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The Advantages of Energy Efficiency Projects and Their Impact on the Economy of Romania and the EU

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Abstract: *Energy efficiency projects play an essential role in shaping a more sustainable and competitive economy in Romania and across the European Union (EU). Reducing energy consumption and greenhouse gas emissions, these initiatives help combat climate change and generate new jobs, enhance living standards, and drive technological advancements. With the EU setting ambitious climate targets, Romania faces the pressing need to implement large-scale energy efficiency programs. This paper researches the benefits and economic implications of these projects at both the national and European levels, using a multidisciplinary perspective that considers economic, environmental, and social factors. The findings underscore the importance of well-defined policies and robust funding mechanisms to unlock the full potential of energy efficiency measures.*

1. INTRODUCTION

Energy efficiency is fundamental to sustainable development and economic resilience (Weg, 2025). The European Union (EU) has established stringent energy policies to reduce greenhouse gas emissions (EU, 2021) by at least 55% by 2030 as part of the Fit for 55 packages (European Commission, 2019). As an EU member, Romania must align its energy policies with these objectives. However, the country faces significant challenges, including outdated infrastructure, inefficient energy use, and limited funding for renewable projects. This paper examines Romania's potential to enhance energy efficiency through geothermal energy, biomass utilization, and sustainable forestry management.

1.1. Romania in Terms of Green Energy Potential and Efficiency

Romania has tried to improve the energy efficiency of its buildings and has had ambitious strategies, but the results have been more modest.

From the quality of the materials used for the energy efficiency of apartment blocks to the replacement of rusty pipelines in major cities, the cost and quality of the works, as well as the proven low efficiency or, more seriously, the lack of monitoring or assessment of the degree of improvement in energy efficiency following the implementation of projects, lead us to view Romania's energy efficiency with considerable leniency.

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Instead of engaging in a harsh, critical analysis of what was done poorly, focusing on our potential and what we could reach in terms of energy efficiency by strictly using Romania's enormous untapped potential—geothermal energy and biomass (Asociația New Projects, 2017).

Currently, according to the form of ownership, the area of the national forest fund is divided as follows:

- Total area – 6.3 million ha.
- Public property of the state – 3.02 million ha.
- Private property – 3.28 million ha.

1.2. Structure by Species of the National Forest Fund

Percentage-wise, the composition of Romania's forests by major species groups is as follows:

- beech: 969,933 ha - 32%.
- conifers: 780,230 ha 25.7%.
- oaks: 551,382 ha - 18.2%.
- various other complex species: 517,727 ha - 17.1%;
- various other soft species: 212,428 ha - 7%.

In line with "Fit for 55," a package of measures proposed by the European Commission aimed at reducing greenhouse gas emissions in the EU by at least 55% by 2030 compared to 1990 levels (Magazine, 2019), Romania has developed National Forest Strategy 2030 (SNP 2030), a document that provides new guidelines for the sustainable development of forests and the forestry sector (Coroianu, 2024).

Today, the new EU Forest Strategy 2030 (EUSF 30), introduced in 2021, is among the flagship initiatives of the European Green Deal. Strategically, EUSF 30 integrates the commitments and objectives outlined in the EU's strategic documents related to forestry. EUSF 30 becomes an integrative policy document for the forestry sector, linking it with the strategic intersectoral objectives assumed at the European Union level (SNP 2030, 2021).

Economic viability is a key parameter in the sustainable management of forests and is crucial for supporting the multiple benefits they provide to society. The national forestry sector has a positive external trade balance, utilizing a renewable resource by exporting finished and semi-finished products. However, economic viability is limited by the high costs of timber harvesting and collection, coupled with outdated technological equipment used in forest exploitation, which often affects the quality of the forest environment. Additionally, the reduced accessibility of Romania's forests presents economic challenges due to the inability to fully harvest the volume of timber established by forest management plans and ecological issues that limit the application of necessary forestry work for the stability of forest ecosystems and nature-based silvicultural treatments.

