# Biomass: The Ultimate Source of Bio Energy

Sushmita Mohapatra*‡, Kasturi Gadgil**

*Department of Applied Science, Bharati Vidyapeeth's College of Engineering

**Center for Energy Studies, Indian Institute of Technology Delhi

monty_s3@yahoo.com, gadgil2k@yahoo.com

‡ Corresponding Author; Sushmita Mohapatra, Department of Applied Science, Bharati Vidyapeeth's College of Engineering, A-4, Paschim Vihar, New Delhi-110063, +919811472722, monty_s3@yahoo.com

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**Abstract-** Growth of civilization with exponential increase in energy consumption through severe energy crisis has drifted the attention towards renewable resources. i.e. biomass. Most of the conversion processes either follow thermal route or biological route. Experiments were conducted in the laboratory with saw dust and wood chips as standard biomass to convert it into useful products. This paper describes the different routes along with the experimental studies that have been undertaken towards achieving the goal of converting biomass into useful energy.

**Keywords-** Gasification, Esterfication, Bio-fuel, Syn-Gas.

## 1. Introduction

Exponential growth in population has increased the energy consumption in such a rate that an alternate route for energy generation has become a mandatory requirement. This is where the role of renewable energy systems creeps in. Biomass is considered as the renewable energy source with the highest potential to contribute to the energy needs of modern society. This is the only renewable source which could generate energy and feedstock A large part of the renewable energy (approx. 14%) is in the form of biomass energy.

Biomass, as has been mentioned, is not only a source of energy but a source of chemical and petrochemical feedstock. Commercial biomass-to-energy (bio-energy) systems have been widely explored in the last 35 years. Mature technologies are now available for converting biomass into thermal and electrical energy or into liquid and gaseous fuels. If biomass is adequately managed and exploited, it can be termed as a truly renewable energy source, which can contribute to displace the consumption of non-renewable fossil sources. Biomass as a source of energy has environmental benefits because its combustion leads to lower (or zero) emissions of greenhouse gases. Growing biomass takes up in fact approximately as much $CO_2$ from the atmosphere as is released when it is combusted either directly or after being converted into bio-fuels. It also emits lesser amounts of noxious pollutants, e.g. sulfur compounds and particulate on combustion. Competitiveness of biomass energy with fossil energy will depend on technology advances in different areas including crop growth, harvesting, residue recovery and conversion technologies. In addition, there is growing interest in the possibility of defining appropriate energy policy to support the adoption of biomass technologies, e.g. by factoring the environmental, economic and social benefits. Conventional sources have various environmental implications and they are slowly depleting. Hence attention has been focused on alternative renewable resources [1].The various technologies with their advantages and disadvantages are described below:

## 2. Gasification of Biomass

The direct conversion of biomass to biofuels has many limitations like the technologies are not economically viable and produce a large number of green house gases Thus the second order technologies like gasification become very important.Large number of literature is available on studies involving gasification, hydro gasification, and combination of both catalytic and non-catalytic processes. The conversion of agricultural, wood waste and other wastes are converted to char, oil and combustible gases. rted [2-4].Some of the tars and hydrocarbons are cracked at high temperatures giving similar molecules with lower percentage of tars. Conversion of biomass to CO and $H_2$ through catalytic steam gasification takes place at high temperatures[5] wheras if pressure is made high then $CO_2$, is formed rather than CO [6] Catalytic gasification with alkali metal carbonates and transition metals have been also reported [7]. Chars obtained by pyrolysis have been found to be useful raw materials for manufacture of activated carbon. Gasification of wastes containing agro-based biomass has given good results. One more advantage of thermochemical route is that it can use lignocellulosic(woody) feedsock which cannot be converted to fuels with the existing biofuels technologies. The heat required for the process is provided by the partial combustion of feedsock in an atmosphere of air/oxygen [8] Some preliminary experiments on gasification of agricultural wastes were tried in the laboratory which gave very encouraging results. The experiments are described in the following section

### *2.1. Materials and Methology*

In the laboratory various experimental works on gasification were taken up using a micro-reactor between a temperature range 450-650$^o$C. Biomass was fed from the top of the gasifier whereas air was fed from sideways near the bottom (shown in Figure-1) Thus the biomass and the gases moved in different directions Depending upon the requirement this gasifier could be run either in pyrolysis or gasification mode. The char and gaseous products were analyzed. Activity of the char was compared with standard BDH charcoal having 100% activity. Pine wood chips, eucalyptus wood chips and rice husk were pyrolysed at 650$^o$C showed activities of 97.9,100 and 97.9 % respectively [9].

