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Study of Biomass Briquettes, Factors Affecting Its Performance and Technologies Based On Briquettes

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Abstract: *Today, renewable energy source of power generation has become very promising. As we know that conventional or non-renewable source of energies are very limited and are depleting very rapidly. Increasing energy needs of the world and continually growing population there is a power demand gap and it needs alternate sources of energy. So, there is a view to generate more and more power from renewable sources of energy. There are various forms of renewable energy sources. Biomass is one of the important sources of renewable energy. India has huge volume of potential for renewable energy sources. In India about 500 million metric tons of biomass energy is produced every year. According to International Energy Agency (IEA), Renewable energy could meet almost half of the global energy demand by 2050. Main aim of this paper is to show the potential of renewable energy in world, in India and in the state of Madhya Pradesh, it's percentage growth in present as compare to previous years as well as its future aspect. The work focuses on the methods of finding the value of different parameters in proximate analysis and its significance. Technologies of power generation through biomass are also discussed.*

Keywords: *Biomass, biomass briquettes, power generation, renewable sources of energy, technologies.*

I. Introduction

Biomass is a biological material derived from living or recently living organisms. It most often refers to plant or plant based materials which are specifically called as cellulosic biomass [1]. As an energy source, biomass can be used directly by burning it to produce heat or indirectly by converting it to various biomass fuels [2]. It is inefficient to burn biomass waste directly in domestic and industrial applications. Transportation, storage and handling problems are also associated with this. One of the approaches for efficient utilization of all biomass waste is its densification by converting it in the form of pellets or biomass briquettes [3]. The briquetting of biomass material leads to increase net calorific value per unit volume, reduces transportation cost, improves bulk density and also improves handling characteristics [4]. In present paper an attempt has been made to study the scenario of renewable energy, the effects of different parameters like calorific value, moisture content, ash content, volatile matter and carbon content of biomass briquettes and various technologies to increase the efficiency of power generation are studied.

II. Present Scenario Of Renewable Energy In World

Global renewable energy installed capacity is 673 GW as on Dec 2014 in which global wind energy consumption is 370 GW, global solar energy consumption is 177 GW as on Jan 2014. In percentage out of total renewable energy source of production 58% comes from wind energy, 25% comes from solar photovoltaic, 16% comes from biomass power and about 1% comes from concentrated solar power [5]. Total installed Renewable energy in world is shown in Fig. 1.

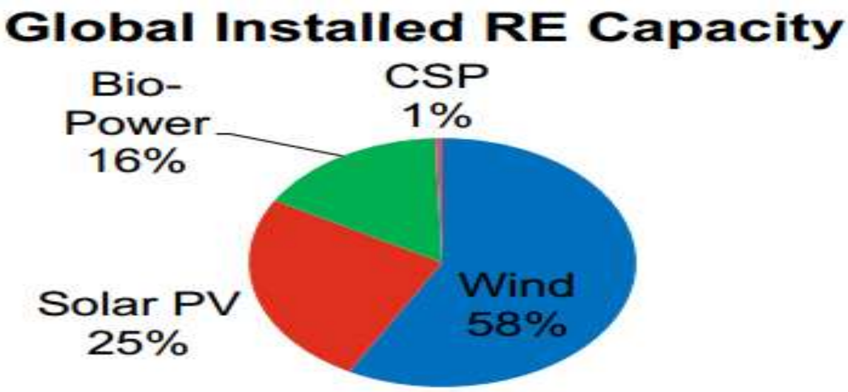


Fig. 1 Global installed Renewable Energy capacity

III. Present Scenario Of Renewable Energy In India 2015

Total installed capacity of India is 263.66 GW out of which renewable energy capacity is 34.35 GW which is 13% of total installed capacity and approximately 7% of the electricity is produced through renewable energy sources as on March 2015. India produces 22.6 GW of wind energy and holds 5th rank in the world and also produces 3.3 GW of solar energy and holds 9th rank in the world. Out of the total energy production in India, 60.1% of the total energy is produced by coal which is nonrenewable and conventional source of energy, 2.2% of energy is produced by nuclear energy, natural gas contributes to 8.7% 0f total energy production, diesel or oil contribute to 0.5%. 15.5% comes from hydro power while other renewable energy sources contribute to 13.1% of total energy production in India. Out of renewable energy sources percentage of energy produced from wind, small hydroelectric plant, biomass, bagasse cogeneration and solar is 8.6%, 1.5%, 0.5%, 1.1% and 1.3% respectively shown in Fig.2. [6].

