

SUSTAINABLE ENERGY SOLUTIONS WITH FOREST BIOMASS IN TURKEY

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Abstract

¹⁰ Renewable energy sources are essential in addressing climate change, achieving energy independence, and meeting sustainable development goals Turkey has a significant potential for forest biomass thanks to its rich natural resources and large forest areas. Forest biomass is a renewable energy source obtained by using organic materials such as trees and plants in energy production. According to 2024 data, Turkey's forested areas cover about %29 of the total land surface and 6 million tons of oil equivalent energy is produced annually from forest biomass. Utilization of this energy source has the potential ² to meet the energy needs of local communities, while supporting environmental sustainability and reducing carbon emissions.

However, sustainable forest management practices are necessary, as there can be negative impacts such as overcutting. Sustainable forest management includes a range of strategies and practices for the conservation and efficient use of forest resources. In this context, forestry policies in Turkey aim to maintain the integrity of forest ecosystems to ensure environmental sustainability. Projects carried out ⁸ by the General Directorate of Forestry focus on protecting the biodiversity of forests, promoting afforestation efforts and improving the health of existing forests.

Existing policies include laws and regulations to protect forest areas, incentives for biomass energy projects, environmental protection and rehabilitation programs. Turkey collaborates with the European Union and various ² international organizations to

expand the adoption of renewable energy sources. This cooperation includes issues such as the transfer of innovative technologies and raising awareness of the local population.

In conclusion, sustainable management of forest biomass offers great opportunities for energy security and environmental sustainability. By taking the necessary steps to utilize the potential of forest biomass and achieve sustainable development goals, Turkey can increase its energy independence and support environmental protection efforts.

Keywords: Forest Biomass, Sustainable Energy, Energy Generation

1. Introduction

The importance of renewable energy sources is increasing today with efforts to combat climate change and achieve energy independence. The limited resources of fossil fuels and environmental pollution increase the need for alternative energy sources. Forest biomass plays an important role by utilizing organic materials such as trees and plants in energy production. Turkey is in an important position in terms of biomass energy potential with its large forest areas and rich natural resources. Turkey's forested areas cover about 29% of the total land surface, which strengthens its biomass potential.

The utilization of forest biomass in energy production not only fulfills the energy demands of local communities but also enhances the nation's energy autonomy. In addition, trees and other waste salvaged from forest fires are included in this energy capacity. By 2024, Turkey will produce 6 million tons of oil equivalent energy from forest biomass, which is an important step towards achieving sustainable energy solutions. Biomass energy plays an important role in achieving carbon emission

reduction targets and effective biomass management and responsible forest policies contribute to the conservation of forest cover. Kaygusuz, K. A. M. İ. L., & Türker, M. F. (2002)

This study aims to examine the potential of forest biomass in Turkey and its contribution to sustainable energy solutions. Together with the sustainable management of Turkey's natural resources and forest structure, the role of forest biomass in modern energy production is of great importance for rural development and environmental sustainability. Starting from the definition of forest biomass, the study will comprehensively address its potential in Turkey, its utilization in energy production, its environmental impacts and its impacts on rural development. In this context, effective management of Turkey's forest biomass resources is critical for both increasing energy independence and ensuring environmental sustainability. In this context, in order ¹¹ to better understand the potential of Turkey's forest biomass resources and the role of these resources in energy production, Fig. 1. is shown.

2. Definition and Importance of Forest Biomass

Forest biomass is the organic mass of trees, shrubs and other plant material. This mass can be used in many fields such as energy production, materials science and agriculture. The importance of forest biomass as a renewable energy source lies in the fact that it provides both environmental and economic benefits in line with sustainability principles. Forest biomass is renewable within natural cycles, thus playing an effective role in combating climate change by maintaining ecosystem balances. Parde, J. (1980)

The use of biomass in energy production balances the carbon cycle, reducing the amount of carbon dioxide released into the atmosphere. Plants take carbon dioxide from the atmosphere through the process of photosynthesis and gain mass through growth. Therefore, planting new trees to replace those used as biomass contributes to offsetting greenhouse gas emissions. Turkey's vast forest areas have great potential for biomass energy production. Communities, especially in rural areas, can meet their own energy needs by utilizing these energy sources.

