Potential, technology and challenges in rice residues based energy conversion in residues

INTERNATIONAL WORKSHOP ON THE INNOVATIVE USES OF RICE STRAW AND RICE HUSK
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Overview of bio-energy in India

- Large biomass resource base
  - Biomass production – 840 million tons
    (Firewood 220 million tons)
    (Agro residues 620 million tons)
- Modern biomass energy technologies focus
  - Gaseous fuels (producer gas, bio gas)
  - Electricity (small-scale using gasification, large-scale using steam route)
  - Liquid fuels
    - First Generation (non-edible plants seeds, bio-ethanol)
    - Second Generation (ligno-cellulosic biomass - rice straw, bagasse, wheat straw, sorghum etc..)
India is second largest producer of rice in the world after China

- Rice Production - about 104.32 million tonnes in 2011-2012 crop year
- Rice residues
  - Rice straw – 148 million tonnes
  - Rice husk – 45 million tonnes
- Second largest source of biomass from agricultural residues
Rice Belt – Low per capita electricity & Most backward region, energy poverty
Utilizations of Rice Husk/Straw

- As organic fertiliser, animal fodder, animal bedding

- **Cogeneration in Rice mills**

- **Briquetting**

  - raw material for paper board making,

- **Boiler and gasifiers fuels**
Feedstock Availability for Ethanol Production in India

<table>
<thead>
<tr>
<th>Feedstock</th>
<th>Annual Production (MMT)</th>
<th>Annual Availability (MMT)</th>
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<tbody>
<tr>
<td>Rice straw</td>
<td>8.9</td>
<td>8.9</td>
</tr>
<tr>
<td>Wheat straw</td>
<td>9.1</td>
<td>9.1</td>
</tr>
<tr>
<td>Sugarcane tops</td>
<td>79.4</td>
<td>97.8</td>
</tr>
<tr>
<td>Sugarcane bagasse</td>
<td>6.4</td>
<td>101.3</td>
</tr>
<tr>
<td>Cotton stalks</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td>Sorghum bagasse</td>
<td>15.6</td>
<td>11.4</td>
</tr>
<tr>
<td>Corn stover</td>
<td>23</td>
<td>1.1</td>
</tr>
</tbody>
</table>

Ref: NIIST – TIFAC Survey
Energy conversion technology options

- **Combustion** – Most common on wide scale with low capital investment (Mainly suitable for large scale), rice straw in co-fired mode
- **Gasification** – Small scale for decentralized electricity generation, mainly through fixed bed gasifier, existing technology needs need further development for energy and environment performance, development of medium/large scale plant based LTFB technology
- **Fermentation** – co-digested rice straw with cow dung technology being developed for better performance.
- **Ethanol production**- **Pre-treatment, Separation and Purification** – Most complex and high capital expenditure, novel dehydration technologies are required – main challenge in commercialization of the process for ethanol production
Biomass based Electricity and Heat generation in India

- More than 2000 MW power is established from biomass resources
- About 800 MW projects are under implementation
- 100 MWe installed for thermal applications in industries
- Large number of agro-residues are used by briquetting industries
- Agricultural residues are utilizes for decentralized thermal use in industries like
  - Brick / lime / pottery kilns,
  - Industrial dryers,
  - Ovens, furnaces and boilers
Biomass Gasifier Based Mini Grids

- Biomass Gasifier based power plants that uses rice husks/agricultural residues
- Small capacity gasifier system with producer gas engine
- Micro-grid/Mini-grids to supply electricity
- Distribution network over an area of about 2 to 5 km
- Serves households and commercial users for 6-8 hours daily
Maximum Theoretical Ethanol Yield from Lignocellulosic feedstocks
TERI Initiatives
Biomass energy technology development

Gasification
- Two stage biomass gasifier for electricity generation, Irrigation applications
- Biomass based poly generation system (electricity + cooling)

Pyrolysis for bio-oil production in decentralised scale
- Development of auger based pyrolysis unit for wide variety of feedstalls including rice straw

Bio-ethanol and Bio-methanation
- Development of pretreatment technologies for rice straw conversion
- Developing rice straw + cow dung biogas production system

Knowledge exchange, technology transfer and market development
Improved two stage gasifier for rural India

Improved prototype developed at TERI Gram;

- Cold starting with thermal gasifier
- Without water simple dry type gas cooling cleaning system developed
- No waste water generation in cleaning and cooling system
- Auxiliary input: about 1.8 kWe (~9%)
Thermochemical Conversion: Pyrolysis

- Developed for large scale production of biofuels globally
- It involves thermal destructive distillation of biomass in the near absence of oxygen at a temperature of around 500°C.
- The products obtained from biomass pyrolysis primarily consist of non-condensable gasses, liquid bio oil (bio crude) and residual bio-char

Research at TERI
- Developed and demonstrated a 100Kg/day pyrolysis prototype for production of bio-oil
- Demonstration of Modular Pilot Pyrolysis Unit of capacity 20 kg/h (max) to Produce Bio Oil from Agro-Industrial Biomass Wastes and Methodology for Analysis, Use and Upgradation of Bio-oil
TERI Research on Lignocellulosic Ethanol

• Lab scale research on cellulosic ethanol – focused on pretreatment of lignocellulosic biomass
• Conducted research on Rice straw & Sweet sorghum bagasse as feedstocks
• Steam explosion and dilute acid hydrolysis studied as pretreatment options
TEAM Process

- Technologies being developed for using tree based organic substrates such as leaf litter, seed starch / cakes, vegetable waste, kitchen waste, etc.
- Biphasic process give higher methane yield with lower retention period
- Working on rice straw + cow dung co-digestion bio-gas model
Facilities Available at TERI

• TERI has developed its own experimental facility which is placed in TERI GRAM at Gual Pahari.

• The infrastructure includes well developed research facilities and prototype development workshop

• TERI has different capacities test beds gasification system, pyrolysis and bio-methanation.

• The comprehensive instrument list includes
  – On line gas analyzer, Gas Chromatograph, FTIR, Simultaneous thermal analyzer (STA), CHNO analyser, Total Organic Carbon analyzer, Flue gas analyzer, Spectrophotometer, Bomb calorimeter etc.

• COMSOL software for optimization of reactor design
Conclusions

- The rice husk is mainly consumed as raw material for competing industries like rice mills, industrial fuels, paper board making,
- Rice straw is used for fodder and significant amount is burnt in the field without being collected and less than 10% are available in surplus.
- Rice husk is largely utilized for energy production with low energy conversion through existing technologies
- Rice straw conversion for ethanol production, gasification (LTFB) is important for utilization.
- Rice residues can become potential source for bio-based economy beyond petroleum for meeting feed, material, industrial chemicals and energy source through integrated bio-refinery model
- Develop country specific database that will provide information on different rice residue production and their current utilization trends in competing sectors using GIS and RS techniques
- Develop methodology and decision support tools to analyze the different rice-residues potential and use in many competing sectors that can be generalized
- Promote regional and global cooperation in rice residues biofuels RTD among developing and developed Countries