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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 in order to reduce the air pollution problems that are caused by the heavy and inefficient utilization of coal, which for instance causes 80% of the air pollution in the capital of Mongolia, which could be reduced by shifting to cleaner energy sources, such as woody biomass. The forest of Mongolia is over-aged, poorly stocked at around 50% below its potential, the deadwood accumulation accounts for 46.5 m^3 per hectare, and approximately 77% of the total harvested wood is firewood. Therefore, there is a potential to use the unused forest resources as an alternative energy source. As a result, small- to medium-scale biomass-powered power plants can be introduced based on the availability of the resources. Therefore, further studies on the availability of resources are essential for the successful utilization of the unused forest biomass.

Keywords: cleaner energy; woody biomass; deadwood

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1. Introduction

In recent years, the world has been moving towards environmentally friendly renewable energy sources in order to mitigate global warming. Global efforts have been taken to combat global warming and reduce CO_2 emissions [1]. Developed nations already have strict regulations and the necessary technologies to manage their local and even global environmental issues. However, it is challenging for developing nations, such as Mongolia, due to a lack of technology and economic development [2]. Mongolia has one of the highest CO_2 emissions per capita in the world. Regardless of having 20.31 tons of CO_2 emissions per capita, Mongolia's annual share of global CO_2 emissions was only 0.18% in 2019 [3]. This phenomenon can be explained as a result of Mongolia's tiny population, which has very high heating demands for around nine months per year [4].

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 [5]. The coal-burning stoves that are used in ger areas of Ulaanbaatar account for 80% of air pollutants because of the low thermal insulation of Gers-circular mobile tents [6].

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

2. Current Situation on Energy and Air Pollution by Coal- and Firewood-Burning in Mongolia

According to the Energy Regulatory Commission [7], 91% of the total electricity was generated with combined heat and power (CHP) plants, which are coal-powered, followed by 9% with the 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 [7]. 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 depended on oil and other sources in 2017, respectively, according to the International Energy Agency [8]. In the same year of 2017, 89% of the total electricity generated came from coal, which shows that country's coal usage was almost two-fold above that of the world average. The country domestically produces 80% (8719.1 million kWh) of the electricity required, and the remaining 20% (1715.8 million kWh) is imported from Russia and China, mainly during the peak hours of use. A total of 90.5% of the total electricity production is solely consumed in Ulaanbaatar.

The rapid urbanization in recent years and the mining sector's development in Mongolia have continuously increased the country's demand for electricity by 6–9% per year in the last few years [9]. As a result of rapid urbanization, the 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 m^3 and approximately 80% of total harvested wood was for firewood [10].

Due to the dependency on coal as the main source of energy and the 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 are considered to be one of the highest in the world, with an annual average concentration of 46.6 $\mu g/m^3$ [4], whereas the WHO states that an annual average concentration below 10 $\mu g/m^3$ minimizes the potential health risks. Even though the annual average exposure is 46.6 $\mu g/m^3$, there are high seasonal and locational variations. During the winter, the PM levels surge as high as nearly 200 $\mu g/m^3$. Moreover, the concentration is much higher in ger areas 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 that are 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, under its State Policy on Energy that was approved in 2015 [11].

Mongolia is plentiful in renewable energy resources, while only a small fraction is currently being used. The country is lagging in exploiting its enormous 2500 GW of renewable energy resources [12]. 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 [13], namely wind, hydro, and solar power, which do not 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 the total energy generated, it has the potential to replace coal as a heating source [14]. According to Altrell [15], the Mongolian forest has the deadwood equivalent of around 40% of the total growing stock volume, most of which is due to the natural self-thinning accumulation process. The usage of these deadwood and unused wood materials is not only beneficial for cleaner energy production, but also for reducing the risks of potential pest infection and wildfire, which is 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, the Mongolian forest has an abundance of deadwood, which accounts for 46.5 m^3 per hectare, making it over 40% of the growing stock [15]. The country's forest is relatively over-aged. According to the stocked forests' age distribution, approximately 30% of the commercially viable growing stock volume in production forests is economically deemed as old [16].

With its over-matured and under-utilized forest conditions, the Mongolian forest is facing serious problems of deforestation and forest degradation, including forest fire (mainly human-induced), forest pests, and over-grazing [17]. As a result, it is necessary to utilize the forest more efficiently in order to prevent the risks mentioned above, while also mitigating climate change at a certain level, by using a cleaner energy source than coal from unused forest materials.

Following the collapse of the communist regime in the 1990's, the 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 m^3 of wood was harvested from 320,000 hectares of Mongolian forest [18]. 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 [16].

