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Biomass Power-Green Energy Commitment in India

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Abstract
Biomass is a renewable energy resource derived from living biological matter. It has environmental benefits because its combustion emits lesser amount of pollutants compared with the conventional fuels like coal, and so on. Another advantage of biomass is that it can be used as a fuel in the existing conventional power plants. In India, approximately 70% of the population is dependent on biomass for its energy and approximately 32% of the total energy is derived from biomass. Electricity generation from biomass uses technologies like cofiring and gasification. In cofiring, power plants a part of coal is replaced with biomass. Carbon monoxide and Hydrogen are produced by gasification as the main products, which are used for synthesizing chemicals and power production. It has been observed that the underdevelopment of technology and lack of commercialization as well as the use of fodder biomass as a fuel could be considered as the possible weakness which has to be overcome in future efforts. Furthermore, it is pointed out that in a developing country like India, an optimum approach could be to promote small power units (30-300 KW) fueled by agro residues. This article deals with the thermo chemical conversion of biomass and the reasons for biomass not being used extensively for power production.

Keywords: *Barriers, biomass power generation, gasification, thermochemical conversion*

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INTRODUCTION

Electricity is most convenient form of energy. The development of a country is reflected by its consumption of electrical energy. The high cost of fossil fuels and the environmental benefits of biomass as a source of renewable energy makes it a good choice for its use as a fuel in power production. In India, still 60,000 villages are not connected to grid; hence renewable energy in general and biomass in particular can play an important role in providing power. Biomass is easily available in rural areas and biomass gasification is a proven technology at low scale (very effective till 2 MW). Renewable energy is thus very important for energy security [1].

In India, approximately 18,000 MW of electricity can be generated through biomass and the 550 sugar mills can generate additional power of 500 MW through bagasse based cogeneration [2] as shown in Table 1. However, despite such a vast potential, the power generation from biomass has not been adopted on a mass scale. Thus, the objective of this article is to discuss the thermochemical routes of biomass conversion and to highlight the reasons for its failure to be adopted on a commercial scale.

Table 1: *Electricity (in MW) From Biomass.*

Biomass power combustion and bagasse cogeneration (MW)	Non bagasse cogeneration (MW)	Biomas gasifiers (Rural and industrial)	Waste to energy (MW)	Total biomass power (MW)
45550.55	602.37	178.77	146.51	5478.28

THERMO CHEMICAL CONVERSION OF BIOMASS

Biomass has a low density and is difficult to handle. Thus, its conversion into fuels having physicochemical properties which can be economically stored and transferred. Some of the processes of biomass conversion are described below:

Combustion

Feed stocks that are often used for direct combustion are rice husk, sugarcane bagasse, corn cobs, coconut shell, municipal solid waste, and so on. Biomass has an advantage that it is highly inflammable and emits fewer amounts of SOX, NOX, and dioxin gases [3] compared with fossil fuels. Heat generated is used in producing steam in the boilers for power production. In most of the boilers, cofiring of biomass with fossil fuel is done. Since biomass is seasonal, cofiring with fossil fuels becomes advantageous because power plants using fossil fuels with little modification can be used. Since biomass is not available everywhere and the transportation cost is high, therefore, the typical size of pure biomass based plants (1 MW to 100 MW) is 10 times smaller than the existing coal plants.

Gasification

Gasification of biomass is either through thermochemical process which is fast and conversion is high or through slow anaerobic digestion with conversion of 50% to 60% of feedstock. The gas produced can either be used in combustion engines, gas turbines, and biomass integrated combined cycles. Based on the flow of the direction of air and biomass fuel the classification of gasifiers is done and is given in Table 2.

