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Renewable energy sources: the key for sustainable future

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Abstract

Using renewable energy sources plays a key role in addressing the growing challenges of climate change. The increase in global temperatures is now an undeniable fact. The extreme weather events, such as prolonged drought, hailstorms, forest fires, and floods have made the switch to sustainable energy sources – such as solar, wind, and hydro – a viable alternative to reducing dependence on fossil fuels, particularly coal, oil and gas. This article examines how renewable energy can help reduce greenhouse gas emissions in the atmosphere, improve energy security, and contribute to the global initiatives and support Bulgaria`s participation in global initiatives aimed at achieving a low-carbon future. It also looks at the economic and social benefits of clean energy deployment and the challenges that hinder its widespread implementation. The study also analyzed the dynamics and trends in the development of renewable energy sources in the EU and Bulgaria. The study is based on EUROSTAT data and examines legislation and reports related to the topic. The results indicate that, despite a 22.8% increase in the share of clean energy derived from renewable energy sources by the end of 2023, the share of coal-fired power in Bulgaria remains significantly high. This poses a major challenge to achieving the climate targets outlined in the Paris Climate Agreement and the Green Deal.

Keywords: climate change, greenhouse gas emissions, low-carbon future

INTRODUCTION

Modern society depends highly on energy to meet the basic needs and to sustain the economic activities. Achieving sustainable development requires secure and environmentally sound access to energy resources. However, a considerable part of the world's energy is still derived from fossil fuels, a major source of man-made greenhouse gas emissions. A shift towards cleaner energy sources is essential to minimize environmental impacts and achieve sustainable development. (Moomaw *et al.*, 2011). The heavy reliance on fossil fuels has led to energy shortages and a dramatic rise in CO₂ emissions, affecting global climate. Fossil fuels account for over 75% of all greenhouse gas emissions and nearly 90% of CO₂ emissions. Emissions are a main driver for climate change (Perera, 2017). The growth of

global population is leading to an increase in energy demand, expected to expand by 56% by 2040. A long-term dependence on fossil fuels will inevitably lead to further increased greenhouse gas emissions (Rahman *et al.*, 2022). To address these challenges, reducing dependence on fossil fuels is essential by investing in reliable, environmentally friendly, affordable, and cost-effective alternative energy sources (Feng, 2022).

Therefore, reducing the dependence on fossil fuels and prioritizing policies to adopt renewable energy options is the best approach to achieve carbon neutrality and sustainably address humanity's energy needs (Rehman *et al.*, 2023). The transition to renewable energy sources for electricity generation is crucial. Beyond reducing carbon emissions, combating climate change, improving environmental sustainability, and preserving biodiversity, it

also provides long-term economic and social benefits, as well as stable economic growth (Halilbegović *et al.*, 2023). The use of renewable energy sources can support the achievement of the goals outline in the EU Green Deal and the Paris Climate Agreement and contribute to sustainable development.

The study aims to analyze the patterns and progress in renewable energy production in Bulgaria, highlighting their role in mitigating climate change and promoting sustainable economic growth. The survey examines how the transition to renewable energy can contribute to reducing carbon emissions and tackling the rise in global temperatures, which in recent decades have been increasing faster than at any time since meteorological measurements were taken.

MATERIALS AND METHODS

The study is based on Eurostat data on energy statistics covered by Regulation (EC) No 1099/2008, as well as reports and data from ember-energy.org on the transition to renewables. The analysis also includes a review of legislation and reports related to energy security and sustainable development, focusing on the effectiveness of different policies to reduce greenhouse gas emissions, and to achieve climate neutrality. Based on the descriptive analyses technics and graphical presentation of the state and trends in energy use in the EU and Bulgaria, industry and policy recommendations are provided.

RESULTS AND DISCUSSION

The world is facing one of its greatest challenges - addressing climate change and reducing greenhouse gas emissions to limit the rise in global temperatures (Chami *et al.*, 2019). Establishing a balance between the amounts of emitted into the atmosphere carbon dioxide and the removed one is a crucial step in reducing the impacts of climate change (Fawzy *et al.*, 2020).

