Biomass-To-Energy Conversion Process

[1] Thermochemical Conversion Process

[2] Biochemical Conversion Process
1. COMBUSTION

Biomass + Stoichiometric oxygen → Hot combustion products

Combustion or burning is a complex sequence of exothermic chemical reactions between a fuel and an oxidant accompanied by the production of heat or both heat and light in the form of either a glow or flames, appearance of light flickering.

In a complete combustion reaction, a compound reacts with an oxidizing element, such as oxygen, and the products are compounds of each element in the fuel with the oxidizing element.
Biomass + Heat → Charcoal, oil, gas

Pyrolysis is the chemical decomposition of a condensed substance by heating. It does not involve reactions with oxygen or any other reagents but can take place in their presence. Pyrolysis is a special case of thermolysis, and is most commonly used for organic materials; extreme pyrolysis, which leaves only carbon as the residue, is called carbonization and is related to the chemical process of charring.

Higher efficiency is achieved by the flash pyrolysis where finely divided feedstock is quickly heated to between 350°C and 500°C for less than 2 seconds.

Fuel bio-oil resembling light crude oil can also be produced by hydrous pyrolysis of many feedstocks.
Pyrolysis of Biomass
Gasification is a process that converts carbonaceous materials, such as coal, petroleum, or biomass, into carbon monoxide and hydrogen by reacting the raw material at high temperatures with a controlled amount of oxygen and/or steam. The resulting gas mixture is called synthesis gas or syngas and is itself a fuel.
• Controlled combustion
• 20-40 % oxygen supply
• Producer gas
• Cal value : 1500 kCal/Nm³
• Major constituent gases CO & H₂ Others CO₂, CH₄, N₂
## Composition of Producer Gas

<table>
<thead>
<tr>
<th>Constituent</th>
<th>% (vol.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO</td>
<td>18-22</td>
</tr>
<tr>
<td>$H_2$</td>
<td>13-19</td>
</tr>
<tr>
<td>CH$_4$</td>
<td>1-5</td>
</tr>
<tr>
<td>Heavier Hydrocarbons</td>
<td>0.2-0.4</td>
</tr>
<tr>
<td>CO$_2$</td>
<td>9-12</td>
</tr>
<tr>
<td>N$_2$</td>
<td>45-55</td>
</tr>
<tr>
<td>Water Vapour</td>
<td>4</td>
</tr>
</tbody>
</table>
Biochemical Conversion Process

1. Alcoholic Fermentation Process
Ethanol, C$_2$H$_5$OH is produced naturally by certain micro-organisms from sugars under acidic conditions, i.e. pH 4-5.

The most common micro-organism is yeast Saccharomyces cerevisiae, is poisoned by ethanol concentration greater than 10 %.

Stronger concentrations up to 95 % are produced by distilling and fractionating.
<table>
<thead>
<tr>
<th>Raw Material</th>
<th>Ethanol Productivity L/Tonne</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sugar beet</td>
<td>90-100</td>
</tr>
<tr>
<td>Sugarcane</td>
<td>60-80</td>
</tr>
<tr>
<td>Sweet sorghum</td>
<td>80-90</td>
</tr>
<tr>
<td>Potato</td>
<td>100-120</td>
</tr>
<tr>
<td>Maize</td>
<td>360-400</td>
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<tr>
<td>Cassava</td>
<td>175-190</td>
</tr>
<tr>
<td>Wheat</td>
<td>370-420</td>
</tr>
<tr>
<td>Barley</td>
<td>310-350</td>
</tr>
</tbody>
</table>
2. Anaerobic Digestion Process
Anaerobic Digestion Process

Complex Organic Substrates

HYDROLYSIS: Performed by hydrolytic bacteria (facultative anaerobes and anaerobes)

Simple Substrates

ACID PRODUCTION: Including acetogenesis (facultative anaerobes and anaerobes)

Acetate, Formate, CO$_2$, CO, H$_2$, Methanol, Ethanol, Methyl Amine, Propionate, Butyrate

METHANE PRODUCTION: Methanogenesis

CH$_4$ + CO$_2$ + Other minor gases
Stage I - Hydrolysis

Complex Carbohydrates $\rightarrow$ Simple Sugars

Complex Lipids (Fat) $\rightarrow$ Fatty Acids

Complex Proteins $\rightarrow$ Amino Acids
Stage II - Acid Production

Simple Sugars + Fatty Acids + Amino Acids

Organic acids, including acetate + Alcohols

Acetogenesis (acetate production):
Organic acids + Alcohols → Acetate
Stage III- Methane Production

**Acetoclastic Methanogenesis**
Acetate $\rightarrow$ CH$_4$ + CO$_2$

**Hydrogenotrophic Methanogenesis**
H$_2$ + CO$_2$ $\rightarrow$ CH$_4$

**Methylo trophic Methanogenesis**
Methanol $\rightarrow$ CH$_4$ + H$_2$O
Overview of Microbial Transformation

Biodegradable waste (100% COD) → Large organic molecules

Acetate → Org acids, alcohols

H₂ and CO₂ → CH₄ and CO₂

72% 17% 13% 28%
Other Biogas Programs in India

On-going Programs:

- Biogas Based Distributed/ Grid Power Generation Programme.
- Programme on Energy Recovery from Urban Wastes
- Programme on Energy Recovery from Municipal Solid Wastes
- Programme on Recovery of Energy from Industrial Wastes
- Demonstration of Integrated Technology Package on Biogas-Fertilizer Plants (BGFP) for Generation, Purification/ Enrichment, Bottling and Piped Distribution of Biogas.
Biomass Cook stove

• Nearly three-fourths of Indian households use open fires or *chulhas*
• 400,000 deaths to children under 5 years of age and 34,000 deaths to women due to chronic respiratory disease. (IAP)
• Aims to distribute approximately 150 million high efficiency stoves in the next 15 years.
Remote Village Electrification Program

• MNRE is implementing Remote Village Electrification (RVE) program for providing financial support for lighting/basic electricity using renewable energy sources.

• MNRE provides Central Financial Assistance of upto 90% of the cost of renewable energy systems.

• Nearly 13,059 villages and hamlets are benefited till now through this scheme.
Thank You