Recent Trends in Biomass Conversion Technology: A Critical Review

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Abstract- **In this paper biomass energy resource, potential, energy conversion technology and policy for promotion implemented by Government of India are discussed. The total installed capacity for electricity generation in India is 2666.64 GW as on 31st March 2013. Renewable energy is contributed 10.5% of total generation out of which 12.83% power is being generated using biomass. India has surplus agricultural and forest area which comprises about 500 million metric tons of biomass availability per year. In India total biomass power generation capacity is 17,500 MW. At present power being generated is 2665 MW which include 1666 MW by cogeneration. The various category of biomass in India is also discussed in this paper. And the research reveals that India has large potential for bio mass feed stock from different sources. Government of India deployed different policies and executed that the strategies for biomass power generation. Such approaches have included the whole biomass energy sector which in corporated the bio gas, bio diesel etc. in the policies. Government of India has focused on the deployment and development biomass energy sector with strategic policy and program which is notable portion of this paper.**

Index Terms- Biomass Energy Resources, Potential, Conversion, Technology.

I. INTRODUCTION

Many developed and developing countries has promoted biomass energy generation through instrumented policies and financial incentives. Many governments introduced feed in tariff schemes as a policy mechanism to accelerate investment in renewable energy sector.

India is a fast developing country; with high economic and industrial growth energy demand is also growing. The major source fulfill the energy requirement of India are Oil and coal. The energy consumption of India using these conventional sources are—151.3 GW by thermal (coal, natural gas and oil), 4.78 GW by nuclear energy, 30.49 GW by hydro and 27.54 GW by renewable energy. Fig. 1 shows the percentage share of various energy resources in India up to 31st March 2013.

Non-renewable resources have used frequently in India due to lack of awareness and acceptability of renewable energy sources by power consumer. There are many disadvantage of using non- renewable energy resources as they have limited existence in environment, non-eco friendly and not economical as India import all these type of energy resources. Therefore it is essential to explore many others sustainable energy sources. One of those non conventional sources is biomass energy which can provide firm power of grid quality. Biomass is a renewable source of energy contains complex mix of carbon, nitrogen, hydrogen and oxygen. Biomass of this content is obtained from living or dead plants, by product of crop production, wood and agro based industry.

Biomass energy consumption is in practice in India since ancient time. It is used in the form of cow dung cake, firewood, husk and many available natural feed stocks. However, direct use of biomass in solid form was not safe and painless as they produce lot of smoke and ash. Therefore Biogas plant are being motivated by Indian Govt. as they produce no smoke i.e. pollution free. Many subsidies are provided for establishment of the biogas plant. New biomass gasification Technology was also evolved which converts biomass in to syngas, which are more efficient. After judging the potential of biomass, technology also implemented the biological and thermo-chemical conversion for utilizing biomass to produce fuel gases. These fuel gases can be used for power generation. The biomass based power generation is now considerably on the rise trend. It is

mainly because power demand is increasing in rural area also and less option for alternative fuel. It has been fundamental now to provide energy by biomass for the development of civilization. In present scenario, global warming, decrement of resources and other international issues have led to the decision of sustainable development. And in power sector use of renewable energy like biomass is the need one of the major green source.

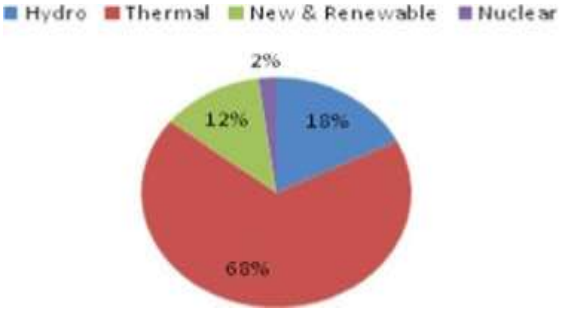

Fig. 1. Percentage share of various energy resources in India upto 31st March 2013.

