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Forest, forestry and energy in Mongolia toward cleaner production†

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Abstract: This review focuses on the current situation of energy resources and usage in Mongolia to reduce the air pollution problems caused by heavy and inefficient utilization of coal by shifting to cleaner energy sources such as woody biomass. As Mongolia's forest is over-aged, and the deadwood accumulation accounts for 46.5 m3 per hectare, there is a potential for using unused forest resources as alternative energy source. Thus, small to medium scale biomass powered power plants can be introduced based on the availability of the resources. Therefore, further studies on the availability are essential for successful utilization of unused forest biomass.

Keywords: Cleaner energy; woody biomass; deadwood

1. Introduction

In recent years, the world is moving towards environmentally friendly renewable energy sources to mitigate global warming. Global efforts have been taken to combat global warming and reduce CO2 emissions. Developed nations already have strict regulations and necessary technologies to manage their local and even global environmental issues. However, it is challenging for developing nations such as Mongolia due to lack of technology and economic development [1]. Mongolia has one of the highest CO2 emissions per capita in the world. Regardless of having 20.31 tones of per capita CO2 emissions, Mongolia's annual share of global CO2 emissions was only 0.18 % in 2019 [2]. This phenomenon can be explained as a result of Mongolia's tiny population that needs very high heating for around nine months per year [3].

As a result of cold winters with high demand for heating and excessive use of coal, Mongolia faces severe air pollution problems. The nation ranks 4th in countries with the worst air quality after Bangladesh, Pakistan, and India [4]. Coal- burning stoves used in ger areas of Ulaanbaatar, account for 80 % of air pollutants because of the low thermal insulation of Gers-circular mobile tents [5].

This review focuses on the current situation of energy resources in Mongolia and possible ways to combat the air pollution problems caused by excessive coal usage by generating sustainable and cleaner energy, namely woody biomass, using unused forest resources of Mongolia in a more efficient way.

2. Current situation on energy and air pollution by coal- and firewood-burning in Mongolia

According to the Energy Regulatory Commission [6], 91 % of the total electricity was generated with Combined heat and power (CHP) plants, which are coal

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powered, followed by 9 % with renewable energy sources of wind, solar and hydro stations, and a tiny fraction from diesel generation stations.

The country's total coal reserves are estimated to be around 173 billion tons [6]. The coal resource abundance of Mongolia makes the country's energy supply 70 % dependent on coal. The remaining 26 % and 4 % of the energy supply depend on oil and other sources in 2017, respectively, according to the International Energy Agency [7]. In the same year of 2017, 89 % of the total electricity generated comes from coal, which shows that country's coal use is almost two-fold above that of the world average. The country domestically produces 80 % (8,719.1 million kWh) of the electricity required, and the rest of 20 % (1,715.8 million kWh) is imported from Russia and China mainly during the peak hours of use. 90.5 % of total electricity production is solely consumed in Ulaanbaatar.

The rapid urbanization of the recent years and mining sector's development of Mongolia has continuously increased the country's demand of the total electricity by 6-9 % per year in the last few years [8]. As a result of rapid urbanization, number of people living in ger areas increased substantially during the last years, resulting in increased coal and firewood burning for heat generation. The annual demand for firewood stood at 4.5 million m3 and approximately 80 % of total harvested wood was for firewood [9].

Due to dependency on coal as a main source of energy and use of inefficient small stoves fueled with coal and firewood, air pollution is becoming a crucial issue in Mongolia. It has been established that particulate matter (PM) constitutes the dominant air pollution problem with coal and firewood burning in ger areas being one of the biggest contributing factors. The PM 2.5 levels in Ulaanbaatar is considered as one of the highest in the world, with annual average concentration of 46.6 μg/m3 [4] whereas the WHO states that the annual average concentration below

10 μg/m3 minimizes potential health risks. Even though the annual average exposure is 46.6 μg/m3, there are high seasonal and locational variations. During the winter, PM levels surge as high as nearly 200 μg/m3. Moreover, the concentration is much higher in ger areas as compared to central areas. The high PM concentration poses a very significant health risk to people, especially children living in the highly polluted areas.