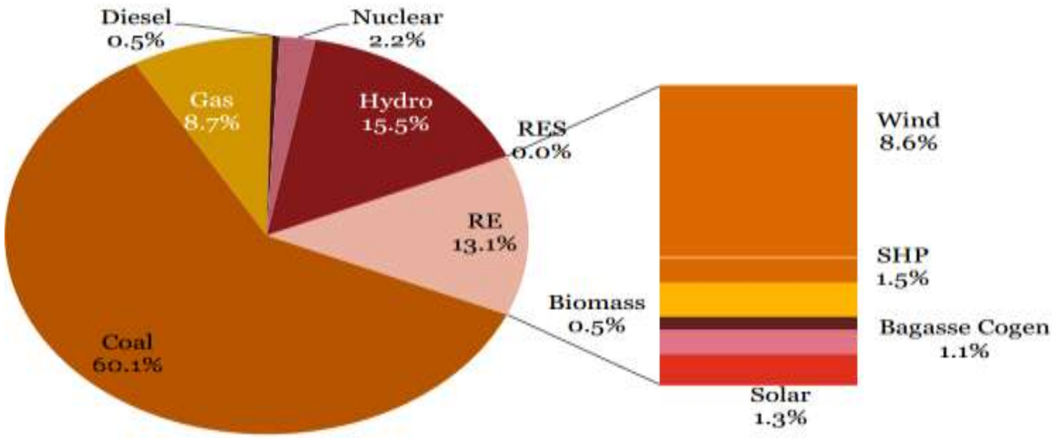
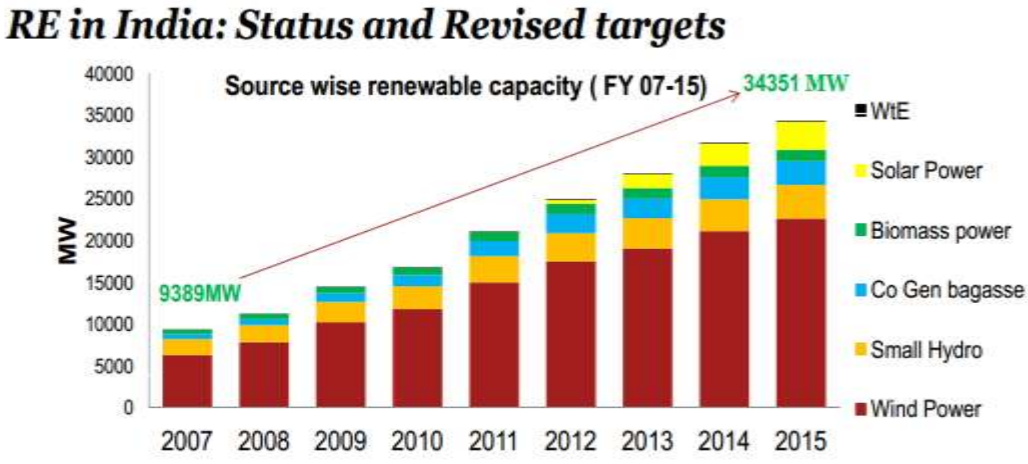


Fig. 2 Total installed capacity of India
(Source: ministry of new and renewable energy as on March 2015)

IV. Growth of Renewable Energy per year



Source	Capacities in MW		
	Installed capacity by end of 11th Plan (March 2012)	Current installed Capacity (March 2015)	Target as per 12th Plan (March 2017)
Solar Power	941	3,383	10,941
Wind power	17,352	22,645	32,352
Biomass Power	3,225	4,183	6,125
Small Hydro	3,395	4,025	5,495
TOTAL	**24,914**	**34351**	**54,914**

Fig. 3&4 Growth of renewable energy sources
(Source: MNRE, Government of India)

This table shows that there is 2442 MW increase in solar power, 5293 MW increase in wind power, 958 MW increase in biomass power and 630 MW increase in small hydro power generation up to March 2015 from March 2012. It shows that there is 37.8% of increase in total renewable energy production as compared to March 2012. From this table it is also concluded that there will be 10000 MW of increase in solar power generation, 18000 MW increase in wind power generation, 2900 MW increase in biomass power generation and 2100 MW increase in small hydro power generation from March 2012 to March 2017 which means there will be total increase of 120.41% in renewable energy power generation from March 2012 11th plan to March 2017 as per 12th plan which shows that renewable energy sources are becoming one of the important source of power generation in our country. (*www.mnre.gov.in*)

