
<th>Ash (%)</th>
<th>Calorific value (MJ/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>T. sacchariflora</em></td>
<td>28.76</td>
<td>31.13</td>
<td>7.13</td>
<td>1.25</td>
<td>17.93</td>
</tr>
<tr>
<td><em>A. donax</em></td>
<td>27.16</td>
<td>32.62</td>
<td>8.08</td>
<td>0.51</td>
<td>18.23</td>
</tr>
<tr>
<td><em>P. americanum × P. purpureum</em></td>
<td>20.11</td>
<td>36.04</td>
<td>8.89</td>
<td>2.14</td>
<td>17.00</td>
</tr>
<tr>
<td><em>Pa. virgatum</em></td>
<td>25.49</td>
<td>30.16</td>
<td>6.35</td>
<td>0.77</td>
<td>17.91</td>
</tr>
</tbody>
</table>

Source: Beijing Prataculture and Environmental R & D Center
Biomass Briquette and Pellet Market in China

Principle: Economic

Substitution: Natural gas, light diesel oil

District: Areas with high environmental protection pressure
Areas with serious pollution
Areas with coal forbidden areas

Application: Small and medium sized boilers
Small and medium sized industrial kilns

Tendency: Integration with other renewable energy sources and fossil energy

Source: Shiping Qin, 2013. Energy Research Institute, NDRC, China
Biomass Briquette and Pellet Policy in China

- The development of biomass briquette/pellet industry will be supported by policy for a long time.
- The economic incentive policy will shift from the end of supporting fuel production to the application side of the customer. The possible way is to switch from the product subsidies to investment subsidies or consumer incentives.
- The elimination of market barriers will be the focus of recent government work, including planning objectives, guidance, technical guidelines, emission standards, testing standards, etc.
- China will support the research and development of various biomass briquette/pellet production and application technology, in order to form a diversified technology system.
- The central government will encourage local governments, especially provincial governments, to introduce local support policies.

Source: Shiping Qin, 2013. Energy Research Institute, NDRC, China
# Relevant Laws, Regulations and Industrial Policies

<table>
<thead>
<tr>
<th>No.</th>
<th>Document</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><strong>Renewable Energy Law</strong></td>
<td>This law is designed to <strong>promote the development and utilization of renewable energy</strong>, increase energy supply, improve energy structure, protect energy security, protect the environment, and achieve sustainable economic and social development.</td>
</tr>
<tr>
<td>2</td>
<td><strong>Medium and long term planning for renewable energy development</strong></td>
<td>By 2010 and 2020, the annual biomass densified fuel utilization will reach 1 million tons and 50 million tons respectively.</td>
</tr>
<tr>
<td>3</td>
<td><strong>Ministry of Finance</strong></td>
<td>Interim measures for management of subsidy funds for crop straw energy utilization: 150 ¥ per ton of crop straw.</td>
</tr>
</tbody>
</table>
| 4   | **Opinions on speeding up the comprehensive utilization of crop straws** | • Orderly development of straw based biomass energy. Actively use straw molding and carbonization and other biomass energy development, and gradually improve the rural energy structure.  
  • Increase capital investment, the **production of biomass briquette/pellet derived from straw** to provide appropriate financial support. |
## Relevant Laws, Regulations and Industrial Policies

<table>
<thead>
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</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Development plan of agricultural biomass energy industry (2007-2015)</td>
<td>By 2010, the country built about 400 straw briquette/pellet production and application demonstration, straw briquette/pellet annual utilization is about 1 million tons, to 2015, annual utilization of straw briquette/pellet reached 20 million tons.</td>
</tr>
<tr>
<td>6</td>
<td>Energy development 11th Five-Year plan</td>
<td>The development of renewable energy resources, such as wind power generation, biomass power generation, biomass densified fuel, solar energy utilization, and other renewable energy resources, with large potential resources and basically mature technology, will promote industrial development with large-scale construction.</td>
</tr>
<tr>
<td>7</td>
<td>The 13th five-year plan for developing biomass energy</td>
<td>To speed up building heating project of advanced large-scale biomass pellet boiler with low pollutant emission. Take advantage of the low sulfur content molding fuel, and vigorously promote the 20-ton steam/hour and low emission biomass pellet boiler heating projects in the industrial park to reach the pollutant emission level of natural gas.</td>
</tr>
<tr>
<td>8</td>
<td>China's national plan for addressing climate change</td>
<td>One of the key areas to reduce the emission of greenhouse gases is to promote the development of biomass energy, biomass power generation, biogas, biomass solid fuel and liquid fuel as the focus, and vigorously promote the development and utilization of biomass energy.</td>
</tr>
</tbody>
</table>
3 Biomass Densified Fuel Production in China