Although the Mongolian government has set the annual harvesting quota at around 0.8–1.8 million m^3 in the past decade, the average harvested wood amount accounts for 724.2 thousand m^3. The average annual harvested wood divides into two main categories, which are timber and firewood. Each of these products account for 22.5% and 77.5% of the annual harvested wood, respectively [16].

In contrast, Glauner and Dugarjav [17] stated that even though the annual quota is approved for industrial purposes and firewood, the local construction wood and firewood are consumed unreported at a portion of 20% and 80%, respectively. Moreover, the demand for firewood is estimated to be approximately 4.5 million m^3, and a large portion of firewood is burnt in the previously mentioned less efficient household stove. Lastly, in order to cope with the problem of the low-efficiency and high-emission stoves that are run on coal and firewood, small- to medium-scale district heating biomass-powered energy plants must be introduced, and possibly be operated in appropriate areas in order 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 the national level to combat climate change. In May 2019, a ban on raw coal usage in ger areas of Ulaanbaatar was issued by the Mongolian Government.

Furthermore, the feasibility of utilizing woody biomass for heating plants as coal replacement was researched as part of a project initiated by the Asian Development Bank (ADB). For sustainable livelihood and increased resilience of forest ecosystems of Mongolia, the Sustainable Forest Management to Improve Livelihood of Local Communities Project was implemented by NIRAS and MonConsult LLC between 2015 and 2018. The project aimed to support the government's forest policies; particularly to strengthen the government initiatives to develop Forest User Groups (FUGs) and private enterprises' engagement in forest management. A total of five aimags or provinces, namely Bulgan, Selenge, Khuvsgul, Khentii, and Zavkhan, were selected to implement the project [14].

As part of the project, a GIS-based model was developed in order 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 the district heating plants if coal prices are above 70,000 MNT/ton and the supply radius for wood does not exceed 30 km [14]. The woody biomass-powered boilers were used to heat key buildings in rural areas, such as kindergartens, three-story buildings, and local administrative offices. This practice shows the further potential for the use of woody biomass as an 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. Forest biomass is one of the most critical parameters for global carbon stock modeling. However, the estimation can be made with great uncertainty [19]. According to Renchin et al. [20], 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 distinct seasonality, as in the north. Altanchimeg et al. [21], 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, the adoption of international best practices regarding the utilization of woody biomass is recommended as a strategy to use the potential resources in the best possible way. Battuvshin et al. [22] estimated the harvesting costs by determining the appropriate harvesting systems according to selected prefectures' topographical features in Japan. The methodologies that were used in this study can be beneficial for the quantification of available woody biomass resources, as well as for the better estimation of the costs associated with woody biomass generation. Based on the available resources, feasible locations for biomass power generation plants can be determined.

Lastly, the government should provide a supportive legal and social framework for the efficient utilization of forest resources. The current challenge for the Mongolian forestry sector is to move from forest resource management with a high emphasis on the protection and conservation of existing forests, to more sustainable forest management with proper utilization. The proper utilization and management of forests would play an important role in improving the living standards of people who live in less-developed parts of the country by creating more employment opportunities [18]. With proper forest management, there is a potential for the use of woody biomass as a source of heat generation at small- to medium-scale heating plants. A more sustainable forest management plan is crucial for mitigating climate change and can also be a source of a cleaner energy, compared to coal. As a result, projects and initiatives towards strengthening the forest enterprises should be implemented in order to provide soft loans for the purchase of modern high-capacity machinery and equipment and to educate and train forest workers [16].

6. Conclusions

Mongolia's excessive burning of coal and firewood in small stoves with low combustion efficiency has led to an air quality crisis in Mongolia, especially in Ulaanbaatar. The coal-burning stoves used in ger areas of Ulaanbaatar account for 80% of air pollutants. The Mongolian forest is rich in deadwood (46.5 m^3 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 a source of heat generation at small- to medium scale heating plants instead of coal. In order to

use the 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 in order to conserve local resources. However, this approach does not benefit Mongolia's resources and misses opportunities to develop income streams from sustainable forest management, which is advantageous for the health of the forest, maintaining ecosystem services, and providing enterprise opportunities and employment.