V. Present Scenario Of Renewable Energy In Madhya Pradesh

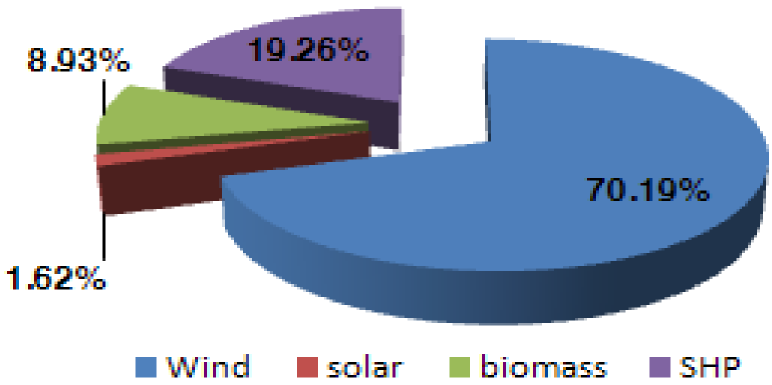


Fig. 5 Installed Renewable Energy capacity in Madhya Pradesh
(Source: MP New and Renewable Energy Department)

The state has witnessed considerable development on Wind power, which constitutes around 70.19 % of total Renewable Energy installed capacity (447.79 MW). Small Hydro and Biomass constitute around 19.26% and 8.93% of the total Renewable Energy installed capacity respectively. While the Solar installed capacity constitutes only 1.62% (7.25MW) of the total Renewable Energy installed capacity in the state [7] (*www.mpnerd.com*)

VI. Sources Of Biomass Waste, Its Uses And Applications

There are two types of industrial waste Hazardous wastes and non-hazardous waste. Non-hazardous waste can be used as alternative fuels or biomass fuels. Following table will show the source of biomass waste and how it can be used as energy source [8].

Industries	**Prominent wastes generated**	**uses**
Sugar mills	Sugar bagasses Press mud Sugar molasses Fermentative yeast biomass	Combustion and gasification Composting Fermentation Biomethanation
Slaughter houses	Organs, tissues, blood, excreta and carcass	Biomethanation
Paper mills	Pulp Paper shavings Wood waste and paper boards	Biomethanation Combustion Combustion and gasification
Dairy plants	Whey and milk cream	Biomethanation
Tanneries	Hides and skins	Acid treatments
Animal husbandries	Human excreta and body fluids	Biomethanation
Fruit and vegetable processing units	Pulp wastes	Biomethanation

Table no. 6.1 Source: www.eai.in

VII. Raw Materials Used

Commonly used materials for making briquettes in India includes sawdust, sugarcane bagasse, groundnut shells, cotton stalks, maize stalks, rice husks, coffee husks, sunflower stalks, mustard stalks, coir pith bagasse, paper waste, wood chips, forest residues etc. [3]. The factors that mainly influence the selection of raw materials are their calorific value, moisture content, ash content, particle size and easy availability. There is a suitable and preferred range of different factors like moisture content should be in the range of 10-15% because extra energy is needed in drying. Ash content upto 4% is preferred because it affects the slagging behavior. The granular size from 6 to 8 mm is preferred so that it can easily flow in conveyers and bunkers. Biomass briquettes can be made with or without binding materials. Combination of raw materials can also be used for making briquettes.[9]. Calorific value and ash content of different biomass fuels are shown in Table. 7.1 & 7.2 respectively.

7.1 Calorific value of different biomass fuels

S. No.	Biomass fuels	Calorific value (kcal/kg)
1.	Paddy straw	3000
2.	Rice husk	3040
3.	Sawdust briquettes	3898
4.	Groundnut	4200
5.	Sugarcane	3800
6.	Wheat straw	3800
7.	Cotton stalks	4700
8.	Maize stalks	3500
9.	Soya bean husk	4170
10.	paper	3226

Table no. 7.1 Source: www.lehrafuels.com

7.2 Ash content of different biomass fuels

S.No.	Biomass fuels	Ash content
1.	Bagasse	1-4% (approx. 1.8%)
2.	Saw dust briquettes	8.2%
3.	Paddy straw	15.5%
4.	Soya bean husk	4.10%
5.	Wood chips	1.2%
6.	Forest waste	7%
7.	Rice husk	19.2%
8.	Cotton stalks	3%
9.	Groundnut	3.8%
10.	Paper	1.5%