It was found that at lower temperatures volatile matter release is less thereby increasing fixed carbon content. Experiments were conducted at 450,550 and 650$^o$C. The gases at every temperature were analyzed by orsat apparatus for CO, and $H_2$. The results are shown in Table-1

**Table 1.** Analysis of Biomass

| Sample | Moisture (%) | Volatile Matter (%) | Ash (%) | Fixed carbon (%) | % of CO | % of $H_2$ |
|---|---|---|---|---|---|---|
| Rice husk | 2.6 | 75.3 | 17.6 | 4.5 | 39.2 | 52.3 |
| Pine wood chips | 4.0 | 90.3 | 0.49 | 5.2 | 20.4 | 37.8 |
| Eucalyptus wood chips | 5.8 | 89.2 | 0.46 | 2.54 | 17.2 | 13.8 |

The results indicate that these agricultural wastes when gasified give combustible gases as shown by the high percentage of volatile matter so can be used as fuels. The syn gas produced from gasification can be used in Fischer Tropsch Synthesis by incorporating the water gas shift reaction.

### *2.2. Liquid-fuels from Biomass by Gasification*

This gasifier can be used for liquid hydrocarbon synthesis via Fischer-Tropsch reaction or for methanol synthesis.

$$CO + H_2O \xrightarrow{\text{Catalyst}} CO_2 + H_2$$

The correct ratio of hydrogen and carbon monoxide which is 2 : 1 should be maintaned for Fischer -Tropsch synthesis. If the ratio is not proper then it is improved by the water- gas shift reaction .The liquid can be distilled to get lighter fractions suitable for direct use as transport/domestic fuel. The heavier fraction would need hydrocracking to get further light fuels [10]. In Fischer -Trposch synthesis if biomass has high percentage of S ,N and Cl impurities then it has a detrimental effect on catalytic activity which should be removed by wet scrubbing [11]

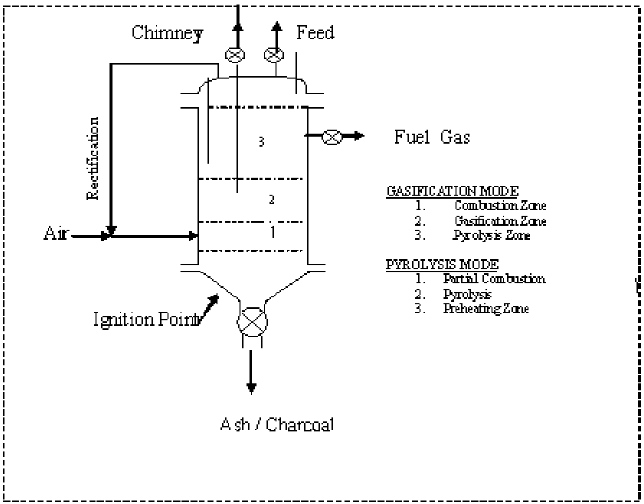


**Fig. 1.** Gasifier showing the gasification of Biomass

### *2.3. Biofuels from Biomass*

Production of Bio-fuels is gaining momentum due to hike in petroleum price. Bio-fuels are liquid fuels produced from biomass. These are produced through different chemicals and biological processes. Liquid bio-fuels normally refer to ethanol or bio-diesel produced from biomass. In sugar producing countries like Brazil normally ethanol is produced from sugarcane, beat etc. However, this is not feasible in India where fermentation of cellulose to produce ethanol in large scale has proved uneconomical.

Currently scientists have developed a different route of production of ethanol from synthesis (Syn) gas generated by catalytic gasification [12] A variety of microorganisms can use syn gas as a carbon source to produce ethanol, The syn gas used here sould not have any tars or other hydrocarbons because they retard the fermentation process by inhibing the cell growth. This process has an advantage over ordinary Fischer -Tropsch synthesis that rhe hydrogen to carbon monoxide ratio is low threby decreasing the dependence on water-gas shift reaction. The tolerance to S impurities depend on microbes used.

Since the direct use of ethanol as a fuel is not possible hence it is used as a blend with gasoline. As only anhydrous ethanol is miscible with gasoline even a little water would result in a phase separation causing stalling of engines.

