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MILAN LUKIĆ[1]

[1]University of Niš,
Faculty of Occupational
Safety

[1]*milanlukic18031@gmail.com*

ALTERNATIVE SOURCES OF ENERGY AND SUSTAINABLE DEVELOPMENT IN NEIGHBOURING COUNTRIES OF SERBIA

Abstract: *The need for energy resources is constantly growing, on a global level. The effects of energy transformations degrade soil, water, and air quality. For this reason, it is necessary to increase investments in the development of alternative energy sources and increase the level of energy efficiency. A common issue in the Balkan countries is the excessive use of fossil fuels. This paper presents a comparative analysis of renewable energy source usage in Serbia, Bulgaria, Romania, Hungary, Croatia, Bosnia and Herzegovina, Montenegro, and North Macedonia. Based on the analysis, the paper concludes that the energy sectors of Croatia and Romania are making significant progress towards sustainable energy development in their respective energy sectors.*

Key words: alternative sources of energy, energy sector, sustainable development

INTRODUCTION

The contemporary issues of climate change and the energy crisis have led to the emergence of various environmental problems that require new approaches to energy development. Overcoming these significant challenges requires the application of alternative energy sources, improving energy technologies, increasing the level of energy efficiency and mitigating the consequences of energy transformations. The basic elements of the national energy policy are primarily a rational energy strategy and energy sustainable development based on available resources.

Energy indicators play a crucial role in addressing energy-related challenges. They are a fundamental component in implementing measures to enhance energy efficiency and are utilized for systematic identification and monitoring of the state and development of the energy sector. The main objective of employing energy indicators in environmental protection management is to achieve optimal energy efficiency by minimizing primary energy consumption and promoting more rational energy usage.

Energy indicators, which refer to energy consumption, alone without any connection to economic variables, do not provide sufficient information [4]. Therefore, linking economic and energy policy measures is necessary to implement an overall economic policy that enables the optimal use and consumption of energy in an economically and energetically efficient manner.

The significance of energy indicators lies in the fact that by comparing actual values obtained from collected data with common or standard values, it becomes evident which sectors can reduce energy consumption and which users are energy-efficient. This analysis provides valuable insights for organizations to effectively implement energy efficiency programs and make informed decisions pertaining to energy consumption and associated costs.

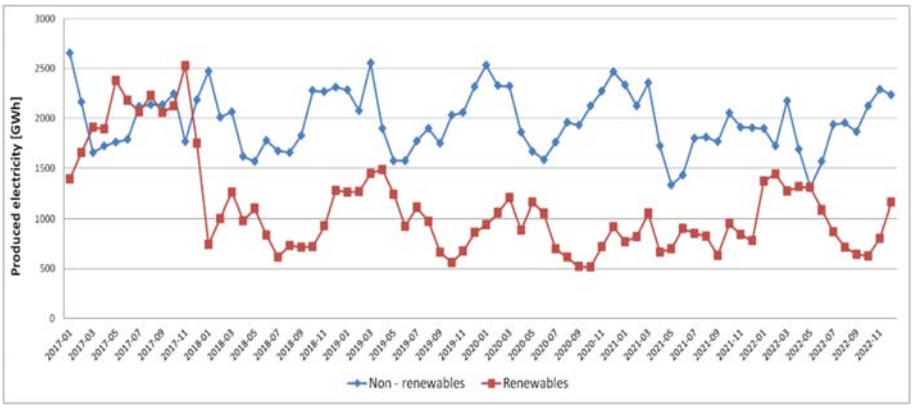
REPRESENTATION OF ENERGY SOURCES AS AN INDICATOR OF ENERGY DEVELOPMENT

Modern civilization, as well as the modern way of life, is based on the use of electricity, which is obtained from various energy sources. One of the indicators of greater significance for energy development is the energy consumption from renewable and non–renewable energy sources. This paper aims to analyze the significance of diverse energy sources in enhancing the state of the environment [2]. It conducts a comparative analysis of the approach to electricity generation and the associated expenses in Serbia and other countries from the region, namely Bulgaria, North Macedonia, Croatia, Montenegro, Bosnia and Herzegovina, Hungary, and Romania from 2017 to 2022.