Table no. 7.2 source: www.lehrafuels.com

VIII. Briquetting Process

There are two techniques by which briquettes can be made. Screw-press, piston press technology and low pressure briquetting technology. In screw press and piston press technology binding material is not needed and high pressure is applied which increases the temperature of biomass. The lignin which is present in biomass is fluidized and it acts as binder whereas low pressure briquetting technique is used for materials having less amount of lignin such as paper. In this process powdered material is mixed into a paste with binder such as clay and water. A briquetting press is used to push the paste into a mold, or it can simply be shaped by hand. The briquettes made by this process are dried so that binder holds and sets the biomass powder together. Drying can be done outdoors particularly if it is sunny, but can also make use of waste heat from other process. Low pressure briquetting machines can be electrically powered but are often hand operated using a liver that drives the piston to compress the paste [3]. The flow chart of briquetting process is shown in Fig. 6 [10]

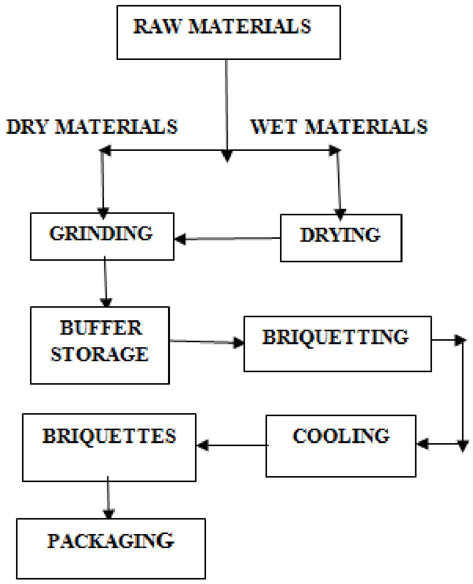


Fig. 6 modified flow diagram of biomass briquette production.

IX. Proximate Analysis Of Biomass Briquettes

Determination of Moisture content

Determination of moisture content of sample is carried out by placing it in an uncovered crucible and it is placed in the oven kept at108±2°Calong with the lid for one hour and up to constant weight loss. Then the sample is cooled to room temperature and it is weighed again. The loss in weight represents moisture. [11]

% Moisture content = $\frac{W2-W3}{W2-W1}$ *x 100*

Where, W_1*= weight of crucible, gm*

W_2*= weight of crucible + sample, gm*

W_3*= weight of crucible + sample after heating, gm*

Measurement of volatile matter

The dried sample left in the crucible was covered with a lid and placed in an electric furnace maintained at 925 ± 20°C for 7 minutes. The crucible was cooled first in air, then inside a desiccator and weighed again. Loss in weight represents volatile matter in percentage. [12]

% volatile matter = $\frac{W5-W6}{W5-W4}$*x 100*

Where, W_4 *= weight of empty crucible, gm*

W_5 *= weight of empty crucible + sample, gm*

W_6 *= weight of empty crucible + sample after heating, gm*

Determination of ash content

The residual sample in the crucible was heated without lid in the muffle furnace at 700 ± 50°C for one and half hour. The crucible was then taken out, cooled first in air then in desiccators and then it is weighed. This process continues till constant weight is obtained. The residue represents the ash content in percentage [12]. In actual practice fixed carbon is derived by subtracting the value of moisture, volatile matter and ash from 100.

% ash content = $\frac{W9-W7}{W8-W7}$*x 100*

Where, W_7*= weight of empty crucible, gm*

W_8*= weight of empty crucible + sample, gm*

W_9*= weight of crucible + ash, gm*

Determination of fixed carbon

Fixed carbon percentage is calculated by using following relationship

% fixed *carbon = 100 - % of (moisture content + volatile matter + ash content)*

Measurement of calorific value

The calorific value of biomass sample can be measured by using bomb calorimeter. Following formula is used to calculate the calorific value [11] [12].

Calorific value (Kcal/Kg) = $\frac{(W + w)\ x\ (T1 - T2)}{X}$

Where, *W = weight of water in calorimeter, Kg*
w = water equivalent of apparatus
T_1 *= initial temperature of water, °C*
T_2*= final temperature of water, °C*
X = weight of fuel sample taken, Kg

X. Significance Of Various Parameters

Moisture content

High moisture content in biomass material reduces its application in thermo- chemical conversion process including combustion. Water content has effect on net calorific value. Increased moisture content of biomass material, decrease the density of pellets considerably even at high applied pressure [13].