1.3. Sustainably Manufactured Wood Products with a Long Lifespan Can Contribute to Achieving Climate Neutrality

Wood products with a short lifespan also play an important role, especially in heating for vulnerable households with limited access to other energy sources. In Romania, firewood is an indispensable resource for most families, particularly in rural areas. A significant challenge is addressing energy poverty (the lack of access to modern energy services) for local communities while adhering to best practices regarding the sustainability of biomass production (Ffe, 2020).

The European concept regarding continuity and maintaining ecological balance has led to the so-called close-to-nature forestry, which was introduced in Romania by Prosilva (2018), a non-governmental organization advocating for forestry practices focused on individual tree extraction. The functional classification of forests in Romania includes two main categories in Table 1.

Table 1. Classification of forests in Romania

Category	Subcategory	%
I. Forests with Special Protection Functions - 1,993,914 ha	Forests for water protection	31%
	Forests for land and soil protection	42%
	Forests for protection against harmful climatic and industrial factors	6%
	Forests for recreation	11%
	Forests of scientific interest for the protection of the ecological and genetic forest fund (including 18,389 ha in the national catalog of virgin and quasi-virgin forests)	10%
II. Forests for Production and Protection - 1,037,786 ha		34%

Source: Own research

Regarding the functional zoning mentioned above, it should be noted that all forests in Romania have been assigned various protection functions, even if the stands they comprise are used for timber production for different industrial purposes or to support game cultivation and intensive growth.

It is observed that forests in Category I have a larger share than those in Category II, with the former continually expanding since 1954.

The high percentage of forests in Category the following factors justify:

- Most forests are in mountainous and hilly regions that are particularly vulnerable to geomorphological and hydrological hazards; most of Romania's water resources are within the forest fund, necessitating protective forestry measures, especially for reservoirs.
- Most protected areas are also within the forest fund, fulfilling biodiversity conservation functions.

Forest management aims to establish the functional effectiveness of Romania's forests by carefully studying the relationship between their structure and the socio-economic functions assigned to the national forest fund. Thus, forest management can be understood as the science of organising and directing forests toward a desired state of multifunctional effectiveness by ecological, economic, and social objectives of forestry management.

2. LITERATURE REVIEW

Developing at the intersection of biological and socio-human sciences, the technologies proposed in the forest management process adhere to modern ecological requirements and strategies.

The Romanian national forest fund is 6.3 million ha of forest, with a forest cover percentage of approximately 27% (below the European average). Examining the distribution of forests territorially highlights characteristic aspects with significant influences on their functions and services, revealing an unequal distribution of forests, which persists both nationally and locally. The characterization of the national forest fund is based on indicators such as area, territorial distribution

of forests, species composition, stand structure by age classes, regimes and treatments applied in the management system, standing timber volume, and the degree of industrialization.

Defining the forest management concept, this represents the process of making medium-term decisions (10-20 years) at the level of a forest production unit based on long-term objectives and data describing the forest at a given time (Drăgoi, 2004).

In Romanian forestry literature, forest management is defined as the science and practice of organizing forests by forest management tasks.

Forest management is the primary means of ensuring the continuity of production and forest policy. Through management, forest policy can be changed when there are enough new elements regarding the dynamics of forest ecosystems or when some political, economic, and social environmental characteristics change radically (Gherghel, 2016).

It is advisable to reintroduce these areas into agricultural use to produce biomass necessary for biofuel production, especially given that today, more than ever, the fossil fuel crisis is ongoing, and there is increasing emphasis on the broader use of renewable, non-polluting energy sources.

Moreover, in our analysis, we must also consider the potential of permanent pastures in our country, which cover approximately 4.9 million hectares. Romania ranks fifth in Europe, after France, the United Kingdom, Spain, and Germany. Pastures in our country, representing 33% of the agricultural area, are a significant part of the national wealth due to the size and quality of forage resources and their other functions that benefit the protection and beauty of the environment.

