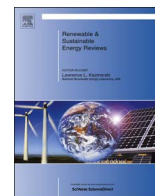




ELSEVIER

Contents lists available at ScienceDirect

## Renewable and Sustainable Energy Reviews

journal homepage: [www.elsevier.com/locate/rser](http://www.elsevier.com/locate/rser)

## Systematic assessment of the availability and utilization potential of biomass in Bangladesh

Md. Mosaddek Hossen<sup>a,1</sup>, A.H.M. Sazedur Rahman<sup>a,1</sup>, Afsana Sara Kabir<sup>a</sup>,  
M.M. Faruque Hasan<sup>b</sup>, Shoeb Ahmed<sup>a,\*</sup><sup>a</sup> Department of Chemical Engineering, Bangladesh University of Engineering & Technology, Dhaka 1000, Bangladesh<sup>b</sup> Artie McFerrin Department of Chemical Engineering, Texas A&M University, College Station, TX 77843, USA

## ARTICLE INFO

## Article history:

Received 13 July 2015

Received in revised form

16 April 2016

Accepted 6 September 2016

## Keywords:

Biomass  
Renewable energy  
Proximate analysis  
Waste residue  
Municipal solid waste

## ABSTRACT

Following the global trend of industrial growth, Bangladesh aims towards significant industrial expansion, which is associated with increased energy consumption. Current energy generation in Bangladesh is highly dependent on fossil fuels. However, increasing energy demands, stringent regulations on fossil fuel-based emissions, and concerns related to national energy-security make it imperative to search for alternative energy sources. Biomass-based renewable sources, such as wood, agricultural residues, municipal solid wastes are attractive alternatives to petroleum-based feedstocks for energy and chemicals. Although biomass shows great potential, limited systematic studies exist on biomass as a feedstock in Bangladesh. In this work, we present an overall assessment of the availability and utilization potentials of different biomass resources. A novel feature is the quantitative assessment of major biomass resources, which are unconventional and were previously ignored. It is estimated that the total available biomass from agriculture, waste, industries, animals and other sources could generate more than 3447 petajoules (> 950 TWh) of energy, which is three times of the current fossil fuel based-energy consumption in Bangladesh. This means that even if only one-third of the overall biomass is utilized for energy generation, it would meet the total energy demand in Bangladesh without utilizing fossil fuels and other sources. A systematic pathway from utilizable biomass to useful chemicals is also presented towards industrial utilization of biomass. This study presents a realistic assessment of available biomass as a prominent source of useful energy and chemicals, and insinuates the potential to be the sustainable source of primary energy that can eventually replace the fossil fuels in the long term.

© 2016 Elsevier Ltd. All rights reserved.

## Contents

1. Introduction . . . . .	95
2. Assessment of available biomass in Bangladesh . . . . .	96
2.1. Forest biomass . . . . .	96
2.2. Crops . . . . .	97
2.3. Municipal solid wastes (MSW) . . . . .	97
2.4. Vegetables . . . . .	97
2.5. Animal Wastes . . . . .	98
2.6. Fish wastes . . . . .	98
2.7. Fruits . . . . .	98
3. Quality analysis of available biomass . . . . .	98
3.1. Proximate analysis . . . . .	98
3.2. Energy contents (heating values) . . . . .	99
4. Energy potentials of available biomass . . . . .	100
4.1. Theoretical potential of available biomass . . . . .	100

\* Corresponding author.

E-mail address: [shoebahmed@che.buet.ac.bd](mailto:shoebahmed@che.buet.ac.bd) (S. Ahmed).<sup>1</sup> Both authors contributed equally.

4.2. Biomass conversion pathways.....	100
5. Chemical conversion potentials of biomass.....	101
6. Challenges in biomass utilization.....	103
6.1. Uncertainty of feedstock availability.....	103
6.2. Variability in biomass types and compositions.....	103
6.3. Deforestation and food security.....	103
7. Conclusion.....	103
Acknowledgement.....	103
Appendix A. Supplementary material.....	103
References.....	103

## 1. Introduction

To satisfy the increasing demand of primary energy in both the developed and developing countries, the need for renewable energy sources is rapidly rising. In 2010, 520 Quadrillion Btu of energy was used worldwide [1]. It is predicted that the annual average global energy demand growth would range from 1.5% to 2.5% for the period between 2000 and 2030 [2]. Sustained population growth will remain a key driver of increasing energy demand, along with economic and social development. Although conventional fossil fuels (e.g., coal, oil and natural gas) are the prime sources of energy worldwide, they do not offer sustainability for longer period, especially for countries which do not have abundant fossil fuel reserves. Fossil fuel reserves are concentrated in a small number of countries. About 80% of the coal reserves are located in only six countries [3]. Moreover, fossils fuels are not the cleanest sources of energy. Carbon dioxide emission from the burning and consumption of fossil fuels adversely affects the global climate. A rise of atmospheric temperature by 2–6 °C is estimated due to global warming and man-made climate change by the next century [4].