Volatile matter

The amount of volatile matter, strongly influence the combustion behavior of fuels. Fuel having low volatile matter or conversely high fixed carbon have to be burned in powdered form otherwise they will take long time for combustion [13].

Ash content

Minerals present in the ash when subjected to high temperature and certain conditions can agglomerate and deposit inside the thermal device leading to slag formation, fouling and bed agglomeration. Ashes are usually formed of Cao, k_2O, Na_2O, MgO, SiO_2, SO3, Fe_2O_3, $P_2O_5$and Cl. The ash content affects its slagging behavior, operating temperature and mineral composition of ash [13].

Fixed carbon

Low fixed carbon reduces the calorific energy of the briquettes. The higher the fixed carbon, the better the charcoal produced because corresponding calorific energy is high [13].

XI. Technologies based on biomass

Bagasse based cogeneration

Cogeneration is the process of using a single fuel to produce more than one form of energy. In normal electricity generating plants, heat rejection takes place in condensers where up to 70% of heat is rejected to the atmosphere whereas in cogeneration, this heat is not wasted and is instead used to meet process heating requirements. The total efficiency of fuel utilization is increased to 60% or even higher. Capacity of cogeneration projects range from few kilowatts to several megawatts [14].

Biomass based power generation

The technology for the generation of electricity from biomass is similar to the conventional coal based power generation. The biomass is burnt in boilers which generates steam which drives turbo alternator for the generation of electricity [14].

Biomass gasification

Biomass gasification is the thermo chemical energy conversion of solid biomass into a combustible gaseous mixture called as producer gas through a partial combustion route with air supply restricted to less than that theoretically required for full combustion. Composition of producer gas is Carbon monoxide (18%-20%), Hydrogen (15%-20%), Methane (1%-5%), Carbon dioxide (9%-12%), nitrogen (45%-55%) [14].

Flow chart of biomass based power generation projects (*Source: mprenewable.nic.in***)**

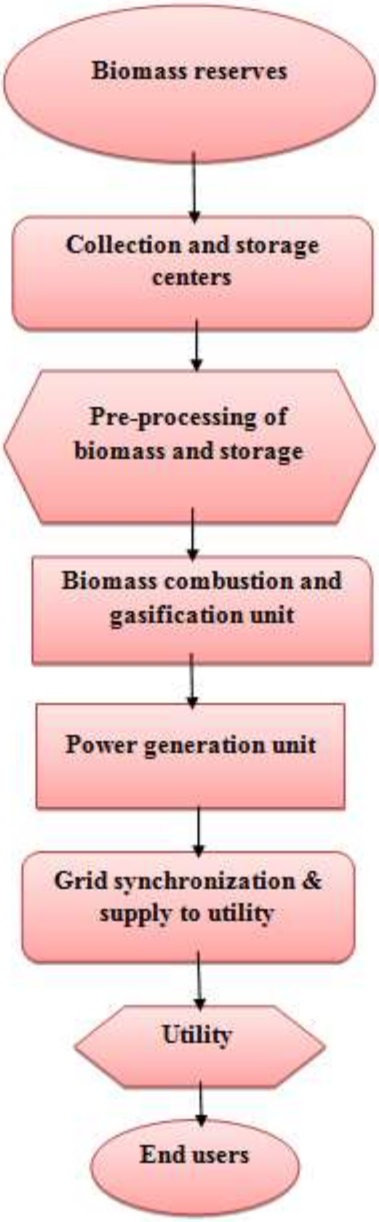


Fig. 7 biomass based power generation (source: MP Urja Vikas Nigam)

XII. Conclusion

Through the study of different aspects of biomass energy it can be concluded that it is easy to select the type of raw materials based on their calorific value, moisture content, ash content, volatile matter, fixed carbon, easy availability and its cost. Through this we can take the combination of raw materials in different ratios and can find the best ratio in which raw materials can be mixed to give the best result in calorific value, moisture content, ash content, volatile matter and fixed carbon. We can also note the variations in the value of these parameters by varying the ratio of raw materials. Also its cost analysis can be done and these all values are compared with coal or other conventional sources of energy to study the merits of this alternative fuel and what are the problems to be solved so that we can give an environmental friendly fuel to world and also fulfill the energy demand gap and decrease the green house gases emissions.

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