Application of energy sources in the energy sector of Serbia

In Serbia, the main problem lies in the fact that the majority of energy production heavily relies on non-renewable sources such as fossil fuels, instead of renewable energy sources. This leads to high levels of pollution and environmental degradation. By shifting towards renewable energy sources, the country can significantly reduce its carbon footprint. Graph 1 illustrates the proportion of electricity generated from renewable and non-renewable sources.

The graph shows that in March 2017, 1958.00 GWh of electricity was obtained from renewable sources and 1656.00 GWh of electricity from non–renewable sources. In the same period of 2018, that number was 1304.00 GWh from renewable sources and 2064.00 GWh of electricity from non–renewable sources. In 2019, 1522.00 GWh of electricity was produced from renewable energy sources and 2552.00 GWh from non–renewable sources.

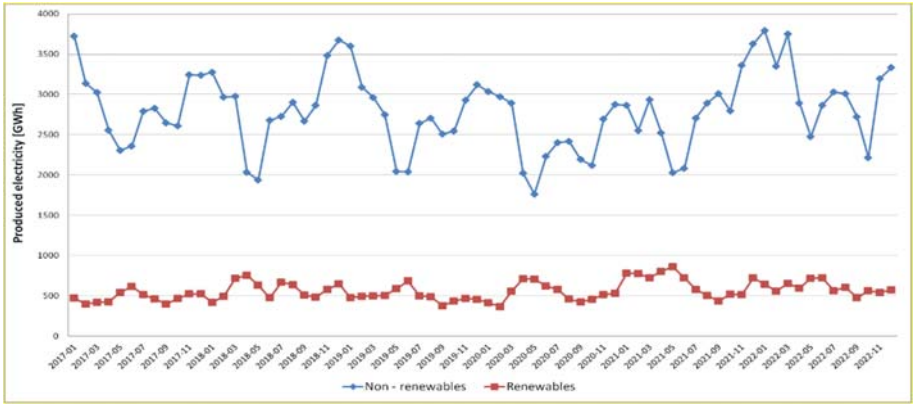


Graph 1. *Application of renewable and non–renewable energy sources in Serbia, from 2017 – 2022.[5]*

During 2020, 1277.00 GWh of electricity was generated from renewable sources and 2322.00 GWh of electricity from non–renewable sources. In 2021, 1045.00 GWh of electricity was obtained from renewable sources and 2355.00 GWh from non–renewable sources. In the last year, 2022, 1251.00 GWh of electricity was obtained from renewable energy sources and 2174.00 GWh from non–renewable sources. Based on these data, it can be concluded that electricity obtained from renewable sources gradually has been decreasing over the years, on the other hand, the production of electricity from non-renewable sources continues to grow from year to year.

Application of energy sources in the energy sector of Bulgaria

In Bulgaria the amount of electricity produced from renewable sources is– renewable very low, as shown in the following Graph 2. According to the graph data, in March 2017, 418.00 GWh of electricity was obtained from renewable sources and 3026.00 GWh of electricity from non – renewable sources. In the same period of 2018, that number was 752.00 GWh from renewable sources and 2978.00 GWh of eletricity from non sources. In 2019, 532.00 GWh of electricity was obtained from renewable energy sources and 2961.00 GWh of electricity from non – renewable sources.



Graph 2. *Application of renewable and non–renewable energy sources in Bulgaria, from 2017 – 2022.[7]*

In 2019, 532.00 GWh of electricity was obtained from renewable energy sources and 2961.00 GWh of electricity from non–renewable sources. During 2020, 519.00 GWh of electricity was generated from renewable sources and 2891.00 GWh from non–renewable sources. In 2021, 782.00 GWh of electricity was obtained from renewable sources and 2936.00 GWh from non–renewable sources. In the last year, 2022, 643.00 GWh of electricity was produced from renewable energy sources and 3751.00 GWh from non–renewable sources.