- Biomass Feedstock and Logistics

- Biomass Pre-treatment
  - Chopping & Shredding (Size reduction)
  - Dehydration & drying

- Biomass Densification
  - Briquette & pellet production
  - Charcoal production
Rapid Detection Technology of Physical Properties of Crop Straws

- Straw Sampling
- Electro-optic exam
- Moisture content of conventional detection
- Physical property test
- Main physical properties change and response rules before and after straw harvest
- To establish main physical property relations
- Algorithm research and modeling for moisture content of electro-optic detection
- Rapid detection technology of main straw physical properties
Rapid Detection Method for Biomass Raw Materials and Fuel Product Component Based on Spectrum Technology

Development of biomass component sensor

Spectral predicting model
Biomass Compression Forming Test

Compression forming test platform

Molding parameters
- Pressure
- Time
- Rate
- Frequency

Straw Characteristics
- Size
- Moisture

Straw
- Maize straw
- Wheat straw
- Rice straw

Elastic-plastic deformation
- Creep feature
- Compression molding
- Density Change

Compression forming mechanism
Crop Straw Collecting & Baling
Biomass Logistics
Biomass Densified Fuel Technology

Source: Vinterbäck 1995
Biomass Briquettes
Wood Pellet

φ 6-8 mm

φ 8-10 mm
Crop Straw Pellet

Diameter: φ 25-30 mm

Rice Straw Pellet  Cotton Stalk Pellet  Corn Stalk Pellet
Raw Material Chopper/Shredder

Source: Jiaxing Xinjiao Machinery Co., Ltd., China
Biomass Extruders for Rodlike Fuel with Highly Density

Source: Jiaxing Xinjiao Machinery Co., Ltd., China
Screw Shaft and Die

Rodlike Biofuel Sample

Source: Jiaxing Xinjiao Machinery Co., Ltd., China
Rodlike Biofuel Production Line with Highly Density

1. Pneumatic Continuous Drying Equipment for Biomass Particles
2. Production Line for Biomass Rod Fuel by Highly Densification
Rodlike Charcoal Production by Kiln System
Purification Equipment of Exhaust Gas during Drying, Densification and Carbonization Process for Environmental Protection
• Rodlike Biofuel

• Rodlike Charcoal
Charcoal Briquette ▶

Charcoal Wafer ▶

Source: Forest Group, Zhejiang, China
Charcoal Briquette for Barbecue

Source: Forest Group, Zhejiang, China
The volume of biomass pellet is small, and its combustion rate is homogeneous. The supply and continuous feed of fuel is easy to implement and control.
Biomass pellet Production from Agricultural and Forestry Waste

Source: Haiyan Jineng Biofuel Co., Ltd., Zhejiang, China
Biomass pellet Production Line

Hangzhou Hopman Agricultural New Energy Equipment Co., Ltd., Zhejiang, China
4 Densified Biofuel Related Standards in China

• Densified biofuel - Methods for sample preparation (NY/T 1880-2010)
• Method for preparation of solid biofuels sample (GB/T 28730-2012)
• Test standards of densified biofuel (NY/T 1881-2010)
  — Total moisture
  — Moisture in general analysis sample
  — Volatile matter content
  — Ash content
  — Bulk density
  — Density
  — Mechanical durability

Note: NY -- Ministry of Agriculture;
   NB -- National Department of Energy;
   GB -- National Standard of China.
4 Densified Biofuel Related Standards in China

- Technical conditions for densified biofuel molding equipment (NY/T 1882-2010)
- Testing method for densified biofuel molding equipment (NY/T 1883-2010)
- Criteria for densified biofuel plant (NY/T 2881-2015)
- Technical code of operation and maintenance for densified biofuel plant (NY/T 2880-2015)

Note: NY -- Ministry of Agriculture; NB -- National Department of Energy; GB -- National Standard of China.
## Test Standard of Densified Biofuel Performance