Larger population of India lives in rural area. According to census 2011, 68.84% population of India lives in rural area. There are 0.638 millions villages in India, therefore to plan for electrification in villages; biomass will be vital option as a renewable source of energy. Ministry of New and Renewable Energy Sources (MNERS) has proposed to reach total 4324.22 MW of power generation based on biomass power and gasification as well as co-generation. MNRE, Govt. of India, has taken initiative like central financial assistance and fiscal incentives for promoting the use of bio-energy from agro residues, plantations and from various waste of urban and industries. MNRE is using the methodology for providing the subsidies based on co-generation and generation by biomass gasification.

In this paper, state wise biomass potential of India is identified. The various category of biomass in India and their conversion processes are also presented briefly. This paper has discussed the scope, potential and scenario of implementation biomass power in India. Policy regarding providing the subsidies for biomass power in India is mentioned. Government of India has focused on the deployment and development biomass energy sector with strategic policy and program which is notable portion of this communication.

II. AVAILABLE BIOMASS RESOURCES IN INDIA

Biomass is defined as bio residue available by water based vegetation, forest or organic waste, by product of crop production, agro or food industries waste. Various biomass resources are available in India in different form. They can be classified simply in the way they are available in nature as: grasses, woody plants, fruits, vegetables, manures and aquatic plants. Algae and Jatropha are also now used for manufacturing bio-diesel. Core distinct sources of biomass energy can be classified as residue of agricultural crop, energy plantation and municipal and industrial waste.

III. INSTALLED POTENTIAL OF BIOMASS ENERGY IN INDIA

Total renewable energy based power generation was achieved 94,125 MW up to 31st March 2013. Out of which wind power contribute 52.20%, small hydro power 20.98%, biomass power 18.63%, cogeneration bagasse 5.31% and waste to energy contribute 2.88%. MNRE is promoting Biomass Gasifier based power plants for producing electricity using locally available biomass resources. These power plants are installed in rural areas where surplus biomass such as tiny wood chip, rice husk, arhar stalks, cotton stalks and other agro-residues are available to meet the unmet demand of electrical energy interlaid for lighting, water pumping and microenterprises counting telecom towers etc. Various projects related to biomass power generation are installed in various state of India for fulfill energy requirement by biomass gasification. The leading state for biomass power projects are Chhattisgarh, Uttar Pradesh, Maharashtra, Andhra Pradesh and Tamil Nadu. The states which have taken position of leadership of baggase cogeneration projects are Andhra Pradesh, Karnataka, Maharashtra, Tamil Nadu and Uttar Pradesh. In baggase cogeneration we use waste of sugar mills known as baggase (The dry pulpy residue left after the extraction of juice from sugar cane, used as fuel for electrical energy generators by gasification technology) by co generation sugar mill improve their audit of energy.

MNRE has installed 130 biomass power projects this is total aggregate to 999.0 MW and 158 bagasse

cogeneration projects in sugar mills with additional capacity which aggregate to 1666.0 MW power to feed the grid. In addition, around 30 biomass power projects aggregating to about 350 MW are under various stages of execution. Approximately 70 Cogeneration projects are under implementation with surplus capacity aggregating to 800 MW.

The contribution of bio-energy to the total primary energy consumption in India is over 27%, mainly because biomass is used in a significant way in rural areas. Total contribution to bio-energy is 25,245 MW in power generation. However, the contribution of biomass to power production in India is less than 2%—currently, biomass comprises only about 3601 MW of installed capacity, out of a total of 17,500 MW of total biomass power installed capacity (May 2013).

IV. BIOMASS ENERGY CONVERSION TECHNOLOGIES

It is clear from the potential of biomass in India that various feedstocks are available for conversion to the bio-fuels as well as for power generation applications. The variety of processes exists for biomass conversions are depends on the type and quantity of biomass feedstock, environment and economic conditions etc. Conversion of biomass to energy is undertaken using two main process technologies: thermo-chemical and bio-chemical/biological. Mechanical extraction (with esterification) is the third technology for producing energy from biomass, e.g. rapeseed methyl ester (RME) bio-diesel. The thermal conversion processes consist of pyrolysis, biomass gasification, combustion and liquefaction.