The distribution area of pastures is found across all types of terrain, from the altitudes of the Danube Delta and plains to the 2,500 meters on the alpine plateaus of the Carpathian Mountains. This makes the land resources for pastures in Romania extremely varied in all aspects: physical-geographical, climatic, hydrographic, soil depth, soil types, and their physicochemical properties. Depending on their use, pastures are classified into grazing lands and meadows. Of the total pasture area in the country, 68% is represented by grazing lands and 32% by meadows. It is noted that 79% of the pasture area is in hilly and mountainous regions.

According to regulations, the average green mass harvested per hectare is about 3 tons. For example, suppose a pasture supports an average of 0.5 livestock units per hectare for 150 days with 25 kg/day of dry matter consumption. In that case, it will result in 3,750 kg/ha, with an additional 30% unused residues. In the case of a poor, degraded pasture, the dry matter production determined by mowing and weighing the grass would be 4,875 kg/ha.

In addition to the two mentioned renewable resources, which are not adequately and judiciously exploited, Romania also has its Black Sea coast, spanning 244 km, where the contribution of freshwater and nutrients brought by the Danube through its three mouths aids the exponential growth of algae, especially in the summer months. Another critical factor for algae development is the predominant direction of marine currents from north to south. Moreover, algae thrive mainly when the waters are rich in nutrients, and the biomass potential from algae harvested from the Black Sea and/or washed ashore is estimated at around 80,000-100,000 tons per year (Maruşca et al., 2014).

3. SUSTAINABLE SOLUTIONS FOR ENERGY EFFICIENCY FOR THE FUTURE

The future we speak of, depending on the intelligence of leaders, could be tomorrow, meaning within a reasonable estimated timeframe, or never if we stubbornly ignore the potential we have and remain energy-dependent on others, with the population paying unjustifiably high costs. We must understand that if, 35 years after the December 1989 Revolution, Romania finally starts to utilize its vast geothermal potential, the same could be achieved with the biomass harvested and not used in Romania—currently not utilized at all.

3.1. Geothermal Energy Potential

Romania's geothermal resources offer a viable solution for energy efficiency. A notable example is the geothermal basin north of Bucharest, covering 300 square kilometers, with water temperatures ranging from 58 to 84°C. On February 7, 2024, ELCEN and the U.S. Department of Energy (DoE) signed an agreement in Washington to explore investment opportunities in renewable geothermal energy and conduct a feasibility study on integrating geothermal resources into Bucharest's district heating system. After evaluating multiple collaboration options, the DoE proposed a partnership between ELCEN and Sage Geosystems. Sage introduced its geothermal technology to ELCEN and drafted a memorandum of understanding to outline the framework for future cooperation (Green Forum, 2024).

Out of the 24 wells drilled in this basin before 1990, 18 produce geothermal water with flow rates between 22 and 35 liters per second. Given the reservoir's qualities, the geothermal resources in the ground north of Bucharest could be used for heating and preparing hot water for consumption in residential buildings, social services such as hospitals, schools, or kindergartens, and in the industrial sector or greenhouses. Suppose substantial investments were made in this green, sustainable, and practically inexhaustible energy. In that case, Romanian government experts have estimated that thermal energy consumption from conventional sources could be reduced by up to 75%, and heating costs for consumers could be reduced by 40%.

Although geothermal energy in Romania is primarily available in the west of the country, in the Banat region and near the Apuseni Mountains, with the most significant geothermal resource located in Bihor, there are also geothermal basins in Oltenia, Muntenia, the Harghita-Covasna counties, the Herculane region, and the Hârșova area.

