

CONCEPTUAL APPROACHES REGARDING THE ENERGY POTENTIAL OF BIOMASS

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RESEARCH ARTICLE

Abstract

In Romania, biomass represents a significant untapped potential, with estimates suggesting over 7.5 million tons of oil equivalent per year, which could meet up to 70% of the country's renewable energy targets. Biomass, including wood, agricultural residues, and waste, is primarily used for heating, but inefficiencies in current systems, especially in rural areas, result in excessive consumption. Romania's abundant biomass resources, particularly from forestry and agriculture, provide substantial opportunities for bioenergy production, such as wood pellets, which are being increasingly adopted in energy-efficient systems. Legislative frameworks at both national and EU levels are essential in promoting biomass energy production and ensuring its sustainability. Biomass has been a crucial energy source throughout history and is now experiencing a resurgence as a key renewable energy resource. This paper explores Romania's biomass potential, the challenges of its current use, and the necessary steps to optimize its role in the country's renewable energy transition.

Keywords: Biomass potential, woody biomass, renewable energy sources,

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INTRODUCTION

Biomass includes all the organic matter in an ecosystem and is the most widely used and widespread renewable resource globally. Also, biomass represents a form of renewable energy that can be transformed into solid, liquid or gaseous fuel and can produce both heat through combustion and electricity through various conversion processes.

Biomass is considered the fourth largest energy source after coal, oil, and natural gas and is currently the most significant and widely utilized renewable energy option (Ladanai & Vinterbäck, 2009). Biomass is defined as an organic material of non-fossil origin, including organic waste that can be converted into bioenergy. According to Eurostat data from 2016, over 60% of the EU-28's total primary renewable energy production comes from biomass sources (EUROSTAT, 2016). Biomass has been an important source of energy since ancient times, although in 1870 it was replaced by fossil fuels, nowadays it has again become one of the main sources of renewable energy. Until the 18th century, biomass it was considered an essential resource for cooking

and continues to be one of the most common sources of energy worldwide (Spârchez, et al., 2019; McKendry P., 2002; Antar et al., 2021). Biomass is recognized as a source of renewable energy, suitable for various uses in both the domestic and industrial sectors, being considered an energy carrier with a neutral impact on CO₂ emissions (Huelsmann et al., 2019)

Biomass includes a wide variety of materials collected from nature or biological portions of waste. The most common example is wood (including firewood, wood residues, wood waste, twigs, logs and wood pellets), which is the largest source of biomass energy (Timofte et al., 2016). Biomass represents a significant percentage of the total renewable energy sources, having a weight of 47%. This is followed by hydro with 45%, geothermal with 5%, wind with 2% and solar with 1%. Solid biomass includes a variety of materials from industry, processes, or forestry and agriculture, such as firewood, sawdust, wood chips, and other solid plant residues, and is mainly used for heat and electricity generation (Cheng, 2022). Romania has an unexploited biomass potential estimated at over 7.5 million tons of

oil equivalent per year, and its exploitation could cover approximately 70% of the country's commitments regarding the contribution of renewable sources to total energy consumption (Nenu, 2023).

Romania already has the most important harnessed SRE potential, due to high-power hydroelectric plants. Renewable energy resources represent a viable alternative for replacing fossil fuels, both in Romania and throughout the world. In Romania, the renewable energy resource with the greatest potential in the short and medium term is biomass - woody and agricultural. (Tenchea A., 2008; Spârchez & Lunguleasa, 2023).

At European level, Directive 2018/2001/EC defines biomass as the biodegradable fraction of products, waste and residues of biological origin from agriculture, including plant and animal substances, from forestry and related industries, including fishing and aquaculture, as well as the biodegradable fraction of waste, including industrial and municipal waste of biological origin.

According to the national strategic plan - ROMANIA from June 2022, bioenergy in Romania constitutes over 65% of renewable energy, this percentage being supported by the balanced distribution of hill and plain areas. In the regions from the Carpathian arc towards the center, the biomass is predominantly rich in lignocellulose, and in the areas east, south and west of the Carpathian arc, plains with a significant amount of agricultural biomass predominate. The most used type of biomass is wood from forests, while a significant proportion of biomass potential is represented by agro-biomass, which includes agricultural residues and energy crops.

The global demand for energy and related services is constantly increasing to meet the needs generated by human, social and economic progress, as well as the improvement of well-being and health (Dolf et al., 2019). Worldwide, biomass covered approximately 70% of energy demand and is currently the main fuel used for energy production in developing countries (Spârchez, 2019).