A. Thermochemical Conversion

Three main processes are used for the thermo-chemical con- version of biomass i.e. combustion, gasification and pyrolysis.

a. Combustion

Combustion is the burning of biomass in air, and it is used to convert the chemical energy stored in biomass into heat energy, mechanical power and also in electricity by different process and devices e.g. furnaces, stoves, steam turbines, boilers, etc. It is possible to burn any type of biomass but in practice combustion is feasible only for biomass with a moisture content less than 50%, unless the biomass is pre-dried. High moisture content biomass is better suited to biological conversion processes.

The scale of combustion plant ranges from very small scale (e.g. for domestic heating) up to large-scale industrial plants in the range 100–3000 MW. Co-combustion of biomass in coal-fired power plants is an especially attractive option because of the high conversion efficiency of these plants. Net bio-energy conversion efficiencies for biomass combustion power plants range from 20% to 40%. The higher efficiencies are obtained with systems over 100 MWe or when the biomass is co- combusted in coal-fired power plants. One heat engine cycle, the Stirling cycle, uses combustion to provide shaft power directly but the development of the cycle is presently limited to small power outputs.

b. Gasification

Gasification is the conversion of biomass into a combustible gas mixture by the partial oxidation of biomass at high temperatures, typically in the range 800–900 LC. The low calorific value (CV) gas produced can be burnt directly or used as a fuel for gas engines and gas turbines. The application of this produced gas can be used as a feedstock (syngas) for the production of chemicals like methanol. One promising concept is the biomass integrated gasification/ combined cycle (BIG/CC), where gas turbines convert the gaseous fuel to electricity with a high overall conversion efficiency. An important advantage of BIG/CC systems is that the gas is cleaned before being combusted in the turbine, allowing more compact and less costly gas cleaning equipment to be used, as the volume of gas to be cleaned is reduced. The combination of gasification and combustion ensures high conversion efficiency, producing net efficiencies of 40–50% for a plant of 30–60 MWel capacity.

The produced syngas from biomass is used for the production of methanol and hydrogen, which can be considered as fuels for transportation and others. In the methanol production, either oxygen blown or hydrogen indirect gasification process are preferred in production of methanol and the higher value CV gas (typically 9–11 MJ ¼ N m3) are produced by these processes.

c. Pyrolysis

Pyrolysis is the conversion of biomass to liquid (bio-oil or bio- crude), solid and gaseous fractions, by heating the biomass in the absence of air to around 500 LC. Pyrolysis can be used to produce bio-oil if flash pyrolysis is used, enabling the conversion of biomass to bio-crude with an efficiency of up to 80%. The bio-oil can be used in engines and turbines and its use as a feedstock for refineries is also being considered. But there are some problems which are still there to overcome such as corrosivity, less thermal stability. Upgrading bio-oils by lowering the oxygen content and removing alkalis by means of hydrogenation and catalytic cracking of the oil may be required for certain applications.

B. Bio-chemical conversion

Two main processes are used, fermentation and an-aerobic digestion, together with a lesser-used process based on mechanical extraction/chemical con-version.

a. Fermentation

Fermentation is used commercially on a large scale in various countries to produce ethanol from sugar crops (e.g. sugar cane, sugar beet) and starch crops (e.g. maize, wheat). The biomass is ground down and the starch converted by enzymes to sugars, with yeast then converting the sugars to ethanol. Purification of ethanol by distillation is an energy-concentrated step, with about 450 l of ethanol being produced by 1000 kg of dry corn. Solid residue obtained from this process can be given to cattle to feed and bagasse which is obtained from sugar cane can be used for next gasification or as a fuel for boilers.