Forest biomass in Turkey generally consists of various materials such as forest residues, pruning waste and industrial by-products. Efficient utilization of these resources has a positive impact on the local economy. The use of biomass energy in rural areas increases local employment and supports rural development. As a result, forest biomass is an important energy source for both environmental sustainability and economic development.

3. Forest Biomass Potential in Turkey

Turkey's forest biomass potential is quite high thanks to the country's rich natural resources and diverse climatic conditions. By 2024, the total area of Turkey's forests is around 23 million hectares, covering about 29% of the total land surface. These large forest areas indicate a huge potential in terms of biomass resources. Forests are an important source not only for wood production but also for energy production. Ersoy, A. E., & Ugurlu, A. (2024)

Forest biomass resources are derived from logging, forest management activities, trees salvaged after fires and natural wastes within the forest. In Turkey, the efficient utilization of these resources both meets the energy needs of local communities and

contributes to national energy policy. Turkey produces about 6 million tons of oil equivalent energy per year from forest biomass. This is an important step to increase the country's energy independence.

In addition, sustainable management of forest biomass is also critical for maintaining environmental balance. Sustainable forest management practices ensure that nature is protected in the process of logging and biomass production. Reforestation and rehabilitation of forests help to increase biomass potential and strengthen ecosystem services. In conclusion, the potential of forest biomass in Turkey offers a great opportunity for sustainable energy solutions and environmental protection.

4. Energy Production through the Use of Forest Biomass

The utilization of forest biomass for energy production can be realized through various methods. These include techniques such as ⁷ direct combustion, gasification, pyrolysis and anaerobic digestion. Direct combustion is the burning of biomass materials to produce heat. This method is often used in heating systems or power plants. However, it is important to control the emissions released during the combustion process to reduce environmental impacts.

Gasification is the heating of biomass at high temperatures and low oxygen levels to produce gas, which is then converted into energy. This gas can then be converted into energy. Gasification offers a more efficient method of energy production compared to combustion. Furthermore, pyrolysis is the process by which biomass is broken down under heat to form liquid and gaseous products. This method provides more energy efficiency by changing the chemical structure of the biomass.

Anaerobic digestion is the process by which organic matter is broken down by microorganisms without oxygen. This method is used to produce biogas and combines waste management and energy production. These various methods of energy production from forest biomass offer significant opportunities to meet Turkey's energy needs and develop sustainable energy solutions. In this context, the following image is presented to illustrate the potential of anaerobic digestion and various energy production methods from forest biomass in meeting Turkey's energy needs. ⁴ Hobson, P. N., Bousfield, S., Summers, R., & Kirsch, E. J. (1974)

⁹ In Turkey, the use of forest biomass for energy production plays an important role in rural areas. Local people meet their energy needs by utilizing biomass resources, thereby reducing energy costs. In addition, the use of forest biomass supports local economies and creates jobs. As a result, the utilization of forest biomass in energy production is a vital element for Turkey's energy strategy. ⁶ Karayılmazlar, S., Saraçoğlu, N., Çabuk, Y., & Kurt, R. (2011)

5. Environmental Impacts and Reducing Carbon Emissions

The use of biomass produces significantly less carbon emissions compared to fossil fuels. Turkey is utilizing biomass energy resources to achieve its greenhouse gas emission reduction targets by 2030. Forest biomass supports environmental sustainability with its carbon sequestration capacity. Cairns, M. A. ve Meganck, R. A. (1994)

Utilizing forest biomass for energy production can lead to both beneficial and adverse environmental effects. Positive impacts include being a renewable energy source,

reducing ³dependence on fossil fuels and the potential to reduce greenhouse gas emissions. As forest biomass is a renewable resource within natural cycles, it helps to develop sustainable energy solutions. In this context, biomass utilization is becoming an important tool in combating climate change by increasing energy security. Hall, J. P. (2002)

However, there are also some negative impacts associated with the use of forest biomass. Over-cutting ²practices can lead to the destruction of forest ecosystems and reduced biodiversity. Furthermore, deforestation or insufficient reforestation can lead to increased carbon emissions. Therefore, managing forest biomass sustainably is critical to minimizing environmental impacts. Sustainable forest management practices contribute to maintaining ecosystem balance by ensuring the efficient and environmentally friendly use of biomass resources.