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References

1. Conference of the Parties, Adoption of the Paris Agreement. 12 December 2015. Available online: https://unfccc.int/resource/docs/2015/cop21/eng/l09r01.pdf (accessed on 13 May 2022).
2. United Nations. Progress towards the Sustainable Development Goals. 2019. Available online: https://sustainabledevelopment.un.org/content/documents/24978Report_of_the_SG_on_SDG_Progress_2019.pdf (accessed on 13 May 2022).
3. Ritchie, H.; Roser, M. Carbon Dioxide Emissions. Available online: https://ourworldindata.org/co2-emissions (accessed on 4 July 2021).
4. Ministry of Nature and Environment of Mongolia. Initial National Communication to the UNFCCC. 2001. Available online: https://unfccc.int/resource/docs/natc/mongnc1.pdf (accessed on 13 May 2022).
5. IQAir. World Air Quality Report. 2020. Available online: https://www.iqair.com/world-air-quality-report (accessed on 13 May 2022).
6. Wold Health Organization. Air Pollution in Mongolia. Available online: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6357570/ (accessed on 4 July 2021).
7. Ministry of Energy of Mongolia. Energy Sector of Mongolia. 2018. Available online: https://eneken.ieej.or.jp/data/8016.pdf (accessed on 13 May 2022).
8. Hans, F.; Nascimento, L.; Schiefer, T.; Gonzales-Zuñiga, S.; Shrestha, H.B.; Röser, F. The Mongolian Electricity Sector in the Context of International Climate Mitigation Efforts. 2020. Available online: https://newclimate.org/wp-content/uploads/2020/03/Decarbonization_Pathways_Mongolia.pdf (accessed on 13 May 2022).
9. Chogdon, O.; Nyamosor, T.; Dashdorj, Z.; Tsegmid, S.; Chinzorigt, B. Energy Sector Current Status, Recent Developments and Energy Policies in Mongolia. 2020. Available online: https://nautilus.org/wp-content/uploads/2020/09/Mongolia-Working-Group-Full-Report-SR-PDF-Sep8-2020.pdf (accessed on 13 May 2022).
10. UN-REDD. Mongolia's Forest Reference Level Submission to the UNFCCC. 2018. Available online: http://reddplus.mn/eng/wp-content/uploads/2018/08/2018-Mongolia-FRL-modified-2.pdf (accessed on 13 May 2022).
11. The Parliament of Mongolia. The State Policy on Energy. 2015. Available online: https://www.legalinfo.mn/annex/details/6812?lawid=11130 (accessed on 13 May 2022). (In Mongolian).
12. IRENA. Renewables Readiness Assessment: Mongolia. 2016. Available online: https://www.irena.org/publications/2016/Mar/Renewables-Readiness-Assessment-Mongolia (accessed on 13 May 2022).
13. Energy Regulatory Commission of Mongolia. Mongolian Energy Sector Statistics. 2019. Available online: http://admin.erc.gov.mn/uploads/files/statistic/statistic-uzuulelt-2019.pdf (accessed on 13 May 2022).
14. NIRAS. Sustainable Forest Management to Improve the Livelihood of Local Communities. *Land* **2018**, *7*, 119.
15. Altrell, D. Multipurpose national forest inventory in mongolia, 2014–2017—A tool to support sustainable forest management. *Geogr. Environ. Sustain.* **2019**, *12*, 167–183. [CrossRef]
16. Ministry of Environment and Tourism of Mongolia. *Report on The State of the Environment of Mongolia 2017–2018*; Ministry of Environment and Tourism of Mongolia: Ulaanbaatar, Mongolia, 2019; pp. 78–88. (In Mongolian)
17. Glauner, R.; Dugarjav, D. Assessment of Wood Product Value Chains and Recommendations for the Mongolian Wood-Processing Industry. 2018. Available online: http://reddplus.mn/eng/wp-content/uploads/2018/09/UNDP-Wood-Product-Value-Chains.pdf (accessed on 13 May 2022).

18. Ykhanbai, H. Mongolia Forestry Outlook Study. 2010. Available online: http://www.fao.org/3/am616e/am616e.pdf (accessed on 13 May 2022).
19. Mette, T.; Papathanassiou, K.P.; Hajnsek, I.; Zimmermann, R. Forest Biomass Estimation using Polarimetric SAR Interferometry. *Eur. Sp. Agency* **2003**, *529*, 141–146. [CrossRef]
20. Tsolmon, R.; Tateishi, R.; Tetuko, J.S.S. A method to estimate forest biomass and its application to monitor Mongolian Taiga using JERS-1 SAR data. *Int. J. Remote Sens.* **2002**, *23*, 4971–4978. [CrossRef]
21. Altanchimeg, T.; Renchin, T.; De Maeyer, P.; Natsagdorj, E.; Tseveen, B.; Norov, B. Estimation Methodology for Forest Biomass in Mongolia Using Remote Sensing. *ISPRS Int. Arch. Photogramm. Remote Sens. Spat. Inf. Sci.* **2019**, *XLII-5/W3*, 7–12. [CrossRef]
22. Battuvshin, B.; Matsuoka, Y.; Shirasawa, H.; Toyama, K.; Hayashi, U.; Aruga, K. Supply potential and annual availability of timber and forest biomass resources for energy considering inter-prefectural trade in Japan. *Land Use Policy* **2020**, *97*, 104780. [CrossRef]