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Overview of electric power potential of surplus agricultural biomass from economic, social, environmental and technical perspective—A case study of Punjab



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ABSTRACT

Biomass is a renewable, economic and readily available resource of energy that has potential to substitute fossil fuels in many applications such as heat, electricity and biofuels. The increased use of the agricultural biomass can help the agricultural based societies in achieving energy security and creating employment without causing environmental degradation. But, the viability and feasibility of electricity generation from agricultural biomass depends upon the availability of biomass supply at a competitive cost. The present study investigates the availability of agricultural biomass for distributed power generation in Punjab. The total production of the crop residues has been estimated by residue-to-product ratio (RPR) method. Further, the restrictions introduced by competitive uses as well as harvesting practices are taken into considerations to evaluate the available biomass potential. The biomass power potential has been obtained on considerations of energy contents of the particular crop residues and selecting appropriate conversion route. A total of 55.396 Mt of the agricultural residues are produced from various major crops. Out of these, 22.315 Mt (40.17%) of the agricultural biomass has been found to be surplus with an average density of 443 t/km². These surplus residues can significantly be used to provide continuous, reliable and sustainable fuel supply for power plants. Cereals (rice, wheat, maize and barley) have major contribution (74.67%) in the surplus biomass, followed by cotton (25.01%) and sugarcane (0.2%). The estimated annual bio-energy potential of unused crop residues is 0.35 EJ (8.43% of India's potential), which is equivalent to 1.43% India's annual primary energy consumption. It has been revealed that a power potential of 2000–3000 MW can be exploited from these resources depending upon thermal efficiency. The study concludes with a discussion on significance and challenges of decentralized electricity generation for rural energy supply, including brief description about economical, social, environmental and technical aspects of bioelectricity.

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1. Introduction

1.1. Role of renewable energy in energy portfolio

The electricity demand in the world, particularly in India is expected to increase drastically, due to rapid industrial growth and increasing population. The installed capacity of the power plants (Utilities) has increased to about 186 GW (by December, 2011) from a meagre 1.713 GW in 1950 [1]. Similarly, the electricity generation has increased from about 5.1 billion kWh in 1950–1951 to 789 billion kWh in 2010–2011. The per capita consumption of electricity in the country is also increased from 15 kWh in 1950 to about 814 kWh in 2011. Therefore, the country continues to have mismatch between demand and supply and experienced energy and peak shortages to the tune of 8.5% and 10.3% respectively during the year 2010–2011.

The native energy reserves of India are not adequate to fulfill the growing energy requirements in the country. This would result excessive pressure on fossil fuel resources, which have inherent problems such as diminishing fuel reserves, precarious oil markets and global warming. According to Kumar and Jain [2], the consumption of coal, which is the major fuel used to produce electricity in India (with contribution of 53%), has increased from 71.2 million tons (Mt) to 462.7 million tons (Mt) during the period 1970–1971 to 2006–2007. Moreover, the electricity produced by conventional resources (thermal, gas and hydel) is distributed around the country through a centralized grid without reaching the remote areas. Non-access to electricity and rural poverty are closely correlated.

Electricity is a prerequisite for improving living standard, also an essential input for productive and economic activities [3]. Poor electricity supply not only hampers household activities but also badly affect health facilities, education system and agricultural activities in rural areas [4]. The growth of rural industries including agro based industries is also badly affected due to inadequate supply of assured electricity in rural areas. This in turn results in

unemployment and associated socio-political problems in a region.

To ensure continuous power supplies to these areas, there is urgent need to construct decentralized power plants, based on renewable energy resources available in a region [4–5]. It has been revealed that only 18% of global electricity is currently met by renewable sources and without hydropower it is only 2.5% [6]. Although the renewable energy sources accounts for 33% of India's primary energy consumption, but their share in the total installed capacity (excluding large hydropower projects) was only 12.7% in June 2014 [7].

India is increasingly adopting responsible renewable energy techniques and taking positive steps towards carbon emissions, cleaning the air and ensuring a more sustainable future [8]. The Government of India (GoI) has also made it mandatory for State Electricity Boards (SEBs) with favourable policy incentives to supplement installed capacity through renewable energy resources.

Solar, wind, micro-hydro and biomass are some of the feasible components of renewable energy resources, which can be used to produce heat, electricity and mechanical energy. Each of these options has its own merits and demerits, primarily due to location specific availability of the resources. In an report presented by statistical office (GoI), it was revealed that the wind energy can be used to produce about 50 GW of electric power, while the hydro and biomass resources (including cogeneration bagasse) has power potential of 15 GW and 22 GW, respectively [9]. The source-wise estimated potential of renewable energy sources is presented in Fig. 1. Therefore, these resources can be explored for sustainable development and energy security in various parts of the country.

1.2. Status of bio-energy and future planning

1.2.1. Sustainability and current uses of biomass resources

In the past decade, there has been renewed interest in the biomass as a renewable energy source worldwide, due to many

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