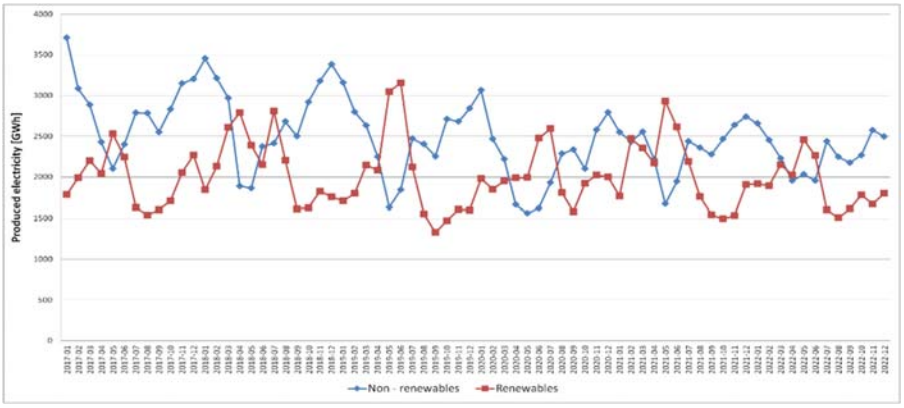
It can be concluded that in Bulgaria the use of renewable energy sources does not vary, generally it has approximate values and is used very low. It follows from this that the use of non-renewable sources should be reduced while the use of renewable sources should be increased in order to achieve sustainable development and decrease the amount of environmental pollution.

Application of energy sources in the energy sector of Romania

Romania employs renewable energy sources at nearly the same rate as non-renewable sources, according to the data in Graph 3. This indicates the country's commitment to a sustainable energy future

The graph shows that in March 2017, 2200.00 GWh of electricity was obtained from renewable sources and

2887.00 GWh of electricity from non – renewable sources. In the same period of 2018, that number was 2607.00 GWh from renewable sources and 2971.00 GWh of eletricity from non – renewable sources. In 2019, 2148.00 GWh of electricity was obtained from renewable energy sources and 2633.00 GWh from non – renewable sources.



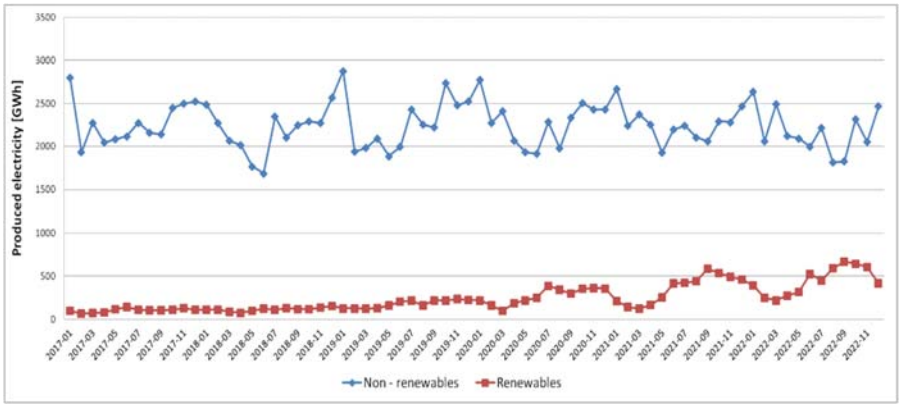
Graph 3. *Application of renewable and non–renewable energy sources in Romania, from 2017 – 2022.[7]*

During 2020, 1951.00 GWh of electricity was produced from renewable sources and 2221.00 GWh from non – renewable sources. In 2021, 2353.00 GWh of electricity was obtained from renewable sources and 2557300 GWh from non – renewable sources. In the last year, 2022, 2153.00 GWh of electricity was produced from renewable energy sources, and 3230.00 GWh of energy from non – renewable sources.

Based on the graph, it can be concluded that Romania has a good renewable capacity, due to the fact that a large amount of electricity is obtained from renewable sources, which causes less environmental pollution.