Being a developing and densely populated country, the situation in Bangladesh is no different. A population totaling more than 160 million has an enormous energy demand. According to the World Bank, the consumption of electricity in Bangladesh exceeded 39.5 billion kWh in 2011. Furthermore, only 62% of the population had access to electricity with a per capita availability of 321 kWh per annum, which is very low in comparison to the other countries of the world [5]. In 2012–13, almost 97.6% power generation in Bangladesh was fossil fuel-dependent [6]. To fully satisfy its energy demand, Bangladesh imports fossil fuels and electricity from other countries. In 2014, Bangladesh imported 5450 thousand tons of crude oil and petroleum products costing approximately 5 billion US dollars [6,7].

Power generation in Bangladesh is mostly dependent on natural gas with fast-depleting and limited national reserves. As of September 2015, Bangladesh has a total installed power generation capacity of 11,877 MW. In reality, these power plants have been generating on an average of 156 GWh/day of electricity (55% of installed capacity), with the maximum daily generation of 174.5 GWh (69% of installed capacity) in August 2015 [8,9]. During 2012–2013, more than 25 GWh of daily load-shedding was reported, which has been reduced significantly over the time [10,11]. However, this has been achieved through fossil fuel-based power generation and power import from other country [8].

Renewable energy, such as biomass, is becoming increasingly popular worldwide. Facing with the challenges due to increasing energy demands, depleting reserves and uncertain price of fossil fuels, stringent environmental regulations on CO<sub>2</sub> emissions, and need to diversify energy portfolio for national security, biomass can be a promising and sustainable source of alternative energy. A major goal of this current study is to quantitatively assess the potential of biomass as an energy source in Bangladesh.

Biomass is a combination of varying organic compounds, which is abundant in nature, yet barely being used up to its potential. Currently, biomass accounts for 7–10% of primary global energy consumption [12–14], whereas, nuclear and hydroelectric power individually contribute ~7% [15], and renewable sources (wind and solar) sum to <1% of the global energy demand [16,17]. Liquid transportation fuels, such as ethanol and biodiesel, are the most popular biomass-based energy alternatives, albeit these currently comprise only 2% of world biomass energy and have potential to contribute substantially [18,19]. Bangladesh produces large amount of conventional and unconventional biomass in different forms that need to be identified and considered for better utilization. Considering the fact that biomass sources are relatively abundant and offer feedstock versatility, these resources have become an attractive alternative to petroleum-based products. Moreover, utilization of biomass also seems promising because of biodegradability and lower greenhouse gas emission ensuring reduced environmental pollution, which is a major concern in fossil-fuel technology. Biomass can range from agricultural byproducts to solid and liquid waste from industrial and municipal sources [20]. Biomass is not only important as a source of energy but also as a source of different valuable fuels [21] and chemicals [22]. Biomass consists of different celluloses, hemicelluloses and some other carbohydrates [23]. These biomasses in turn might be used as a raw material of chemicals including different alcohols, organic acids which have a huge market demand.

The total amount to biomass fuel consumed in Bangladesh in the year 2000 was approximately 45 million tons [24]. While this amounts only a fraction of the total energy available through biomass, biomass is in fact the principal source of energy supply in rural areas contributing more than 90% to the primary total energy supply [25]. Small Biogas plants are being introduced generate energy utilizing biomass [26]. Biomass also has a potential to contribute in the industrial and manufacturing sectors in a developing country like Bangladesh. Efficient utilization of available biomass can be useful to reduce the net import of fuels, chemicals, and industrial goods and raw materials.

Despite of its potentials as fuel and raw material, there has not been any organized study performed on feedstock types, quantities and characterization of the available biomass in Bangladesh. Few studies have been reported on biomass, which focus only on electricity production without considering other applications or the individual contributions of variety of biomass resources [27,28]. Even fewer studies considered the distinct characteristics of different feedstock biomass [29–31].

The assessment of the biomass availability and quality is an important first step toward utilizing biomass for energy generation and conversion to value-added chemicals. Countrywide assessment of biomass resources has been performed for many countries [32–36]. In this paper, we present an organized assessment of different biomass resources in Bangladesh evaluating their gross available quantity, waste fraction, basic properties and proximate

Download English Version:

<https://daneshyari.com/en/article/5482720>

Download Persian Version:

<https://daneshyari.com/article/5482720>

[Daneshyari.com](https://daneshyari.com)