The conversion of lingo cellulosic biomass (such as wood and grasses) is more complex, due to the presence of longer-chain polysaccharide molecules and requires acid or enzymatic hydrolysis before the resulting sugars can be fermented to ethanol. Such hydrolysis techniques are currently at the pre-pilot stage.

b. Anaerobic digestion

In Anaerobic digestion (AD) organic material is directly converted to a gas which is termed as biogas. It is a mixture of mainly methane and carbon dioxide with small quantities of other gases such as hydrogen sulphide. The biomass is converted in anaerobic environment by bacteria, which produces a gas with an energy of about 20–40% of the lower heating value of the feedstock. AD is a commercially proven technology and is widely used for treating high moisture content organic wastes, i.e. 80-90% moisture. Biogas can be used directly in spark ignition gas engine and gas turbines and can be upgraded to higher quality i.e. natural gas quality, by the removal of CO2. The overall conversion efficiency can be 21%. As with any power generation system using an internal combustion engine as the prime mover, waste heat from the engine oil and water-cooling systems and the exhaust could be recovered using a combined heat and power system.

C. Mechanical extraction

Extraction is a mechanical conversion process in which oil is produced from the seeds of various biomass crops such as ground- nuts, cotton, etc. The process produces not only oil but also a residual solid or 'cake', which is suitable for animal fodder. Three tons of rapeseed is required per ton of rape-seed oil produced. Rapeseed oil can be processed further by reacting it with alcohol using a process termed esterification to obtain.

V. INDIAN BIOMASS ENERGY CONVERSION POLICY

In recent years, India's energy consumption has been increasing at a relatively fast rate due to population and economic growth. With rapid urbanization and improving standards of living for millions of Indian households, the demand is likely to raise a lot. Therefore, Govt. of India is now making various planning and policies in energy sector. Since Sustainable Development is now the key target of the world, therefore Renewable Energy Resources are considering for power generation. Ministry of New & Renew- able Energy of India has developed many project and policies in this field and promoting to adopt these methodologies by providing various subsidies and incentives.

In the 12th five year plan period government is allocating total Rs. 46.00 crores for biomass Gasifier scheme which includes the promotional and other administrative activities.

Programs implementation during 12th five year plan period has included the following components:

- Off-grid/distributed power program based on Biomass Gasifier, to be implemented for rural areas to fill the unmet demand of electricity.
- 100% engines based on producer gas are supported at MW level in Biomass gasifier based grid connected power program.
- Boiler Turbine Generator (BTG) based on biomass, would be supported with maximum acceptable capacity of 2 MW.
- Programs also cover promotional activities, publicity, seminars/ training programs etc.

Indian Government providing many types of subsidies for promoting the growth of bio power market. They are making various patterns to attract investor in bio power market, in both types of schemes i.e. off grid and on grid. MNRE providing various types of subsidies for, private and government sector.

A. Subsidy for generation based projects

MNRE, Government of India, is administering a MNRE—UNDP/ GEF assisted Project on "Removal of Barriers to Biomass Power Generation in India". The objective of the Project is to increase the use of environmentally sustainable biomass power and cogenerations based technologies in the country and enhance electricity supply through renewable energy sources.

The proposals are invited by MNRE for establishment of Model Investment Projects (MIPs) based on gasification technology, which should be of minimum 1 MW capacity using 100% producer gas engines for generation of grid interactive power. The proposals of higher capacity can be considered on merit such as innovative technology configuration/power utilization pattern; economy of scale etc.

Financial supports are provided for MIPs based on installed capacity as per details given below :

- Grid connected power projects with 100%: Rs 150 lakh/MW producer gas engine of at least 500 KW each.
- Creation of infrastructure for fuel supply linkages, Rs 30 lakh/ MW evacuation of energy, biomass drying, utilization of char etc.
- 50% cost of the plant and machinery subject to max of Rs 20 lakh towards installation of Vapor Absorption Machine (VAM) for cooling/chilling and steam generating system from waste heat.

B. Subsidy for cogeneration based projects

Scope of Co-generation by biomass is to meet the requirement of captive power and thermal power. The setting up of biomass co-generation projects (excluding bagasse co-generation) is to be promoted in industry, with at least 50% of power for confined use, and a stipulation for the surplus power to be selling to grid. This will amplify the use of non-conventional energy sources and conserve the use of fossil fuels such as natural gas, coal and oil.