In 2019, the European Union took a notable step in its climate leadership by introducing the European Green Deal. This ambitious framework outlines a comprehensive approach to climate change and the transition to sustainable low-carbon economies (European Commission, 2019). In addition, the Green Deal sets a target for greenhouse gas emissions, and with specific goals of reduction of 55% by 2030, based on 1990 levels, and a 100% reduction by 2050. This plan covers many sectors, including energy, industry, agriculture, and transport. Aimed to stimulate innovation, create green jobs, and ensure a healthier and more sustainable environment for future generations (Atanasov *et al.*, 2023). To mitigate climate change, reaching net-zero emissions will be essential. This includes ensuring balanced and reduced volume of greenhouse gases emitted into the atmosphere (Drouet *et al.*, 2021). Over the past century, the accumulation of greenhouse gases in the atmosphere has proven to be a major driver of significant increase in global temperatures. These gases trap heat emitted from the Earth's surface, leading to a steady atmosphere warming and contributing to various environmental and climate changes (Akimoto *et al.*, 2021).

Climate change is causing multiple side effects, such as rising sea levels, more frequent extreme weather events, and major ecosystem disruptions, leading to biodiversity loss. Addressing these challenges requires using renewable energy sources, improved energy efficiency, carbon capture technologies, and the construction of modern infrastructure, such as electric vehicle charging stations and systems for storing energy obtained from renewable sources (Jaumotte *et al.*, 2021). Renewable energy sources encompass diverse technologies capable of providing electricity, heat, and other forms of energy to meet various needs. The key renewable energy sources are illustrated in Figure 1 (IPCC, 2011).

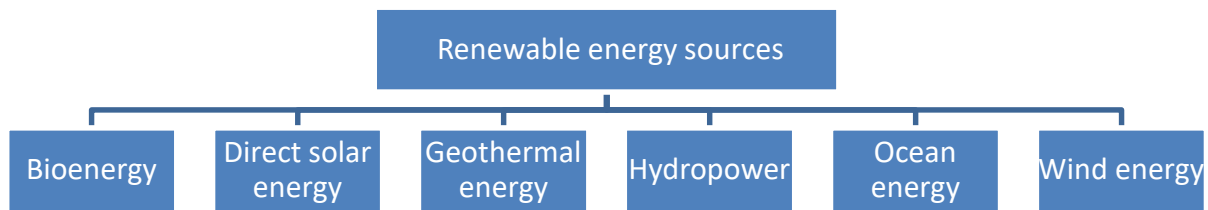


Figure 1. Renewable energy sources
 Source: Own survey based on IPCC (2011)