<table>
<thead>
<tr>
<th>Items</th>
<th>Test Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Physical property</strong></td>
<td></td>
</tr>
</tbody>
</table>
| Bulk density, real density, Total moisture, Mechanical durability | LY/T 2378-2014  General technical specification of the woody biomass solid molding stove  
GB/T 28733-2012  Determination of total moisture for solid biofuels |
| **Chemical property**     |                                                                               |
| Proximate analysis        | GB/T 28731-2012  Proximate analysis of solid biofuels                        |
| Elemental analysis        | GB/T 28734-2012  determination of carbon and hydrogen in solid biofuels      |
| Heating value             | GB/T 30727-2014  Determination of calorific value in solid biofuels           |
| **Combustion performance**|                                                                               |
| Exhaust gas               | GB13271-2014  Emission standard of air pollutants for boilers                |
| CO emission               |                                                                               |
| SO₂ emission              |                                                                               |
| NOₓ emission              |                                                                               |
| Smoke dust                |                                                                               |
| Dust, PM 2.5              |                                                                               |
| **Ash property**          |                                                                               |
| Ash fusibility            | GB/T 30726-2014  Determination of ash fusibility of solid biofuels           |
| Fluxing                   |                                                                               |
| Ash component             | GB/T 30725-2014  Determination of ash composition in solid biofuels          |
## European Standard of Wood Pellet

<table>
<thead>
<tr>
<th>Items</th>
<th>Requirement</th>
<th>Items</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter /mm</td>
<td>6~8</td>
<td>Ash /%</td>
<td>&lt;0.5</td>
</tr>
<tr>
<td>Length /mm</td>
<td>&lt;5 × d</td>
<td>HHV/(MJ/kg)</td>
<td>&gt;18</td>
</tr>
<tr>
<td>Density /(kg/dm³)</td>
<td>&gt;1.12</td>
<td>Sulfur /%</td>
<td>&lt;0.04</td>
</tr>
<tr>
<td>Moisture /%</td>
<td>&lt;10</td>
<td>Nitride /%</td>
<td>&lt;0.3</td>
</tr>
<tr>
<td>Dust /%</td>
<td>&lt;2.3</td>
<td>Chlroid /%</td>
<td>&lt;0.02</td>
</tr>
<tr>
<td>Adhesive /%</td>
<td>&lt;2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# Basic Performance Requirements of Densified Biofuel

<table>
<thead>
<tr>
<th>Items</th>
<th>Biomass pellet</th>
<th>Biomass briquette</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Herbaceous feedstock</td>
</tr>
<tr>
<td>Diameter or max dimension of cross section (d) /mm</td>
<td>≤25</td>
<td>&gt;25</td>
</tr>
<tr>
<td>Length /mm</td>
<td>≤4d</td>
<td>≤4d</td>
</tr>
<tr>
<td>Density /(kg/m³)</td>
<td>≥1000</td>
<td>≥800</td>
</tr>
<tr>
<td>Moisture /%</td>
<td>≤13</td>
<td>≤16</td>
</tr>
<tr>
<td>Ash /%</td>
<td>≤10</td>
<td>≤6</td>
</tr>
<tr>
<td>LHV /(MJ/kg)</td>
<td>≥13.4</td>
<td>≥16.9</td>
</tr>
<tr>
<td>Shatter rate /%</td>
<td>≤5</td>
<td></td>
</tr>
<tr>
<td>Sulfur /%</td>
<td>≤0.2</td>
<td></td>
</tr>
<tr>
<td>Potassium /%</td>
<td>≤1</td>
<td></td>
</tr>
<tr>
<td>Chlorine /%</td>
<td>≤0.8</td>
<td></td>
</tr>
<tr>
<td>Additives /%</td>
<td>≤2, non-toxic, tasteless, harmless</td>
<td></td>
</tr>
</tbody>
</table>
5 Biomass briquette/pellet Application and Emission

**Wood Pellet**

- Industrial boiler to replace oil
- Non-electric central air conditioning
- Town bath boiler
- Town fireplace and furnace, etc.
- Others

**Straw Pellet**

- Biomass power plant boiler
- Co-fire power plant boiler
- Industrial coal boiler, bath furnace
- Agricultural production, greenhouse
- Rural energy using, cooking, heating and bath, etc.
- Others

**Straw Briquette**
Domestic Fireplace Using Biomass Pellet

1. Cover of hopper
2. Bio-pellet hopper
3. Fume pipe
4. Expansion tank
5. Ash box
6. Combustion box
7. Pyroceram
8. Burning chamber
9. Heat exchanger
10. Air vent
11. Marble cover
12. Axial flow fan