Geothermal energy has been exploited in this region for approximately a century, providing heating for 5,500 homes in Oradea, and the city of Beiuș is the only city in the country heated exclusively with geothermal resources. Currently, the geothermal capacity exploited in Romania is 480 MW, making the country the third largest in Europe, after Greece and Italy, in terms of geothermal energy. However, geothermal power plants are costly to build, with a 1 MW capacity plant costing between $3-10 million, although the initial cost can be recovered over time as a long-term investment.

3.2. Biomass Utilization

Returning to biomass is the biodegradable part of products, waste, and residues from agriculture, including plant and animal substances, forestry, and related industries, as well as the biodegradable part of industrial and urban waste (e-mc2, n.d.). Biomass has been used for energy purposes

since humans discovered fire. The energy embedded in biomass is released through various methods, ultimately representing the chemical process of combustion (chemical transformation in the presence of molecular oxygen, an exergonic process par excellence). Biomass is the most abundant renewable resource on the planet. It includes all organic matter produced through the metabolic processes of living organisms. Typically, plants contain 25% lignin and 75% carbohydrates (cellulose and hemicellulose) or saccharides, which help initiate "fermentation" reactions that produce biogas through gasification.

In Romania, both local administrative units (UATs) and the National Company for Road Infrastructure Administration (CNAIR), as well as CFR Infrastructure (CFR), the National Administration of Romanian Waters (ANAR), and the National Forest Administration Romsilva (RNP, n.d.), harvest enormous quantities, as demonstrated, from the areas they manage. The combined investment potential of these entities amounts to several hundred million euros annually.

Table 2. Clearance achievements – vegetation cutting and hazardous tree cutting as of 31 December 2023

	SRCF	Vegetation clearance for gauge and signal visibility as of 31.12.2023 (sqm)		Vegetation clearance at level crossings (LC) with railway as of 31.12.2023		Total vegetation cutting and clearance as of 31.12.2023 (sqm)		Hazardous tree cutting completed for trees with a diameter between 30-60 cm and greater than 60 cm (number of trees)	
		Own strengths	Third parts	Own strengths	Third parts	Own strengths	Third parts	Own strengths	Third parts
1	Bucuresti	1.492.000	0	244.721	0	1.736.721	0	10	0
2	Craiova	731.425	0	221.450	0	952.875	0	7	1
3	Timisoara	1.592.760	202.700	334.920	0	1.927.680	202.700	0	160
4	Cluj	1.643.540	0	521.510	0	2.165.050	0	0	0
5	Brasov	1.278.066	0	0	0	1.278.066	0	0	808
6	lasi	1.097.973	0	130.148	0	1.228.121	0	0	0
7	Galati	1.421.295	0	129.390	0	1.550.685	0	0	360
8	Constanta	846.357	0	272.228	0	1.118.585	0	0	0
	Total network	10.103.416	202.700	1.854.367	0	11.957.783	202.700	17	1329

Source: CFR (2022)

By leveraging the exceptional potential available, with proper organisation and an investment program focused on this area of green energy derived from biomass, biomass power plants could likely be established throughout Romania. Utilising inexpensive raw materials, these plants could not only balance Romania's energy portfolio and contribute to achieving climate neutrality for Romania and the EU, but they could also serve as a model for other countries.

Based on the data analysed and the information collected from the National Forest Administration, the National Company for Road Infrastructure Administration, CFR Infrastructure, and the National Administration of Romanian Waters, there is no comprehensive data on the total biomass collected during the "cleaning" campaigns for roads, railways, or even water bodies and forests. This lack of data prevents us from determining the available volume of biomass for "industrialisation." For example, CNAIR allows mowed grass to decompose on the sides of roads, while RNP collects the wood mass. Similarly, algae collected by ANAR decompose, despite the expense of cleaning the coastline, and disposing of them in landfills incurs additional costs. This annual energy waste is significant.