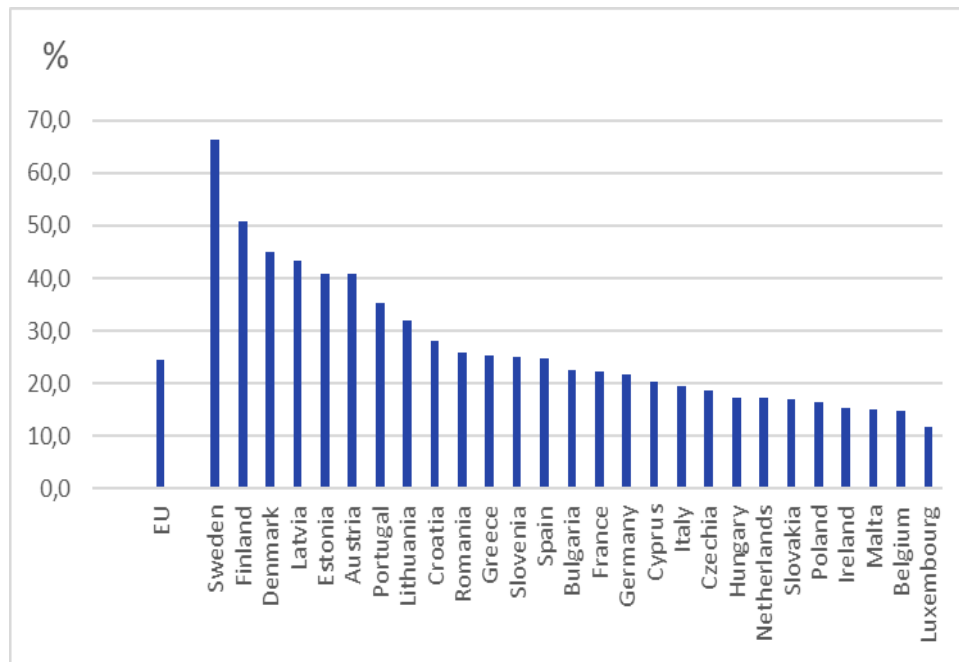


Figure 2. Share of total electricity generated by renewables, 2023 (%)
 Source: EUROSTAT, 2023

The Role of Renewable Energy in the European Union's Energy Transition: Trends and Targets by 2030

In 2023, renewable energy contributed significantly to the EU's overall energy consumption, accounting for 24.5%. The trend marked an increase from 2022, when the share was 23.0%, reflecting the EU's ongoing efforts to move away from fossil fuels and embrace more sustainable energy solutions. The share is around 1.5 percentage higher than the increase from the previous year and almost three times higher than the share of renewable energy in 2004, which was 9.6%. In parallel with this positive trend, the EU has set a new target for renewable energy for 2030, increasing it from

32% to 42.5%, and furthermore to 45%. As a result, the EU Member States will have seriously to increase their efforts to raise the share of renewable energy in the EU's total consumption by almost 20 percentage points by 2030 (EUROSTAT, 2023).

Based on the Eurostat data, figure 2 shows the share of renewable energy in the European Union. Sweden can be highlighted as the leading country, with an impressive 66.4% of its energy produced from renewable sources. Sweden relies mainly on solid biofuels, wind and hydropower. Notably, the country has surpassed other member states and even achieved the new EU target for 2030 of 42.5% in 2007.

The other country that has achieved the new EU target for 2030 is Finland, with 50.75%, which main energy sources are the same as utilized by Sweden. Denmark follows Finland with 44.9%, where energy is produced mainly from solid biofuels and wind power. In the Eastern Europe, the best results are registered in Latvia, with 43.22% of energy from renewable sources. The last place, in terms of share of energy from renewable sources, is occupied by Luxembourg (11.6%), Belgium (14.7%) and Malta (15.1%). Bulgaria achieved a renewable energy share of 22.6% in 2023.

The Energy Mix in Bulgaria in the Context of the EU: Achievements, Challenges, and Perspectives

Figure 3 illustrates the trend in renewable energy development, showing an upward tendency from 2004 to the present. The only exceptions are 2021 and 2022, where a decline from the 2020 levels is observed.

The renewable energy market in Bulgaria continues to grow rapidly, attracting significant investments in the large-scale projects. Currently, the country generates over 2,800 megawatts of solar energy and more than 700 megawatts of wind energy. By the end of 2025,

several new photovoltaic parks are expected to be build, increasing the share of renewable energy in the country. These projects will play a key role in expanding solar energy production capacity and contributing to the achievement of sustainable energy development goals (CEE, 2024).

Based on the results, several key conclusions can be drawn regarding the energy mix in Bulgaria compared to the EU. Nuclear energy in Bulgaria accounts for 41.8% of total energy, significantly above the EU average of 23.6%. On the other hand, the share of solar energy in Bulgaria is 14.4% compared to the EU average of 11%. Wind energy in the country is relatively low at just 4% compared to the EU average of 17.5%, while bioenergy shares are similar – approximately 5%. Fossil fuel energy in Bulgaria is 27%, slightly below the EU average of 28.8%. Despite the close levels, if coal is considered separately, the share of energy produced from fossils in Bulgaria is 21.6%, compared to 7.9% in the EU, which shows a significant difference. This trend highlights a serious issue with environmental pollution and climate change, considering the pollution from coal combustion (Wu *et al.*, 2024).