Shanghai Yizimai Machinery Co., Ltd.
Central Heating

Central heating system based on flat-panel solar water heater and fireplace is widely promoted in European families. Operating costs are much lower than of conventional heating, in addition to increased environmental benefits.
Rice Straw Pellet
Cotton Stalk Pellet
Corn Stalk Pellet

For Cooking Stove
For Industrial Boiler
Biomass pellet used for cooking stove

Biomass pellet used for small scale boiler
### Parameters of 100 kg biomass steam generator

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product model specification</td>
<td>LSG 0.1-0.7-S</td>
</tr>
<tr>
<td>Work pressure</td>
<td>0.7 MPa</td>
</tr>
<tr>
<td>Evaporation capacity</td>
<td>100 kg/h</td>
</tr>
<tr>
<td>Water capacity</td>
<td>29 L</td>
</tr>
<tr>
<td>Power consumption</td>
<td>350 W</td>
</tr>
<tr>
<td>Fuel consumption</td>
<td>20 kg/h</td>
</tr>
<tr>
<td>Storage capacity</td>
<td>100 kg</td>
</tr>
<tr>
<td>Boiler weight</td>
<td>559 kg</td>
</tr>
<tr>
<td>Size</td>
<td>1550<em>650</em>1480 mm</td>
</tr>
<tr>
<td>Air-blowing fan</td>
<td>85 W</td>
</tr>
<tr>
<td>Induced draft fan</td>
<td>250W</td>
</tr>
<tr>
<td>Water pump</td>
<td>750 W</td>
</tr>
<tr>
<td>Feeding motor</td>
<td>90W</td>
</tr>
<tr>
<td>Steam outlet diameter</td>
<td>25 mm</td>
</tr>
<tr>
<td>Chimney diameter</td>
<td>108 mm</td>
</tr>
</tbody>
</table>
Parameters of 500 kg biomass steam generator

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product model specification</td>
<td>LSG 0.5-0.7-S</td>
</tr>
<tr>
<td>Work pressure</td>
<td>0.7 MPa</td>
</tr>
<tr>
<td>Evaporation capacity</td>
<td>500 kg/h</td>
</tr>
<tr>
<td>Water capacity</td>
<td>49 L</td>
</tr>
<tr>
<td>Power consumption</td>
<td>4600 W</td>
</tr>
<tr>
<td>Fuel consumption</td>
<td>100 kg/h</td>
</tr>
<tr>
<td>Storage capacity</td>
<td>200 kg</td>
</tr>
<tr>
<td>Boiler weight</td>
<td>2650 kg</td>
</tr>
<tr>
<td>Size</td>
<td>2150<em>1400</em>3000 mm</td>
</tr>
<tr>
<td>Air-blowing fan</td>
<td>1100 W</td>
</tr>
<tr>
<td>Induced draft fan</td>
<td>2200W</td>
</tr>
<tr>
<td>Water pump</td>
<td>1100 W</td>
</tr>
<tr>
<td>Feeding motor</td>
<td>200 W</td>
</tr>
<tr>
<td>Steam outlet diameter</td>
<td>40 mm</td>
</tr>
<tr>
<td>Chimney diameter</td>
<td>159 mm</td>
</tr>
</tbody>
</table>
Biomass pellet used for warming system in seedling greenhouse in winter season
Horticulture Greenhouse Warming System in Winter for Low Energy Consumption and Low Cost
Biomass pellet for Warming Insect Breeding Greenhouse in Winter
Biomass Gasification for Steam Boiler （2t/h）

Demonstration Project at Huzhou, Zhejiang by Hangzhou Hantai Energy Engineering Co., Ltd., China
Biomass Gasifier Integrated with Boiler, Heating System or Cooking Stove

Source: Zhejiang Jiufan New Energy Co., Ltd., China
Detection and Analysis of Pollutant Emission

Densified biofuel combustion and emission

- Flue gas: CO, SO$_2$, NO$_x$
- Particulate Matter: PM$_{2.5}$

Portable detection instrument
Summary

- Governments encourage customers to use biomass briquette/pellets with incentives.
- To form and promote the industrial chain of biomass densified fuel.
- Bottlenecks: the cost of straw collection and transportation.
- Improvement of technology and equipment of biomass densified fuel.
- Environmental protection: combustion of biomass densified fuel has to meet the national emission standard to realize clean energy utilization.
Thanks for your attention

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