An investment consortium involving these four entities, potentially supplemented by other large local administrative units (UATs) on a case-by-case basis, could invest in all 40 counties. This project, extending over 5 years, could amount to over 200 million euros. It would not only generate green energy and use an untapped resource but also create jobs, utilise materials and equipment from Romania's horizontal industry, and balance and diversify the energy portfolio of the National Energy System. This would provide an excellent backup when wind or solar energy production is insufficient, with biomass energy as a valuable and significant backup option. Certainly, in-depth studies would reveal the capacities to be installed along the coast, the cost-benefit analysis, and the possibilities for efficiently producing this type of energy. This energy could be used not only by the consortium members for their own consumption needs but also by local communities. "From the perspective of biomass energy potential, Romania's territory has been divided into eight regions (Figure 1), namely: 1. The Danube Delta – a biosphere reserve, 2. Dobrogea, 3. Moldova, 4. The Carpathian Mountains (Eastern, Southern, Apuseni), 5. The Transylvanian Plateau, 6. The Western Plain, 7. The Subcarpathians, 8. The Southern Plain".

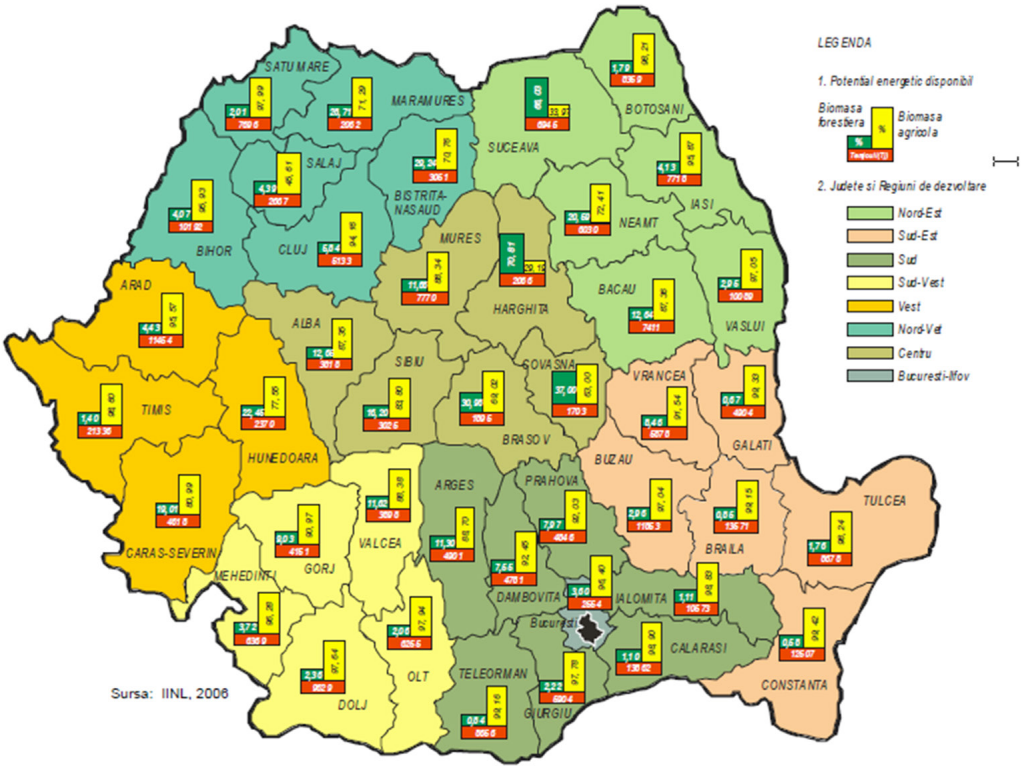

Figure 1. Biomass Energy Potential Regions in Romania
Source: Asociația New Projects (2017)

Analysis of the Geographic Distribution of Biomass Resources with Available Energy Potential:

- The wealthiest counties in forest resources are: Suceava: 647.0 thousand cubic meters, Harghita: 206.5 thousand cubic meters, Neamț: 175.0 thousand cubic meters, Bacău: 132.0 thousand cubic meters;
- The poorest counties in forest resources are in the south: Constanța: 10.4 thousand cubic meters, Teleorman: 10.4 thousand cubic meters, Galați: 10.4 thousand cubic meters;
- The richest counties in agricultural resources are: Timiș: 1432.0 thousand tons, Călărași: 934.0 thousand tons, Brăila: 917.0 thousand tons;
- The poorest counties in agricultural resources are: Harghita: 41.004 thousand tons, Covasna: 73.000 thousand tons, Brașov: 89.000 thousand tons.