Figure 3 shows the trend values related to forest biomass and sustainable energy in Turkey from 2015 to 2024. Toklu, E. (2017)

The green line represents the increase in forest areas (in million hectares) over the years, while the blue dashed line illustrates annual biomass energy production (in million tons of oil equivalent). In line with sustainability principles, an integrated approach should be adopted for the utilization of forest biomass in energy production. This approach should ensure that environmental impacts are minimized and economic benefits are maximized in energy production. Thus, the utilization of forest biomass will both enhance energy security and support environmental sustainability. Ayan, A., & Senturk, A. (2023)

6. Impacts on Rural Development

The use of forest biomass offers significant opportunities in terms of rural development and energy access. Rural regions of Turkey experience difficulties in terms of energy access. Problems such as distance to electricity networks, high energy costs and inadequate energy infrastructure make it difficult for rural communities to meet their energy needs. At this point, forest biomass stands out as a sustainable solution that can be used to meet ¹ the energy needs of local people. Shrestha, S. (2019)

In rural areas, the use of forest biomass not only meets ¹ the energy needs of local people, but also has the potential to create employment. Employing local labor in forest management, biomass collection and energy production processes contributes to the strengthening of the rural economy. This process, together with the increase in local job opportunities, supports rural development and increases the economic well-being of the society. Mukherjee, M., & Shaw, R. (2021).

The use of forest biomass also helps to increase energy security by utilizing local energy resources. Local people can meet their own energy needs using biomass resources, thus reducing external dependency. This strengthens the energy independence of rural communities while also contributing to environmental sustainability.

As a result, the use of forest biomass is an important tool for Turkey's rural development policies and energy access strategies. In this context, local governments and relevant institutions need to evaluate the potential of forest biomass in energy production and develop sustainable energy solutions.

7. Current Policy and Management Strategies

The use of forest biomass in energy production in Turkey is supported by various policy and management strategies. As of 2024, the Republic of Turkey provides a comprehensive ¹ framework for the development of renewable energy sources and implements various programs and incentives to evaluate this potential. ¹ The Ministry of Energy and Natural Resources develops strategies for increasing biomass energy and raises awareness in this area.

Existing laws ¹ for the use of forest biomass in energy production encourage sustainable forest management. The Forest Law and the Renewable Energy Resources Support Mechanism (YEKDEM) ensure the support of biomass projects and the effective implementation of these projects. These regulations increase the participation of local governments and the private sector in biomass projects and support energy production processes.

In addition, universities and research institutions in Turkey are investigating the potential of forest biomass in energy production and developing innovative solutions. These studies cover topics such as the efficient use of biomass resources, the application of energy production technologies and the reduction of environmental impacts. Collaborations at the local level ensure that forest biomass is utilized more effectively and offer innovative approaches in energy production.

The active role of local governments and non-governmental organizations (NGOs) in this process contributes to the sustainable management of forest biomass. Raising awareness in society about the use of biomass in energy production helps local people understand how they can benefit from these resources. Education programs and

information seminars are organized to increase knowledge and ensure participation in biomass energy.

In summary, Turkey's current policy and management strategies encourage the use of forest biomass in energy production and support renewable energy projects.

Sustainable forest management and the effective use of biomass resources both increase energy security and offer great opportunities in terms of environmental sustainability.

8. Challenges Encountered in the Use of Forest Biomass and Policy

Recommendations for Sustainable Biomass Use in Turkey

Although the use of forest biomass in energy production provides many benefits, it faces various challenges. These challenges may affect the sustainable management of biomass resources and the efficiency of energy production processes.

First of all, the difficulties experienced in the supply of biomass resources are noteworthy. Sustainable management of forests is of critical importance for the efficient use of biomass resources. However, excessive cutting practices can lead to the destruction of forest ecosystems and the reduction of biodiversity. This situation poses a significant threat to the sustainability of biomass production. Therefore, forest management practices need to be reviewed and improved.