In light of the life-threatening circumstances in Mongolia caused by coal and firewood burning, it is crucial for the country to take measures to shift towards cleaner energy production. The government of Mongolia has set a target of increasing the renewable energy portion in the total energy production from 9 % to 20 % and 30 % by 2023 and 2030, respectively, in accordance with its State Policy on Energy approved in 2015 [10].

Mongolia is plentiful in renewable energy resources, while only a small fraction is currently being used. The country is lagging in exploiting its enormous 2,500 GW of renewable energy resource [11]. The first large-scale wind and solar farms were built in 2013 and 2017 with 52 MW and 10 MW capacity, respectively. There are three major renewable energy sources in Mongolia, according to the Energy Regulation Commission [12], namely wind, hydro, and solar power, which don't include woody biomass.

However, when the woody biomass is used in small to medium boilers and household stoves, which account for 20 % and 10 %, respectively, of total energy generated, it has the potential to replace coal as a heating source [13]. According to Altrell [14], the Mongolian forest has dead wood equivalent to around 40 % of the total growing stock volume, most of it due to the natural self-thinning accumulation process. Usage of these dead wood and unused wood materials is not only beneficial for cleaner energy production but also for reducing the risks of potential pest infection and wildfire recurrent with aged forests.

3. Current situations on forest, forestry, and forest products, mainly firewood in Mongolia

The forest of Mongolia is poorly stocked compared to its potential by over 50 % and, only 4 % of the total forest area is designated for green-wood utilization. Moreover, Mongolian forest has abundancy of deadwood, which accounts for 46.5 m3 per hectare making

it over 40 % of the growing stock [14]. The country's forest is relatively over-aged. According to the stocked forests' age distribution, approximately 30 percent of the commercially viable growing stock volume in production forest is economically deemed as old [15].

With its over-matured and under-utilized forest conditions, Mongolian forest is facing serious problems of deforestation and forest degradation, including forest fire (mainly human induced), forest pests, and over grazing [16]. As a result, it is necessary to utilize the forest more efficiently to prevent the risks mentioned above while mitigating climate change at a certain level using more cleaner energy than coal generated from unused forest materials.

Following the collapse of communist regime in 1990s, Mongolian forestry sector experienced a sharp decline. The sector's share in Gross Net Production (GNP) decreased from 4.1 % in 1990 to 0.26 % in 2010. Between 1940 and 2002, 45 million m3 wood was harvested from 320,000 hectares of Mongolian forest [17]. In order to prevent forest degradation and depletion, and to increase greenhouse gas absorption, Mongolia has been implementing a policy of meeting the demand for wet wood for production with imported wood and wood for household use from forest thinning activities [15].

Although Mongolian government set the annual harvesting quota around 0.8- 1.8 million m3 in the past decade, the average harvested wood amount accounts for 724.2 thousand m3. The average annual harvested wood divides into two main categories, which are timber and firewood. Each of the product accounts for 22.5 % and 77.5 % of the annual harvested wood, respectively [15].

In contrast, Glauner and Dugarjav [16] stated that even though the annual quota is approved for industrial and firewood, the local construction wood and firewood are consumed unreported at the portion of 20 % and 80 %, respectively. Moreover, the demand of firewood is estimated to be approximately 4.5 million m3 and the very big portion of firewood is burnt in previously mentioned less efficient household stove. Lastly, to cope with the problem of low efficiency and high emission stoves run on coal and firewood, a small to medium scale district heating biomass powered energy plants must be introduced, possibly be operated in appropriate areas to step-up the local heat generation efficiency.

4. Projects harvesting and using woody biomass as new materials and energy toward the cleaner production

Mongolia signed the United Nations Framework Convention on Climate Change (UNFCCC) at the United Nations Conference on Environment and Development (UNCED), held in Rio de Janeiro in June 1992. In order to comply with the obligations and commitments under the UNFCCC, Mongolia has been undertaking certain measures and actions at national level to combat climate change. In May 2019, ban on raw coal usage in ger areas of Ulaanbaatar was issued by the Mongolian Government.