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Biomass energy (bioenergy) is a versatile and flexible solution that can contribute decisively to the European Commission's objectives of achieving climate neutrality in the 2050 horizon, simultaneously supporting economic growth and creating new jobs. Currently, in Romania between 3.5 and 4 million households depend on bioenergy for home heating, especially through individual systems, wood stoves, with low efficiency.

MATERIAL AND METHOD

A comprehensive literature analysis was carried out to extract official data for the evaluation of biomass potential. Data sources and collection of information were performed through a detailed survey of providers on European, global and national.

The purpose of this paper is to provide an analysis of the current state of biomass research, thus contributing to the understanding of trends in this field. Biomass is the primary and dominant resource among all renewable sources available in Romania.

Romania's average annual availability of agricultural and forest residues for bioenergy is estimated at 228.1 PJ. This includes 137.1 PJ from annual crop residues, 17.3 PJ from permanent crop residues, and 73.7 PJ from forestry residues, firewood, and by-products of wood processing (Scarlat, et al., 2011)

The assessment of renewable sources in Romania (1 TEP = 11.63 MWh) is presented as follows (figure 1):

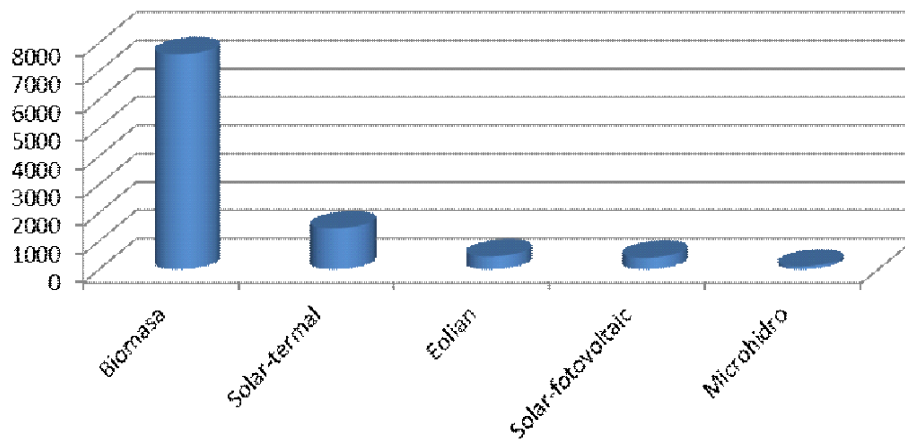


Figure 1 The energetic potential of Romania (ICEMENERG quoted by Badea et al, 2022)

The share of biomass in Romania's electrical energy balance is as follows: 62% - wind power plants; 28% photovoltaic plants; 7% hydro (figure 2).

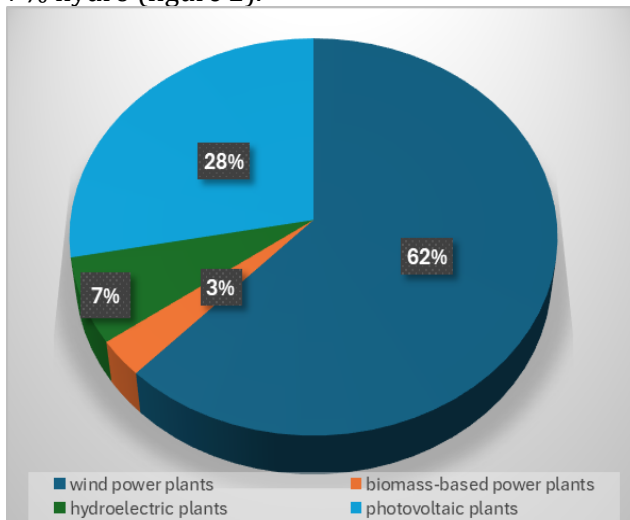


Figure 2 The share of biomass in the electrical energy balance of Romania (ICEMENERG quoted by Badea et al, 2022)

According to the study carried out by Badea and his collaborators, biomass is predominantly used to produce thermal energy, known as "wood heating". The biomass used has a weight between 39% - 45% of the total energy consumption of domestic consumers (figure 3).

This large amount of biomass is used inefficiently, with most heating stoves having very low efficiencies (between 10% and 40%), which implies increased biomass consumption to maintain the desired thermal comfort.