Application of energy sources in the energy sector of Hungary

Hungary has very low electricity production from renewable resources as shown in Graph 4. In March 2017, it received 92.00 GWh of electricity from renewable sources and 2275.00 GWh of electricity from non–renewable sources. In 2019, 143.00 GWh of electricity was obtained from renewable energy sources and 1982.00 GWh from non–renewable sources. In the same period of 2018, that number was 106.00 GWh from renewable sources and 2065.00 GWh of electricity from non–renewable sources. During 2020, 2410.00 GWh of electricity was generated from renewable sources and 231.00 GWh of electricity from non–renewable sources. In 2021, 322.00 GWh of electricity was obtained from renewable sources and 2370.00 GWh from non–renewable sources. In the last year, 2022, 2493.00 GWh was obtained from renewable energy sources and 457.00 GWh from non–renewable sources.



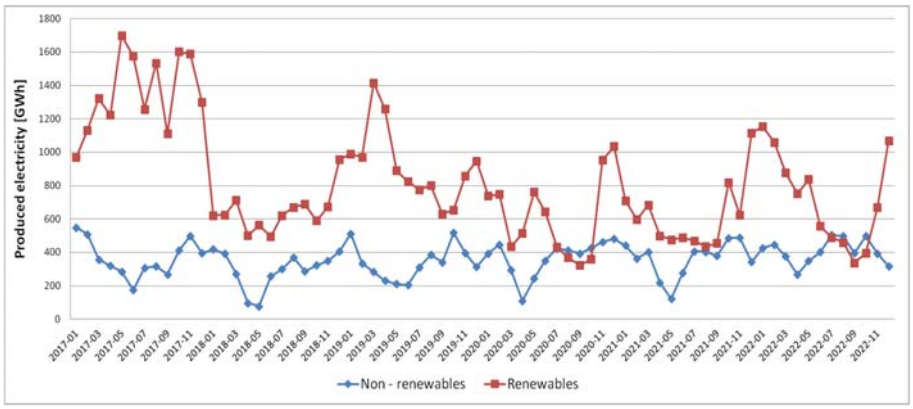
Graph 4. *Application of renewable and non–renewable energy sources in Hungary, from 2017 – 2022.[7]*

Based on the data one can come to the conclusion that Hungary does not invest enough in reducing the amount of pollution, due to the fact that it mainly uses non–renewable energy sources while using renewable ones in minimal quantities

Application of energy sources in the energy sector of Croatia

Croatia represents a country that mainly uses renewable energy sources and takes care of environmental pollution, which can be seen from Graph 5.

The graph shows that in March 2017, 1215.00 GWh of electricity was produced from renewable sources and 357.00 GWh of electricity from non-renewable sources.

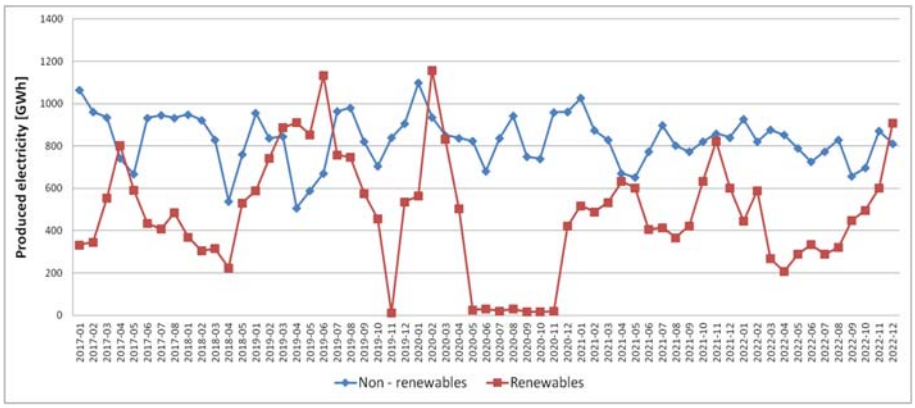


Graph 5. *Application of renewable and non–renewable energy sources in Croatia, from 2017 – 2022.[7]*

In the same period of 2018, that number was 758.00 GWh of electricity from renewable sources and 271.00 GWh from non-renewable sources. In 2019, 1250.00 GWh of electricity was obtained from renewable energy sources and 284.00 GWh from non-renewable sources. During 2020, 556.00 GWh of electricity was obtained from renewable sources, and 294.00 GWh of electricity from non-renewable sources. In 2021, 645.00 GWh of electricity was obtained from renewable sources and 401.00 GWh from non-renewable sources. In the following year, 2022, we received 842.00 GWh of electricity produced from renewable energy sources and 375.00 GWh from non-renewable sources.