According to Şumălan (2011), the energy content of various types of biomasses (electric MWh) is as follows:

- 1 ton of coal = 2.5 MWh,
- 1 ton of wood pellets = 1.8 - 2 MWh,
- 1 ton of sawdust = 1.8 MWh,
- 1 ton of wood chips = 0.8 - 1.5 MWh,
- 1 ton of coffee grounds = 1.6 MWh,
- 1 ton of organic waste = 10 MWh,
- 10,000 liters of oil = 40 tons of wood chips = 22 tons of pellets,
- 1 ton of oil = 2.5 tons of pellets.

4. DISCUSSION

With a national forest area in Romania of 6.3 million hectares and the potential of permanent pastures in the country, which cover approximately 4.9 million hectares, Romania ranks fifth in Europe after France, the United Kingdom, Spain, and Germany. This gives Romania a vast potential for green energy from biomass, estimated at around 65%, according to the Ministry of Environment, which remains underutilized.

In addition to the two previously mentioned non-exhaustible resources that are not properly and judiciously exploited, Romania also has the Romanian coastline along 244 km of the Black Sea. Here, the influx of fresh water and nutrients brought by the Danube into the sea through its three mouths fosters the exponential growth of algae, especially during the summer months. Another important factor for algae development is the predominant north-to-south direction of marine currents. Furthermore, algae grow particularly well when the waters are rich in nutrients, and the biomass potential from algae harvested from the Black Sea and/or brought to shore is estimated at around 80,000 to 100,000 tons per year.

Biomass is the biodegradable part of products, wastes, and residues from agriculture, including plant and animal substances, forestry, and related industries, as well as the biodegradable part of industrial and urban waste (i.e., that which essentially ends up in landfills!). It includes all organic matter produced through the metabolic processes of living organisms. Plants typically contain 25% lignin and 75% carbohydrates (cellulose and hemicellulose) or sugars, which help trigger "fermentation" reactions that produce biogas through gasification.

In Romania, both local administrative units and the administrator of the national and motorway network, the National Company for Road Infrastructure Administration (CNAIR), as well as CFR Infrastructure (CFR), the National Administration of Romanian Waters (RNAR), and the National Forest Administration Romsilva (RNP), collect huge quantities, as demonstrated, from the areas they manage. The combined investment potential of these entities amounts to several hundred million euros annually. By harnessing this exceptional potential with proper organization and an investment program in green energy from biomass, biomass power plants could be established across Romania, utilizing inexpensive raw materials. This would not only balance Romania's energy portfolio and contribute to achieving climate neutrality for Romania and the EU but could also serve as a model for other countries.

From the analyzed data and information collected from the National Forest Administration, the National Company for Road Infrastructure Administration, as well as CFR Infrastructure and

the National Administration of Romanian Waters, there is no data on the total amount of biomass collected during the "cleaning" campaigns of roads, railways, or even waters and forests, to determine the volume of biomass available for industrialization. For example, CNAIR allows mown grass to rot along roadsides, while RNP takes the wood mass. Similarly, algae collected by RNAR also rot, despite the cost of cleaning the coastline and disposing of them in landfills incurs additional expenses. This energy waste occurs annually. An investment consortium comprising these four entities, possibly including other large local administrative units, could invest in all 40 counties to utilize the obtained biomass. Such an investment project, spanning over 5 years, could be valued at over 200 million euros annually, from own funds, government or attracted funds, and European funding. This would not only generate green energy and utilize an unused resource but also create jobs, use materials and equipment from Romania's horizontal industry, balance and diversify the energy portfolio of the National Energy System, and provide an excellent backup during periods when wind or solar energy is insufficient.