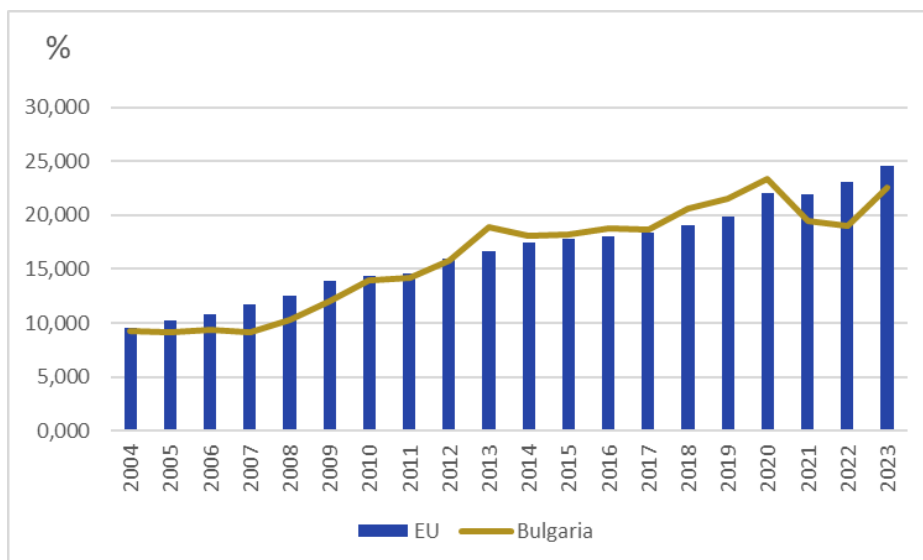


Figure 3. Share of the total electricity generated by renewables. Comparison between Bulgaria and the EU average, 2023 (%)
 Source: EUROSTAT, 2023

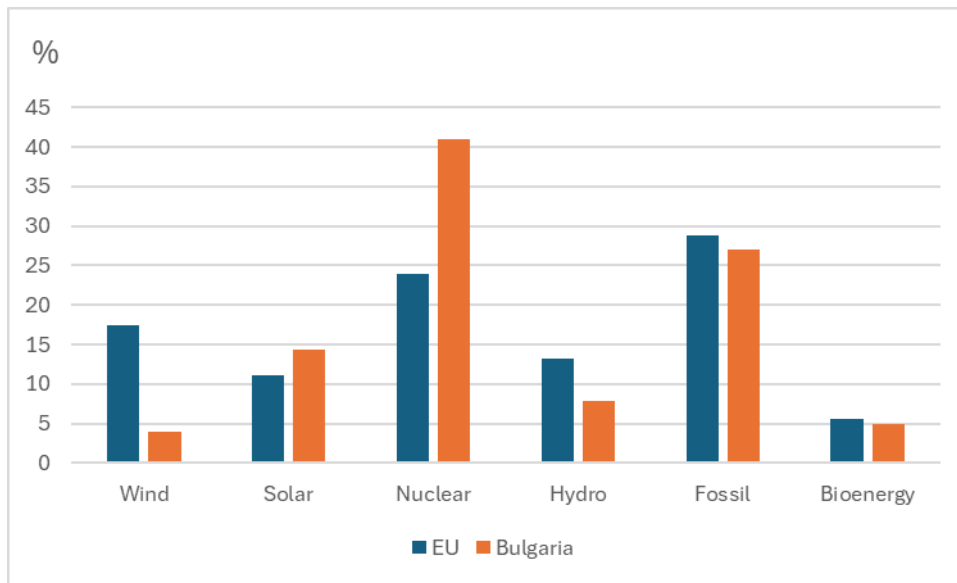


Figure 4. Electricity generation by source, 2024 (%).

