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Review

Bioenergy potential and consumption in Pakistan



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ABSTRACT

The usage of biomass by mankind can be traced back to thousands of years. The biomass utilization in developing countries like Pakistan has always played a major role to fulfill energetic demands of poor inhabitants of the country. Pakistan being an agricultural country has a tremendous potential to utilize agricultural by-products like bagasse, rice husk, cotton stalks etc. The major share of biomass utilization in Pakistan comes from household sector i.e. 76%. The small scale combustion systems used in households for cooking and heating purposes consist of different types of stoves. However, a lot more has to be done in order to harness the full potential of this renewable energy resource and change the technology pattern by overcoming different social, economic, cultural and political barriers. This objective can only be achieved by initiating effective R&D projects throughout the country.

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1. Introduction

About 14% of the worldwide primary energy supply is provided by biomass resources – equivalent to 72 EJ each year, and 38% of total energy supply in developing countries [1]. Since half of the world population lives in rural areas of developing countries, most of biomass is consumed in these regions. It has been estimated that Kenya derives about 68%, India 47%, Pakistan 27%, Brazil 25% and China 13% of their total energy from biomass. Due to rapid industrialization and economic growth in developing countries, the incorporation of fossil fuels in total energy supply has declined the total share of biomass. However, an increasing trend in usage of biomass resources can be observed in these countries, growing at an annual rate of over 2% [2]. The increase in utilization of biomass is mainly attributed to ever growing population rate, poor economic conditions, and unavailability of

modern fuels. Fuelwood has the largest share in total biomass energy consumption in developing countries which has ultimately led to an increase in rates of deforestation in such countries, surpassing the afforestation rate. Consequently, the tropical Asian forest lands have become net emitters of carbon dioxide. With the growing demand of biomass in developing countries, the need of the hour is to integrate existing biomass resources with modern energy crops or plantations and introduce efficient biomass energy conversion technologies.

2. Consumption of biomass in Pakistan

Pakistan is located in south Asian region and covers an area of 796,095 km². It has a population of 170.6 million, which is the 6th largest in the world. According to the Economic survey of

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Pakistan 2010, with a growth rate of 2.05% per year, Pakistan will become the 4th largest nation of the world by 2050. Pakistan is an agricultural country and its economy is primarily based on producing agricultural commodities. Nearly 62% of country's population resides in rural areas and are more or less affiliated with agriculture for their livelihood. Pakistan is among the countries with low forest cover occupying nearly 4.8% of its total area, 5% of which is protected [3].

In Pakistan, the households are strongly dependent on bio-fuels like firewood, dung, crop residues, gobar gas (produced by anaerobic digestion of manure in small scale digestion facilities) for cooking and heating purposes. Nearly 27% of country's energy demands are met through biomass resources like fuelwood, agricultural residues, dung etc. as shown in Table 1. Since 62% of population lives in rural areas, it is highly unlikely to bring an abrupt shift from traditional energy resources to modern energy resources in rural areas of Pakistan due to poor economic conditions and non-affordability of modern fuels.

The major biomass resources utilized for energetic purposes in Pakistan are:

2.1. Fuelwood

The dependence of population in Pakistan on fuelwood is expected to remain high in near future due to country's atrocious economic conditions. It has caused an incredible increase in deforestation rate. Pakistan has the second highest deforestation rate in the world [IUCN 2002]. It has lost on average 420 km² or 1.66% per year. According to United Nations Food and Agriculture Organization (FAO), Pakistan is deprived of 33.2% of its forest cover, or around 8400 km² between 1990 and 2010. Though, Pakistan is committed to increase its forest cover from 4.8% to 5.7% by the year 2011 and 6% by end of 2015 [4].

There are two main sources of fuelwood in Pakistan namely:

1. State forests
2. Farmlands

State forests cover 42.24 km² which is 4.8% of total land area whereas farmland trees and plantations along the canals, roads and railway lines constitute 4820 km². It has been calculated that 10–15% of total fuelwood consumption is supplied by forests whereas remainder is provided through farmlands [5]. In Pakistan, there is an abundance of free fuelwood and roughly about 65% of total fuelwood is collected mostly by woman and

children in rural areas. Generally, they collect fuelwood from sources like public forests, wastelands or private farmlands etc. Woodfuel and other forest based fuel resources include split wood, cones, bark, leaves and needles. They are bound to do this under some traditional rights according to which people can remove already dead or fallen trees with least use of cutting tools. On the other hand, in urban areas only 14% of urban population collects fuelwood to fulfill their needs.

According to a survey conducted by UNDP (United Nations Development Program) in collaboration with World Bank and Energy Wing of the Government of Pakistan, titled "House Hold Energy Strategy Study (HESS)", 91% of rural households were surveyed and it was concluded that average consumption of fuelwood for a single household came out to be 6.7 kg per day [6]. At the same time, for 52% of urban households, the average consumption was found to be 5 kg per day.

Due to poverty rates the fuelwood consumption has risen and contributes to deforestation – in 2010 the consumption of 52 Mt exceeded the sustainable supply potential of 21 Mt [7]. So there is a considerable amount of gap between fuel supply and demand.

2.2. Dung

Another biomass which has a substantial share in Pakistan's biomass consumption is cattle dung. It has been estimated that Pakistan has approximately 40 million animals including cattle, camels, horses and mules, having an annual growth rate of about 8%. A medium sized animal, on an average, has a daily dung production of 3 kg. It will result in daily dung production of 0.12 Mt. It has also been investigated that about 25% of total dung production is wasted during collection and 50% of remaining dung is used as fuel [4].

2.3. Agricultural residues

Due to highest production rates of agricultural commodities in Pakistan like wheat, cotton lint, rice paddy, sugarcane and cotton seeds, there exists an enormous potential of agricultural residues which can be generated and later on used as a source of energy. The term agricultural residue is used for organic materials generated as a by-product during harvesting or processing of agricultural crops. These residues can be divided into two categories: primary residues and secondary residues. The agriculture residues generated in the field at the time of harvest are defined as primary residues (e.g. rice straw, sugarcane tops) whereas residues co-produced during processing are called secondary residues (e.g. bagasse). The main crops of Pakistan are cotton lint (4th largest producer in the World), sugarcane (5th largest producer in the World) and rice paddy (11th largest producer in the World). So there exists a paramount importance in usage of these crop residues for energy production.

2.3.1. Cotton stalks

Cotton stalks are obtained as a by-product after removing cotton from the crop trees. The cotton stalks are manually harvested and then left in the field for drying until the next crop plantation. It has been estimated that about one fourth of cotton sticks is burnt every year due to their excessive supply as compared to fuel requirements.

Table 1 – Fuelwood production in Pakistan [7].

Fuelwood	Production [Mt]	Share %	Energy [PJ]
Natural forests	0.816	3.86	11.8
Natural forests (wood wastes)	2.578	12.17	38.31
Plantations	0.645	3.05	9.838
Other wooded lands	0.640	3.05	9.838
Agriculture areas	16.465	77.87	242.75
Total	21.144	100	312.536

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