Furthermore, feasibility of utilizing woody biomass for heating plants as coal replacement was researched as part of a project initiated by Asian Development Bank (ADB). In relation to sustainable livelihood and increased resilience of forest ecosystems of Mongolia, Sustainable Forest Management to Improve Livelihood of Local Communities Project was implemented by NIRAS and MonConsult LLC between 2015 and 2018. The aim of the project was to support the government's forest policies, particularly strengthen government initiatives to develop Forest User Groups (FUGs) and private enterprises' engagement in forest management. 5 aimags or provinces, namely Bulgan, Selenge, Khuvsgul, Khentii and Zavkhan were selected to implement the project [13].

As part of the project, a GIS based model was developed to assess the potential of available deadwood in the project areas as coal replacement by providing biomass energy for the heating plant in one of the project areas.

Based on the study, the result showed a possibility of coal replacement with woody biomass in district heating plants if coal prices are above 70,000 MNT/ton and the supply radius for wood is not exceeding 30 km [13]. The woody biomass powered boilers were

used to heat key buildings in rural areas such as kindergarten, three-story building and local administrative offices. This practice shows the further potential for use of woody biomass as alternative to replace coal for heat generation in the remaining unstudied areas. In order to effectively utilize the available woody biomass resources, it is of utmost importance to carry out a feasibility study, plan and develop projects, accordingly.

5. Recommendations on estimating economical availability of wood materials with practical uses in Mongolia

The starting point for a cohesive forest management strategy has to be the quantification of available resources. The forest biomass is one of the most critical parameters for global carbon stock modeling. However, the estimation can be made with great uncertainty [18]. According to Renchin et al. [19], the forest biomass cannot be measured directly from space for the time being, but the remotely sensed greenness can be applied to measure biomass on decadal and long- term scales in regions of a distinct seasonality, as in the north. Altanchimeg et al. [20], developed an approach using ground truth measurements in which the species' specific coefficients of various trees can be used to further estimate the forest biomass resources.

Moreover, adoption of international best practices regarding utilization of woody biomass is recommended as strategy to use the potential resources in the best possible way. Battuvshin et al. [21] estimated harvesting costs determining appropriate harvesting systems according to selected prefectures' topographical features in Japan. The methodologies used in this study can be beneficial for quantification of available woody biomass resources as well as for better estimation of costs associated with

woody biomass generation. Based on the available resources, feasible locations for biomass power generation plants can be determined.

Lastly, the government shall provide a supportive legal and social framework for efficient utilization of the forest resources. The current challenge for Mongolian forestry sector is to move from forest resource management with high emphasis on protection and conservation of existing forest, to more sustainable forest management with proper utilization. Proper utilization and management of forests would play an important role in improving the living standards of people living in less-developed parts of the country by creating more employment opportunities [17]. With proper forest management, there is a potential for using woody biomass as source of heat generation at small to medium scale heating plants. More sustainable forest management plan is crucial for mitigating climate change and as well can be a source of cleaner energy source than coal. As a result, projects and initiatives towards strengthening the forest enterprises should be implemented to provide soft loans for the purchase of modern high-capacity machinery and equipment, and to educate and train forest workers [15].

6. Conclusion

Mongolia's excessive burning of coal and firewood in small stoves with low combustion efficiency, led to an air quality crisis in Mongolia, especially in Ulaanbaatar. Coal-burning stoves used in ger areas of Ulaanbaatar, account for 80 % of air pollutants. Mongolian forest is rich in dead wood of 46.5 m3 per hectare which accounts for 40 % of the growing stock. Approximately 77 % of the harvested wood is used as firewood each year. With proper forest management, there is a potential for using woody biomass as source of heat generation at small to medium scale heating plants instead of coal. In order to use unused forest resources for cleaner and more sustainable energy production, it is recommended to quantify the available resources.

The Government of Mongolia's current approach is to promote the import of wood and raw material by exempting import taxes to conserve local resources. However, this approach does not benefit Mongolia's own resources and misses opportunities to develop income streams from sustainable forest management, which is advantageous for health of

the forest, maintaining ecosystem services, and providing enterprise opportunities and employment.

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