Materials and Methodology

Laboratory studies with sugarcane bagasse, rice hulls, corn cobs, coconut shell, and wheat straw as standard biomass, using steam gasification technique in a micro-batch reactor under isothermal conditions showed significant results. This gave an indication that the only viable, cost effective route would be to produce liquid hydrocarbons (not alcohol) from total consumption of biomass. For calculating the HHV, proximate analysis of biomass samples were done adopting the standard method and is given in Table 3. Heating values (MJ/kg) can be calculated [4] by Equation (1).

$$HCV = 0.3536FC + 0.1599VM + 0.0078Ash \quad (1)$$

(FC = Fixed Carbon &VM = Volatile Matter).

Table 2: *Types of Gasifiers Based on Biomass Injection.*

	Updraft gasifiers	Downdraft gasifier	Fluidized bed	Entrained flow
Functioning	• Biomass enters from the top and • Air/Oxygen/steam is injected from the lower end and moves upwards and the product gases leave at the top	• Fuel and gasification agent move in the same direction	• Fine particle size biomass, air/oxygen, steam enter from the bottom.	• Fuel is in the form of dust. Feed and air/oxygen,steam move co-currently.
Advantage	• Used in small scale application, can use feedstock with high moisture content and ash with less carbon content • The exit temp .of gas is low due to high internal heat exchange • Can use a variety of feedstock (sawdust, cereal hulls, etc.) • Equipment efficiency is high	• Produces clean gas lower level of organic components in the gasifiers condensate leads to environmentally benign emissions	• Uniform temperature distribution throughout the reactor. • Conversion rate is high with low tar	• Conversion is approximately 100%
Disadvantage	• Limited size of feedstock can be used • High tar content • Can be explosive because of oxygen break-through	• Feedstock with low moisture used • Secondary heat recovery system • Unsuitable for unprocessed fuels and fuels with high tar content	• Intolerant to biomass with high moisture content • System design is complex	• Little experience with biomass

Table 3: *Proximate Analysis and HCV of Biomass Fuels (% Dry Basis).*

Biomass fuels	% Ash	% Volatile matter	% Fixed carbon	HCV (MJ/kg)
Sugarcane bagasse	4.5	45.5	50.0	24.9905
Rice hulls	18.3	60.2	21.5	17.3711
Corn cobs	7.1	40.1	52.8	25.1374
Coconut shell	2.0	44.6	53.4	26.0293
Wheat straw	8.2	46.2	45.6	23.5755

Gasification of Biomass in the Laboratory

The experiments were conducted in a micro-reactor in a temperature range of 450ºC to 700ºC. Biomass fuel was fed from the top [5], whereas air was fed sideways from the bottom as shown in Figure 1. The experiments were conducted in a micro-reactor in a temperature range of 450ºC to 700ºC. Semidried biomass material catalyzed with lime was fed from the top of a vertical packed bed reactor. Oxygen/air were introduced near the bottom. The lowest part of the reactor acted as a gasification zone where combustion reactions occurred. The zone just above it was the devolatization zone where the formation of tar along with other hydrocarbon gases took place. The top zone which is the most crucial zone, carbon monoxide reacts with steam to produce hydrogen.

$$CO + H_2O \leftrightharpoons CO_2 + H_2 \; \Delta H=41 \text{ kJ/mol} \qquad (2)$$

The gases coming out of the reactor after cooling gave a liquid (tar + water) and a gas consisting of CO, CO_2, and H_2. After removal of CO_2, the remaining gas could be suitable for the synthesis of either hydrocarbon liquid through Fischer–Tropsch process or methanol synthesis. The experiments were conducted between 300^0C and 500 ºC and it was found that gasification reaction was favorable above 400ºC. The gases CO, H_2, H_2O were analyzed by Orsat Appratus and shown in Table 4.

The results indicated that the agricultural wastes on gasification gave combustible gases hence could be used as fuels in the gasifiers. The char that is produced during thermochemical processes can be sequestered in the soil which can be a long term carbon sink [6].

Pyrolysis of Biomass

Biomass pyrolysis is when it is decomposed thermally either when air is absent or in such limited amounts where appreciable gasification is not possible. The three products which are generally produced are product gases, pyrolysis oils, and charcoal [7].