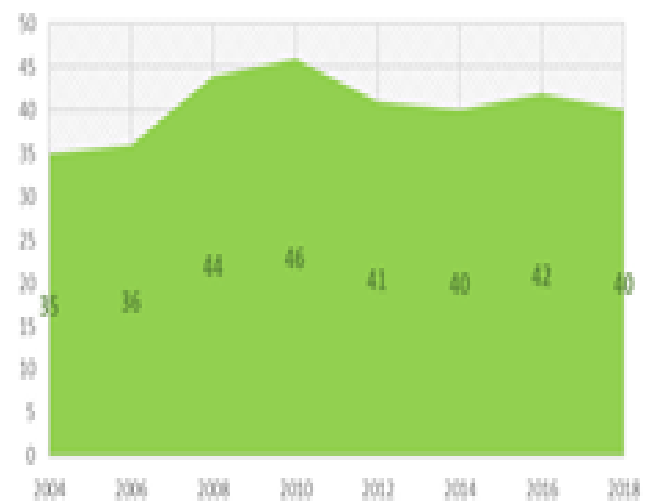


Figure 3 Biomass consumption for heating (Mil.Mwh) (EUROSTAT, quoted by Badea et al, 2022)

At present, forest biomass is the primary source, comprising approximately 71.4% of the biomass used for bioenergy, while agricultural biomass and waste biomass contribute 15.3% and 13.3%, respectively (figure 4).

Bioenergy is Europe's most important renewable energy source and in 2021, bioenergy represented 55,7% of all renewable energy. As 22% of the EU's energy mix is renewable, this means that overall, bioenergy represented 10,2% of the gross final energy in 2021.

According to Eurostat, more than 40% of the energy consumption in Romania is produced from renewable sources, being above the European average and in front of countries much more developed from an economic point of view, such as the case of Italy, France or Poland.

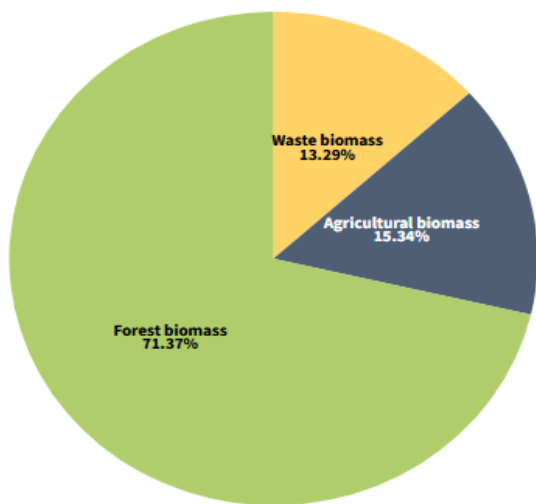


Figure 4 Distribution of the various biomass feedstock for energy in 2021 (%) (<https://bioenergyeurope.org/bioenergy/>)

The top of the countries with the highest consumption of energy from renewable sources is led by Austria (76.2%), followed by Sweden (over 75%) and Denmark, being completed by Portugal and Croatia.

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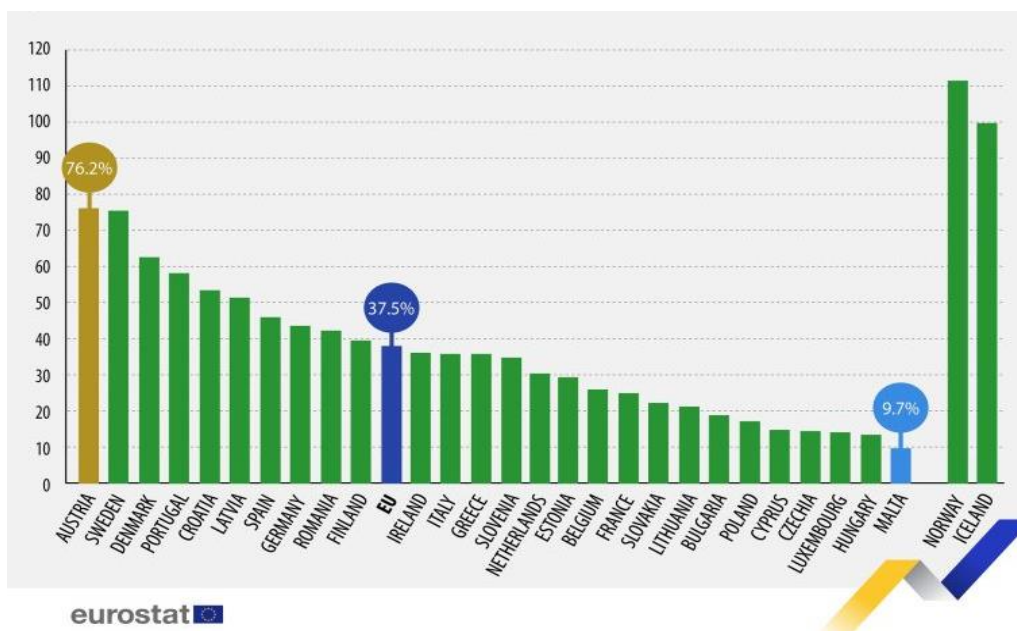