5. FUTURE RESEARCH DIRECTIONS

To fully leverage Romania's green energy potential, future research should prioritize the development of advanced energy monitoring systems, enhancing technological innovations in geothermal and biomass energy, comprehensive cost-benefit analyses of large-scale green energy investments, and strengthening public-private partnerships to attract foreign and domestic investors.

6. CONCLUSION

Romania's transition to a sustainable energy model requires significant investment and policy coherence. Geothermal and biomass energy have the potential to play key roles in reducing energy dependency, lowering costs, and enhancing environmental sustainability. Implementing well-structured energy efficiency projects, supported by EU funding and strategic national policies, is crucial for Romania's economic growth and alignment with EU climate objectives. Future research and investment in sustainable energy solutions will be essential to maximizing Romania's energy potential.

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References

Asociația New Projects. (2017). Biomasa – o alternativă de energie verde pentru România. *Revista online New Projects*. ISSN 2065-7781. https://revista.newprojects.org/?p=1160

CFR. (2022). *Raport de activitate*. https://cfr.ro/wp-content/uploads/2023/06/Raport-activitate-CFR-2022-v7.pdf

Coroianu, E. (2024). *The 2030 National Forest Strategy*. Radio Romania International. https://www.rri.ro/en/features-and-reports/green-planet/the-2030-national-forest-strategy-id153516.html

Drăgoi, M. (2004). *Amenajarea pădurilor*. Editura Universității Suceava.

e-mc2. (n.d.). *Biomass energy*. https://www.e-mc2.gr/en/vivliothiki/energy/biomass-energy

European Commission. (2019). Fit for 55.. https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/delivering-european-green-deal/fit-55-delivering-proposals_en

European Union. (2021). *Norgesportalen*. https://www.norway.no/en/missions/osce/norway-and-the-osce/statements/statements-with-norwegian-alignment-2021/eu-statement-on-the-occasion-of-earth-day/

Ffe. (2020, March 3). *Fundación Finanzas Éticas engages Endesa on energy poverty*. Shareholders For Change. https://www.shareholdersforchange.eu/fundacion-finanzas-eticas-engages-endesa-energy-poverty/

Gherghel, M. (2016). *Cartea pădurarului*. Regia Națională a Pădurilor, București, România.

Green Forum. (2024). Romanias ELCEN Signs MoU with US company Sage Geosystems. *Green Forum*. https://www.green-forum.eu/business/20240723/romanias-elcen-signs-mou-with-us-company-sage-geosystems-1270

Magazine, A. P. O. (2019). Palm oil strategy requires reconsideration. *Asia-PalmOil*. https://www.asia-palmoil.com/post/palm-oil-strategy-requires-reconsideration

Marușca, T., Mocanu, V., & Haș, E. C. (2014). *Ghid de întocmire a amenajărilor pastorale*. Capolavoro, Brașov.

Prosilva. (2018). *Pro Silva*. https://www.prosilva.org/

RNP. (n.d.). *Regia Nationala a Padurilor*. https://www.rosilva.ro/articole/prezentare_generala__p_178.html

SNP 2030. (2021). *Schița Strategiei Naționale pentru Păduri*. https://strategieforestiera.ro/process/snp30

Șumălan, R. (2011). BIOMASA - Sursă de energie regenerabilă. *Gazeta de Agricultură*. https://www.gazetadeagricultura.info/eco-bio/565-energie-regenerabila/11375-biomasa-sursa-de-energie-regenerabila.html

Weg. (2025). The importance of energy efficiency in water management. *Smart Water Magazine*. https://smartwatermagazine.com/news/weg/importance-energy-efficiency-water-management