The pyrolysis of biomass is important because it can easily convert the solid fuel into liquid fuel. Since biomass is seasonal, the liquids as crude oil become easy in transportation and storage hence becomes profitable in marketing.

BIOMASS IN POWER PRODUCTION

Most of the power plants which are biomass based can be used directly in IC engines to generate power. The efficiency of such power plants is generally about 20%. However, in some cases, the heat produced is used up in heating of the buildings so the overall efficiency of such CHP goes to 80% [8]. In India, power production [9] from biomass using combustion and gasification is given in Figure 2.

As is evident from the above table that Gasifier technology is very popular in rural electrification [9] but not economically viable for large sized plants.

The top five states of India having high-biomass potential [10] and can be exploited for power production is given in Table 5.

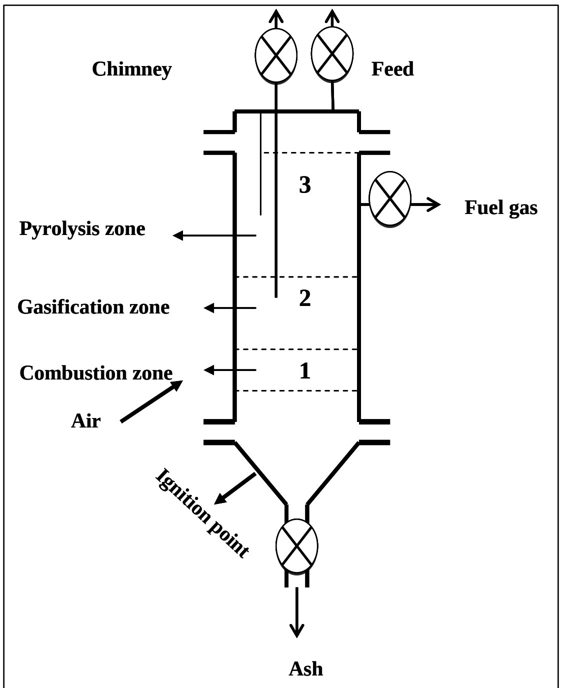

Fig. 1: *Gasifier Showing the Gasification of Biomass.*

Table 4: *Composition of Various Gases from Biomass Fuels.*

Biomass fuels	%CO	%H_2	%CO_2
Sugarcane bagasse	16.5	17.8	12.5
Rice hulls	18.0	10.5	NIL
Corn cobs	21.4	18.2	NIL
Coconut shell	25.6	15.8	15.2
Wheat straw	16.8	18.5	13.5