Figure 5 Share of energy from renewable sources in gross electricity consumption, Eu, 2021

RESULTS AND DISCUSSIONS

In Romania, firewood is the primary biomass used for energy, typically burned in low-efficiency stoves. Roughly one-third of households (about 2.5 million) use natural gas for heating, either through apartment-based central heating or stoves with very low efficiency—at least 500,000 homes fall into the latter category. Approximately 3.5 million homes, predominantly in rural areas, rely on solid fuels, such as wood or coal, burned in similarly inefficient stoves. The remaining homes use liquid fuels (oil, diesel, or LPG) or electricity for heating, and over half of

Romanian households only partially heat their living spaces during winter. To address these issues, a broad reform of heating technology is essential, particularly focused on rural areas.

The current legislative framework addresses biomass in a broad manner, referring to it both as a raw material for generating electricity and heat, alongside firewood—which is the primary product of forestry operations—and as waste, including green residues.

Eurostat data from 2019 indicates that biomass used as fuel is considered carbon neutral, since the carbon emitted during combustion was originally absorbed from the atmosphere during its growth cycle. However, there are several sustainability concerns associated with biomass as

a fuel source. Without a universally accepted definition encompassing all categories of biomass, it will continue to be viewed in a fragmented and incomplete way, and in some cases, may be mistaken for other resources. The Green Energy Association proposes the following classification:

- Natural biomass — sourced directly from ecosystems (wood waste resulting from dressing fruit trees; wood waste from the maintenance of access roads; minor and major beds of temporary and permanent watercourses; meadows, hayfields and pastures; green spaces in localities; bordering areas of uninhabited localities);
- Residual biomass (wood material resulting from wood processing);
- Energy crops (refers to crops intended exclusively to produce biomass for energy purposes) ;
- Agricultural residues (represent the waste resulting from agricultural activities).

Directive (EU) 2018/2001 on the promotion of energy from renewable sources aims to create a favourable framework for those who want to produce their own energy from clean sources. Biomass from woody and agricultural residues, is considered a significant and promising resource for pellet production due to their high availability, low cost, and potential to contribute to a circular and sustainable economy. Wood pellet production was identified as a rapidly growing sector, offering a sustainable solution with benefits such as compactness, low moisture content, and improved energy efficiency.

According to the Order of the Minister of Agriculture and Rural Development no. 304 of 2017, amended by Order no. 251 of September 27, 2021, the energy willow and poplar crop was removed from the list of non-agricultural energy crops. The strategy for the development of the agri-food sector in the medium and long term, with a horizon of 2020-2030, approved by the Ministry of Agriculture and Rural Development, has as its strategic objective the limitation and reduction of the carbon footprint of agriculture, the promotion of ecological agriculture and climate change resilience, as well as the stimulation efficient water management and renewable energy production. Although, the strategy encourages "the establishment of crops of forest species with a short vegetation cycle on agricultural land for the use of biomass for energy purposes", Order no. 251 of September 27, 2021, issued by the Minister of Agriculture to amend the annex to Order no. 304/2017, excludes the culture of energy willow and poplar from the list of non-agricultural energy crops (Badea et al., 2022).

The energy sector in Romania is booming, moving towards increasing the share of energy

generated from biomass, with a particular focus on woody biomass resources. Currently, only 3% of electricity comes from biomass, both from wood and agricultural sources.

According to Eurostat, electricity production from renewable sources increased by 5% in 2021, while the share of green energy in total consumption at European level reached 37.5%. Regarding the SRE share in the final gross energy consumption, Romania has assumed a share of 41.1% in 2035, respectively 86.1% in 2050.

CONCLUSIONS

Woody biomass has been and will continue to be an essential fuel resource with a long tradition of human use. Over time, it has played and still plays a vital role in the global energy economy. Biomass resources play a significant role in the global economy, although they are often used primarily as raw material in the wood processing industry. However, biomass has great potential as an energy material, being able to generate energy through conversion processes or direct combustion.

Romania is one of the EU countries with the greatest natural potential in terms of renewable energy sources. Biomass is regulated by a series of legislative acts that focus both on the exploitation of natural resources and on the promotion of renewable energy. Current EU legislation currently encourages a considerable expansion of the use of biomass for energy, with the aim of reducing emissions and mitigating the effects of climate change.

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