### *2.4. Esterification*

In esterification, an alcohol (Ethanol/Methanol) in presence of a catalyst (NaOH/KOH) converts fatty acids into methyl or ethyl esters. From the chemical point of view it means taking a molecule from triglyceride or a complex fatty acid to neutralize the free fatty acids and produce glycerin and an ester [13]. The fats and oils required for the process can by obtained by extraction or pressing of seeds.

$$
\begin{array}{lllll}
CH_2-O-COR_1 & & & R_1-COOCH_3 & CH_2OH \\
| & & & + & | \\
CH-O-COR_2 & +3CH_3OH & \xrightarrow[Catalyst]{Heat} & R_2-COOCH_3 & +\ CHOH \\
| & Methanol & & + & | \\
CH_2-O-COR_3 & & & R_3-COOCH_3 & CH_2OH \\
Triglyceride & & & Fatty\ acid\ methyl\ ester & Glycerol
\end{array}
$$

### *2.5. Methanol from Syn Gas*

Syn gas is a mixture of hydrogen, Carbon monoxide and Carbon Dioxide. Methanol can be produced from Syn Gas over a heterogeneous catalyst.

$$CO + 2H_2 \longleftrightarrow CH_3OH, \quad \Delta H_{298\,K} = -21.7\ K.\ Cal\ mol^{-1}$$
$$CO_2 + 3H_2 \longleftrightarrow CH_3OH + H_2O, \ H_{298\,K} = -9.8\ K.\ Cal\ mol^{-1}$$
$$CO_2 + H_2 \longleftrightarrow CO + H_2O, \ \Delta H_{298\,K} = -11.9\ K.\ Cal\ mol^{-1}$$

Experiments were conducted on black liquor waste generated in an agro-based paper mill combined with biomass [14].The results of this study revealed that a waste like black liquor in combination with biomass like rice husk when gasified with proper controlled temperature between 800-850$^{o}$C, could give granular ash containing both sodium carbonate and sodium silicate The recovery of caustic soda from these chemicals were to an extent of above 70% Gasification was tried both in deep bed and shallow bed. Though there were other associated problems, but under controlled temperature these waste-mixture with biomass could be gasified.

The exit gas from gasification comes out at a very high temperature, normally between 600-650 $^{o}$C. By cooling this gas a lot of energy is wasted. So a study was conducted to use this exit gas in a high temperature furnace directly without cooling. High temperature furnaces are used at various places, e.g. glass, ceramic and pottery industries are some of them. Clean combustion is required depending upon the product quality. Gasified gases from carbonaceous materials are most suitable for this purpose. Since very high temperatures (above 1600$^{o}$C) are required for this type of work, these high temperature gasae could be tried.

### *2.6. Anaerobic Digestion of Biomass*

Biogas is produced by the anaerobic digestion of biomass which, after purification, can be put to various uses, e.g. cooking, lighting and pumping water and also as a fuel. The methane component can be a source of methanol production via partial oxidation [15] and can become feed stock for chemical and petrochemical production.

## 3. Strength and Weakness of Biomass as a Potential Source of Energy

Technologies applicable to biomass based on coal conversion appeared to be unattractive because of the simple reason that the raw material (biomass) is highly scattered with associated high cost of collection, transport as well as diverse physical and chemical nature of the material. Focus is therefore led on the production of high value products. Some visible active programme of biomass conversion and utilization in and around the country are:

- Generation of the biogas by fermentation where gas could be used for rural energy supply (cooking, lighting and irrigation pumps through gas engines) and the residue can be used as manure.
- Direct gasification with air (with or without steam) for generation of lean gas with development of lean gas engines for application in irrigation pumps, refrigeration in cold storage, power generation etc.
- Partial charing of biomass and the conversion of the char to briquetted fuels as substitution of coal or coke.
- Improvement of burning appliances for direct combustion of biomass for higher efficiency or to make combustion possible for those materials which are difficult to burn in conventional appliances.
- The conversion of biomass into biofuels like ethanol and biodiesel by fermentation, esterification etc.

The problems associated with the above processes are low efficiency of energy utilization and high initial costs.ass. So the development of the strategies have to be fixed to look for some high value materials like hydrocarbon oil or methanol, which can be easily stored and transported.

## 4. Conclusion

The current energy scenario demands the need of alternate sources of energy. However complete switching to cleaner source is difficult to achieve because of the economic, technical and social constraints The existing technologies have many advantages and disadvantages. From the above studies it is observed that research should be diverted towards the formation of value added chemicals from bio-mass rather than the use of biomass as direct fuel. Government subsidy is also necessary to improve the economic viability of the above technologies. Thus it may be concluded that there are many possibilities as well as restrictions in the use of biomass in energy supply.

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