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Bioenergy potential from crop residue biomass in India

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ABSTRACT

Biomass based energy generation is one of the major focus areas of renewable energy programs in India. The strength of India's biomass resources mostly lies in the agricultural sector. A large quantity of crop residue biomass is generated in India. However, crop residue biomasses are distributed resources with variation in spatio-temporal availability and its characteristics. Competing uses of residues also vary geographically. Therefore, local biomass databases are important for decentralized bioenergy programs. However, in India, state wise crop level biomass database is limited. The present paper assessed crop residue biomass and subsequently bioenergy potential in all the 28 states of India using crop statistics and standard procedure. A total of 39 residues from 26 crops cultivated in India are considered for the study. Overall, India produces 686 MT gross crop residue biomass on annual basis, of which 234 MT (34% of gross) are estimated as surplus for bioenergy generation. At state level, Uttar Pradesh produces the highest amount of crop residue amongst all the 28 states. Amongst all the crops, sugarcane produces the highest amount of surplus residue followed by rice. The estimated annual bioenergy potential from the surplus crop residue biomass is 4.15 EJ, equivalent to 17% of India's total primary energy consumption. There exists variation from 679 MJ (West Bengal) to 16,840 MJ (Punjab) of per capita crop residue bioenergy potential amongst the states of India. The information generated in this study is expected to be useful for decentralized crop residue based energy planning by the states of India which in turn would positively influence the overall renewable energy growth in India.

Contents

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1. Introduction

1.1. India's energy concern and growth of renewable energy

Improving living standard, economic and industrial expansions, population growth has possess serious challenges on India's energy sector. Although the country is recognized as one of fastest growing economies of the world, basic energy needs of thousands of millions of its citizens are yet to be fulfilled. It is reported that by 2031–2032, power generation capacity must increase to nearly 800 GW from the current capacity of around 183 GW, inclusive of all captive plants to meet the basic energy needs of its citizens [1]. Taking a historical prospective, Kumar and Jain [2] reported that during 1970–71 to 2006–07, coal consumption in India has increased from 71.2 MT to 462.7 MT, crude-petroleum consumption has gone up from 18.4 MT to 146.5 MT and the natural gas consumption rose from 0.64 Giga cubic meters (GCM) to 31.36 GCM. Similarly, electricity consumption has also increased from a level of 43.7 TWh to 443.1 TWh during the same period.

Contrary to the demand, native energy reserves of India are not adequate and therefore, the country is fairly dependent on foreign imports of oil. For instance, against the consumption of 161 MT crude oil in 2008–09, indigenous production was only 34 MT [3]. India imports nearly 80% of crude oil. Similarly coal and LPG are also imported to meet the domestic demand. Major portion of coal produced in India is used for electricity generation (almost 54% of electricity generation is based on coal fired power plants). Other energy options like, large hydro and nuclear power projects are facing serious environmental criticisms and beleaguered with problems. Thus, there is a serious energy supply–demand imbalance in the country. Demand for electricity has also exceeded supply with improving living standard. The electricity supply constrain has forced almost all the sectors-industrial, commercial, institutional or residential to rely on diesel or furnace oil. Lack of adequate rural electricity supply has been leading to large scale use of kerosene. About 78 million people in India mainly depend on kerosene for lighting [4].

Growing energy demand coupled with limited conventional fuel options, geo-politics of oil and environmental concern has compelled India to search for renewable and sustainable energy options. Biomass, solar, wind and small hydro have been identified as the thrust areas of renewable energy development in India. The estimated grid-connected power potential together from biomass, wind and small hydro in the country is more than 87 GW. Similarly, solar potential ranges in between 20 and 30 MW/km^2 [5]. Biomass resources are relatively uniformly available in India compared to other renewable sources. Realizing the potential of bioenergy generation, the Ministry of New and Renewable Energy (MNRE), India has initiated several biomass programs, with encouraging degree of success.

1.2. Existing status of bioenergy uses in India and needs for future planning

1.2.1. Traditional uses of biomass

Although accesses to electricity and LPG have been improved in India compared to the last few decades, consumption of biomass as traditional fuel also increases in parallel and it dominates the fuel mix of rural households. Bhattacharya [6] reported that 64% rural households in India rely on firewood for cooking and another 26% rely on crop residue or animal wastes. Further, in the urban sector almost 30% households rely on traditional energy for cooking. On a comparative study of household energy uses pattern in India and China, Pachauri and Jiang [7] reported that at an aggregate level, solid fuels (traditional biomass and coal) comprise 80% of total residential energy use in both the countries. Large scale use of firewood as cooking fuel is reported in India. Annually about 220 MT of firewood is utilized for cooking in the rural sectors of India [8]. Firewood contributes the major portion of final energy consumption with a variation between 65% and 80% depending on income level of households [9]. Apart from household uses, biomass is also extensively used in various traditional and rural enterprises such as brick making, rice par-boiling, hotel, restaurants, bakeries, potteries and charcoal making [8].

1.2.2. Modern uses of biomass

The modern uses of biomass take the advantages of modern biomass conversion technologies (combustion, pyrolysis, gasification, fermentation, and anaerobic digestion) for production of heat and electricity, liquid and gaseous transportation fuel, biogas for cooking *etc*. There is a huge potential for modern uses of biomass energy in rural India, especially in the cooking and lighting sectors. Balachandra [10] advocated several points in favor of adopting modern biomass energy, especially for rural India *viz*., (i) biomass resources potential in India is high to produce adequate amount of modern energy, (ii) advanced biomass energy technologies for decentralized utilization in rural areas have reached near commercialization, (iii) India has local expertise in developing and deploying biomass gasifier technologies for power generation and bio-methanation technologies for biogas production, (iii) CDM potential is also significant, and (iv) scopes for medium, small and micro scale rural enterprises are large which would help to promote rural income generation and employment.

As per the MNRE (Ministry of New and Renewable Energy, GoI), a total of 288 biomass power and cogeneration projects aggregating to 2665 MW capacity have been installed in the country for feeding power to the grid. The common biomass feedstock for power generation in India includes sugarcane bagasse, rice husk, straw, cotton stalk, coconut shells, soya husk, coffee waste, jute wastes, groundnut shells, saw dust *etc*. A variety of biomasses have been tested for bioenergy generation including woody biomass [11] and loose biomass such as rice husk [12], cashew nut shell [13], areca nut [14], sugarcane residue [15]. Village level decentralized biomass power generation of kilowatt scale has also been commissioned in the country. In a recent study, Dasappa et al. [16] reported deployment of six biomass gasifier based power plant projects with total installed capacity of 0.88 MW in Tumkur district of Karnataka.

1.2.3. Need for crop residue based renewable energy planning

Being an agriculturally dominant nation, the strength of India's bioenergy programs mostly lies in the agricultural sector. Agriculture is regarded as the backbone of India's economy. Although agriculture contributes only 17% to India's GPD, it is the source of subsistence for nearly 60% of its population. About 60% of land area of the country is under various agricultural practices [17]. The arable land in the country is 159 million hectare (Mha), 11.2% of global share. Globally India ranks first in the production of jute and second in rice, wheat, sugarcane, cotton and ground nut. Thus, because of the agricultural strength of the country, crop