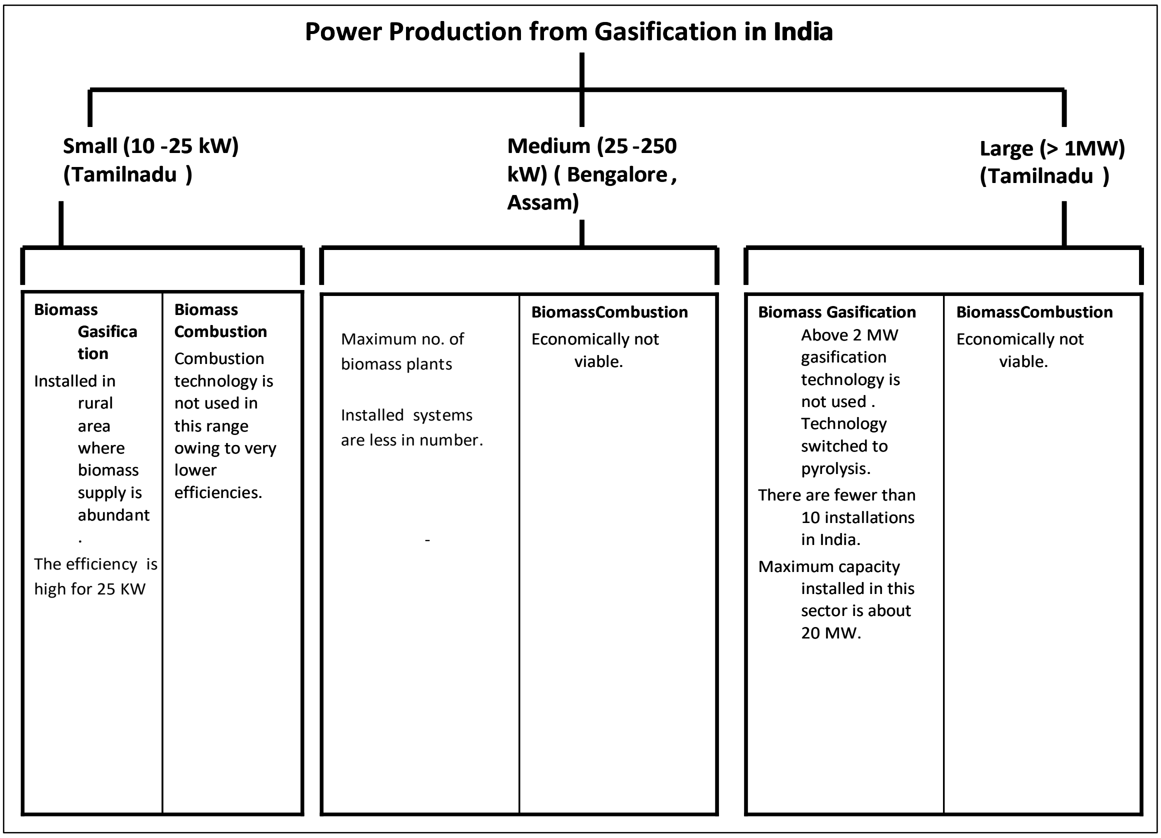

Fig. 2: *Power Productions from Gasification in India.*

Table 5: *Top Five Biomass Rich States of India.*

States	Uttar Pradesh	Maharashtra	Andhra Pradesh	Karnataka	Tamil Nadu
Capacity MW	1,746	1,984	863	1,196	1,160
Already installed MW	581	289	363	336	419

Barrıers in Biomass Power Generation

High moisture content of biomass is a big limitation for biomass conversion efficiency because the combustion temperature becomes high. The experience has been that although cogeneration-based plants are running successfully, biomass-based power projects are facing technical problems. The other limitation of using biomass as a fuel is because of the low-energy density of biomass fuels, particularly before processing, [10] transportation of biomass can be costly both in terms of energy and economic costs [11]. At present, the cost of biomass power plant is Rs 6.0 cr/MW as compared with Rs 4.5 cr/MW for a thermal power plant [12].

In India till date, conventional grate firing technology is used to produce biomass power in most of the installed biomass power plants whose average capacity is 10 to 15 MW. These power plants have an efficiency of approximately 20%only. This means that 2.2 kg of biomass is required to produce 4.3 kg of steam to generate 1 kWh of power [13].

Removal of Barrıers

The government should lay emphasis on renewal energy program and spread public awareness to exploit the underutilized energy resources. The government should not only make advanced policies like buying back, wheeling and banking of electricity generated by biomass but also should ensure that it is strictly implemented by the State Electricity Board. The regulatory commission should fix tariffs on the State Electricity Board. To purchase electricity from biomass-based power generation plants. Focus should be on the evaluation of the techno-commercial status of each technology in terms of specification, inputs, outputs, and capital and operating costs.

CONCLUSIONS

India has committed that it will reduce emission intensity by 20% to 25% of its GDP by 2020. With the advancement of the technology, it is possible to overcome the technological hurdles in using biomass as a fuel for power production instead of conventional fossil fuel. But a lot has to be done in defining strong renewable energy program and implementation of the same. Emphasis should be on large scale power plants with biomass like rice husk, sugarcane bagasse, wheat husks, and so on. The investments in biomass-based power plants will be beneficial to the environment (less GHG emissions), society (employment), and economy (market development).

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