Application of energy sources in the energy sector of Bosnia and Herzegovina

In recent years, Bosnia and Herzegovina has been fluctuating between relying on renewable and non-renewable energy sources, as illustrated in Graph 6. Based on the use of these sources, it can be concluded that Bosnia and Herzegovina is established around the average in terms of pollution and that the values are, according to the use of renewable and non-renewable energy sources, approximate.



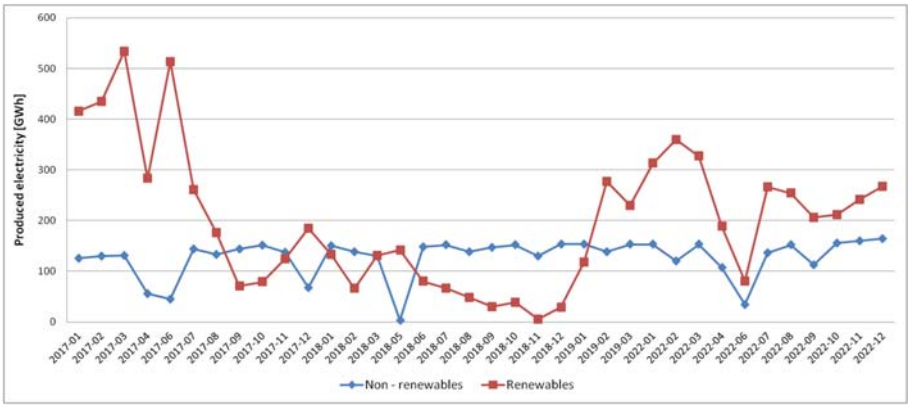
Graph 6. *Application of renewable and non–renewable energy sources in Bosnia and Herzegovina, from 2017 – 2022.[7]*

From the graph, it can be seen that in March 2017, From the graph, it can be seen that in March 2017, 467.00 GWh of electricity was produced from renewable sources and 936.00 GWh of electricity from non-renewable sources. In the same period of 2018, that number was 325.00 GWh of electricity from renewable sources and 830.00 GW from non-renewable sources. In 2019, 888.00 GWh of electricity was obtained from renewable energy sources and 846.00 GWh from non-renewable sources. During 2020, 800.00 GWh of electricity was generated from renewable sources, and 851.00 GWh of electricity from non-renewable sources. In 2021, 529.00 GWh of electricity was obtained from renewable sources and 828.00 GWh from non-renewable sources. In the following year, 2022, it produced 236.00 GWh of electricity from renewable

energy sources and 876.00 GWh from non-renewable sources.

Application of energy sources in the energy sector of Montenegro

Montenegro has made significant strides in transitioning to renewable energy sources in recent years, which has led to a reduction in pollution levels. As of the latest available data, Montenegro has been predominantly using renewable energy sources to meet its energy needs. However, it is worth noting that there is currently no data available for 2020 and 2021, which can be analyzed from Graph 7. Continued use of renewable energy sources in Montenegro would be a significant step towards a cleaner and more sustainable environment.

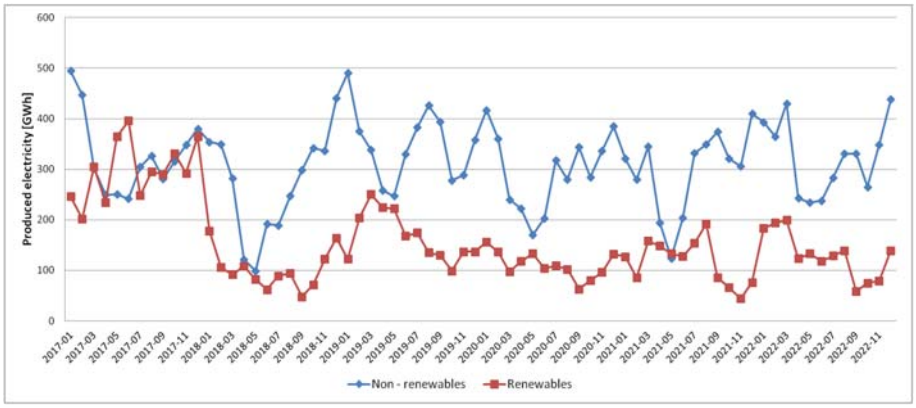


Graph 7. *Application of renewable and non–renewable energy sources in Montenegro, from 2017 – 2022.[7]*