Source: EMBER, 2024

Lignite is Bulgaria's primary local energy resource and plays a key role in the country's energy security. The Maritsa East complex, located in the country's southeastern part, is a major centre for coal mining and electricity production, operating for more than six decades (Todorov *et al.*, 2024).

The sharp rise in carbon emission prices in the EU, which reached 100 € per ton of CO₂ in 2023, and dramatically increases conventional electricity costs. This requires rapid political and technological measures to ensure energy security, transition to cleaner energy, and address socio-economic challenges (Trading Economics, n.d.).

Despite the issue with emissions, in October 2023, Bulgaria updated its climate neutrality roadmap, allowing coal-fired power plants to operate without restrictions until 2038. In December, the country received €1.2 billion from the Just Transition Fund to support reskilling over 15 000 people in the most coal-intensive regions. Apostolopoulos *et al.* (2023) explored how the coal-fired power plant workers can adapt their skills to transition to a green economy and renewable energy sources. They examined the different perspectives of workers and green entrepreneurs, highlighting

the differences between countries based on their energy systems and the need for tailored strategies for successful transition (Apostolopoulos *et al.*, 2023).

Although that various studies showed that the introduction of renewable energy sources have a positive impact on economic growth (Fareed *et al.*, 2022; Nikas *et al.*, 2020), some technologies, related to their implementation, face resistance from local communities in different countries (Atanasov *et al.*, 2021). An example from Bulgaria is the plan for building wind farms in the water area of the Black Sea, which encountered significant resistance from fishermen, coastal residents, environmentalists, and some hoteliers. They were concerned about the potential impact on fishing, marine ecosystems, and the tourism industry. Using the good examples of other European countries and their experience related to wind farms building in the coastal water areas would be beneficial. Another example from Bulgaria is considerable public dissatisfaction with large solar parks, which are often built on the fertile agricultural land, resulting in diminished future benefits and disruption to the local landscape. People express concerns about related to the projects environmental and social consequences on the

local ecosystems and natural environment. The negative attitudes of societies towards building huge solar energy parks in rural areas can challenge their realization. Locals often express concerns that these projects do not consider their economic interests and could disrupt their daily livelihoods. All these concerns and social tensions could slow down the development and implementation of renewable energy projects in the regions. Some authors emphasize the importance of public acceptance of such technologies (Ryghaug *et al.*, 2018). A thoughtful strategy and effective communication among social groups regarding renewable energy alternatives' ecological and financial advantages should be adopted.

Bulgaria has decided to start constructing two new nuclear reactors at the Kozloduy nuclear power plant to ensure the country's energy security in the future, and thus to reduce the use of fossil fuels. Increasing renewable sources and reducing fossil fuels will lead to global environmental benefits, such as decreased carbon emissions and improved air quality (Yuan *et al.*, 2022).

CONCLUSIONS

The EU is setting ambitious goals, which are expected to bring the EU-27 closer to achieving the 42.5% renewable energy target by 2030. Solar energy is the most widely used renewable energy source in Bulgaria. In contrast, wind energy is not implemented to its full potential despite the many locations with characteristics suitable for construction of wind farms. The high dependence of the Bulgarian energy system on fossil fuels will be the main challenge to achieve the climate goals outline in the Green Deal. Other demographic and educational factors, along with environmental awareness are important indicators for social acceptance of renewable energy technologies. Active participation of local communities, awareness, and building trust among stakeholders are required for successful

implementation of new projects. Despite the potential of renewable energy sources to contribute to economic growth and sustainability, obstacles such as high upfront costs, fossil fuel subsidies, and lack of coordination between authorities slow down their implementation. Overcoming these barriers requires appropriate incentives and coordinated efforts from all stakeholders. Additionally, in Bulgaria, geothermal energy and bioenergy hold significant potential as sustainable energy sources with minimal environmental impact on biodiversity. However, they are not yet being utilized to their full capacity.

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