C. Central financial assistance and fiscal incentives

The Ministry of New and Renewable Energy (MNRE) provides Central Financial Assistance (CFA) in the form of capital subsidy and financial incentives to the biomass energy projects in India. CFA is fixed to the projects on the basis of installed capacity, energy production mode and its application etc. Economic support will be made accessible selectively through a transparent and competitive procedure.

The government provides a onetime capital subsidy based on the installed capacity of the project. The entire capital subsidy amount is transferred directly to the lead bank/lending financial institution for the purpose of offsetting the loan amount after winning commissioning of project. In case the project is situated by the promoters through their personal resources, the CFA would be transferred directly to promoters after thriving commissioning of the project.

VI. INTERNATIONAL ACCEPTANCE OF BIOMASS

By the end of 2012, global bio-power capacity was approaching 83 GW, up 12% over 2011, with notable increases in some of the BRICS countries. Around 350 TW h of electricity was generated worldwide in 2012, a 5% increase over the previous year. Averaging national bio-power generation outputs over the phase 2010–2012, the United States had a significant lead, with Germany second, chased closely by Brazil and China, both of which are gaining ground quickly Almost 90% of biopower is generated with solid biomass fuels. Landfill gas,

biogas, synthesis gas (also known as syngas), and liquid biofuel are also usually used for bio-power generation and make up the remaining 10%.

In the United States, 100 bio-power projects (543 MW) came on line in 2012, bringing total capacity to 15 GW—about 18% of the global total 42 Net bio-power generation increased from 60.5 TW h in 2011 to 65.0 TW h in 2012. Germany, Europe's leading bio- power producer, increased its generation by 11% to 41 TW h, with half of this coming from biogas plants. In Asia, China increased its capacity by around 14% to 8 GW by the end of 2012 and saw generation increase 21% to 36 TW h. Japan's capacity remained at 3.3 GW but generation declined 8% to 17.2 TW h. India leads the world in total capacity of small gasifiers for electricity generation, with a capacity exceeding 155 MW. At the end of 2012, India had approximately 1.3 GW of solid biomass and MSW-fired power capacity, as well as more than 2.7 GW of CHP capacities.

The biomass power plants market will grow throughout the world in the future. 3500 biomass power plants will be operational in 2020. This makes the growth of almost 50% in 8 years. Similar increment can be soon in the installed biomass power capacities as they will increase from 37.5 GWel at present to almost 55 GWel in 2020. The increasing subsidization of renew- able energies is the main reason for this growth internationally. Biomass has a special status among the renewable energies as generating energy from biomass can follow the demand—contrary to the energetic use of sun or wind. More and more countries want to increase their dependency on renewable energy sources for improve economy and environment. They are creating the necessary framework conditions for a fast growth of the biogas industry.

VII. CONCLUSIONS

A robust analysis of the resources and potential of biomass has been presented. It can be concluded that huge potential exist for exploration of available biomass in India to convert it to energy. Various resources in wide variety and different form of biomass are available in India. Diverse sources are there to obtain waste biomass e.g. agricultural waste, food wastes, industrial waste- waters generated in large volumes which hints the tendency to switch over to non conventional source of energy. Agencies and industries are practicing the conversion of different waste biomass to energy in India and reported benefits from these. MNRE showed the huge potential data of installed capacity and surplus biomass. At present two major technologies are being used to convert biomass into energy; thermo-chemical and bio-chemical. Selection of conversion technologies for biomass depends upon the form in which the energy is required like combustion produce heat, mechanical, electricity energy; pyrolysis, fermentation and mechanical extraction produce liquid fuels suitable for use as transportation fuels etc. Gasification processed biomass to form syngas. Various projects related to biomass power generation are installed in various state of India for fulfill energy requirement by biomass gasification. The states are also generating power by baggase cogeneration which uses the waste of sugar mills. A number of power generation projects are already proved successful in India based on gasification based cogeneration rural electrification plants. These plants have not only solved the rural electrification problem for the remote villages, where infrastructural costs could have been quite high for conventional electrification, but also the power generation cost has also been relatively low. The prime motto of Govt. to provide the subsidy or providing financial assistance is to encourage the use of non conventional sources of energy, which helps in sustainable development of nation.

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