Secondly, the cost of technologies used in energy production processes can be a significant obstacle, especially for small-scale enterprises. ² The implementation of innovative technologies and reducing the cost of these technologies are critical factors for the success of biomass energy projects. In addition, the installation and operating

costs of biomass energy systems may make it difficult for local people and small enterprises to benefit from these resources.

Thirdly, the lack of sufficient knowledge and experience in the operation and management of biomass energy systems is also a significant challenge. Local people and small businesses may not have the knowledge and skills required to effectively use biomass resources. Therefore, it is important to increase training programs and technical support services.

Finally, legal and regulatory barriers encountered in biomass energy production should also be taken into account. Local and national regulations need to be updated to support biomass energy projects. This will contribute to increasing energy production by paving the way for biomass energy projects.

Appropriate policies and incentive mechanisms need to be established for the dissemination of biomass energy. The government's provision of supportive laws and incentives for biomass projects will accelerate developments in the sector. In addition, initiatives that increase cooperation with the private sector will help Turkey use its biomass potential more effectively.

The future potential of forest biomass plays an important role in meeting Turkey's energy needs. Developing technology and increasing energy demand enable more efficient and effective use of biomass resources. Global trends towards renewable energy provide opportunities for Turkey to evaluate its forest biomass potential. In particular, the use of forest biomass is of great importance in meeting the energy needs of local people and ensuring environmental sustainability.

However, there are also some challenges related to the use of forest biomass.

Excessive cutting practices can lead to the destruction of forest ecosystems and the reduction of biodiversity. In addition, bureaucratic obstacles encountered during the financing and implementation of biomass energy projects can make it difficult to implement the projects. Raising awareness and educating local people about biomass energy is important in overcoming these challenges.

In order to realize the future potential of forest biomass, innovative technologies must be used and an integrated approach must be adopted. In this context, sustainable management of forest biomass will both increase energy security and support environmental sustainability. Turkey can increase its energy independence and achieve its sustainable development goals by taking the necessary steps to evaluate its forest biomass potential.

9. Future Potential and Opportunities

The future potential of forest biomass in energy production is directly related to Turkey's rich natural resources and increasing energy needs. The increasing demand for renewable energy means that forest biomass will gain more importance. Turkey can increase energy security and contribute to environmental sustainability by utilizing its forest biomass potential in a sustainable way.

In the future, diversification of biomass energy projects offers more opportunities in energy production. For example, small-scale biomass energy systems established to meet ¹the energy needs of local people can support rural development and create employment. In addition, the local implementation of biomass energy systems will

increase energy independence and contribute to the strengthening of local economies.

Springer, Nature, (2012)

In addition to biomass energy, forest biomass has other potential areas of use in Turkey. The processing and transformation of forest products can provide efficient use of biomass resources. In this context, supporting research and development activities can help to emerge innovative solutions. In addition, organizing awareness-raising campaigns on the use of forest biomass will contribute to informing the society on this issue.

As a result, the use of forest biomass in energy production offers great opportunities for Turkey. Sustainable forest management and efficient use of biomass resources play an important role in terms of energy security, environmental sustainability and rural development. Turkey can achieve its renewable energy targets and take important steps for a sustainable future by efficiently evaluating forest biomass.

10. Conclusion

This study examines the potential of forest biomass in energy production, its environmental impacts, its role in rural development and current management strategies in Turkey. Turkey's rich natural resources and large forest areas offer a great potential for forest biomass in terms of energy production. The use of forest biomass both meets ¹the energy needs of local people and contributes to the country's energy independence.

The use of forest biomass in energy production supports environmental sustainability and has the potential to reduce carbon emissions. However, sustainable forest management practices need to be adopted to prevent negative impacts such as

excessive cutting practices. Current policy and management strategies in Turkey encourage the use of forest biomass in energy production and support renewable energy projects.

As a result, sustainable management of Turkey's forest biomass offers great opportunities in terms of energy security and environmental sustainability. The efficient use of forest biomass plays an important role in rural development, employment creation and strengthening of local economies. By efficiently utilizing forest biomass, Turkey can develop sustainable energy solutions and take important steps towards a greener future.

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