From the graph, it can be concluded that in March 2017, 610.00 GWh of electricity was obtained from renewable sources and 131.00 GWh of electricity from non-renewable sources. In the same period of 2018, that number was 233.00 GWh of electircity from renewable sources and 130.00 GWh from non-renewable sources. In 2019, 230.00 GWh of electricity was obtained from renewable energy sources, and 153.00 GWh from non-renewable sources. We do not have data for the years 2020 and 2021.

Application of energy sources in the energy sector of North Macedonia

North Macedonia primarily relies on non-renewable sources, leading to significant pollution levels as presented in Graph 8. In 2019, 236.00 GWh of electricity was obtained from renewable energy sources and 338.00 GWh of electricity from non-renewable sources. During 2020, 98.00 GWh of electircity was produced from renewable sources and 240.00 GWh of electricity from non-renewable sources.



Graph 8. *Application of renewable and non–renewable energy sources in North Macedonia, from 2017 – 2022.[7]*

In 2021, 156.00 GWh of electricity was obtained from renewable sources and 345.00 GWh from non-renewable sources. In the following year, 2022, it produced 193.00 GWh of electricity from renewable energy sources and 430.00 GWh from non-renewable sources. Considering the data, it can be stated that North Macedonia uses mainly non-renewable energy sources and therefore has a large amount of pollution.

CONCLUSION

The consequences of climate change have significantly The consequences of climate change have significantly increased the importance of energy efficiency as a crucial component of sustainable living and economic development. The primary objective of energy indicators, in general, is to enhance energy efficiency and mitigate energy consumption, which ensures the optimal use of energy resources.

Total energy consumption at the global level is increasing year by year. At the global level, non-renewable energy sources are mostly used for energy production; however, in recent decades, the most developed countries of the world have plans to reduce the consumption of primary forms of energy and to increase the use of renewable energy sources.

As for the situation in the Republic of Serbia, although fossil fuels are still the dominant source of energy in total consumption, the share of renewable energy sources has grown significantly in recent years. The use of renewable energy sources is extremely important because it reduces the amount of pollution, which is important from the aspect of environmental protection. On the other hand, the use of non-renewable energy sources, besides shortening the period of their future use, affects the growth of global warming, with very serious consequences for human health and the environment.

Observed within the situation in the region, Croatia and Romania can serve as good examples of how renewable energy sources should be used, given that these two countries get most of their electricity from renewable sources.

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BIOGRAPHY of the author

Milan Lukić was born in Prokuplje, Serbia, in 2000.

He received the diploma in occupational safety engineering and the MSc. degree in fire protection engineering from the University of Nis, Faculty of Occupational Safety in Nis.

His main areas of research include fire protection, occupational safety and health, environmental protection, etc.

ALTERNATIVNI IZVORI ENERGIJE I ODRŽIVI RAZVOJ

Milan Lukić

Rezime: *Potreba za energetskim resursima je u stalnom porastu, na globalnom nivou. Posledice energetskih transformacija narušavaju kvalitet vazduha, vode i zemljišta. Neophodno je povećati ulaganja u razvoj alternativnih izvora energije i povećati nivo energetske efikasnosti. Karakterističan problem balkanskih zemalja je visok nivo upotrebe fosilnih goriva. U radu je izvršena uporedna analiza primene obnovljivih izvora energije u Srbiji, Bugarskoj, Rumuniji, Mađarskoj, Hrvatskoj, Bosni i Hercegovini, Crnoj Gori i Severnoj Makedoniji. Na osnovu analize u radu se zaključuje da energetski sektori Hrvatske i Rumunije ostvaruju značajan napredak ka održivom energetskom razvoju u svojim energetskim sektorima.*

Ključne reči: alternativni izvori energije, energetski sektor, održivi razvoj.