

Usability of renewable energy in Bulgaria - challenges, opportunities and barriers

Nedelin Markov^{1*}

¹Trakia University, Faculty of economics, Stara Zagora, Bulgaria,

Abstract. Energy is a resource that both drives the world economy, but also sustains the existence of individuals. Energy is a strategic good that provides advantages for some and disadvantages for others. Traditional energy sources are not evenly distributed, and this is a challenge for politicians and economists to meet the ever-increasing energy demand. Renewable energy sources bridge the gap between traditional understandings of growth and modern demands for environmental protection. They are a compromise between the past and the future. The purpose of the report is to synthesize the possibilities and limitations of the use of renewable energy in Bulgaria. The research used empirical methods such as analysis and survey. The results, as expected, confirm that in our country there are unused opportunities for the development of energy production from renewable sources. The conclusions show that the poorly regulated electricity market, regulatory restrictions, and the low incomes of Bulgarians are a deterrent to the more intensive use of renewable energy.

1 Introduction

Energy is a resource that both drives the world economy, but also sustains the existence of individuals. Energy is a strategic good that provides advantages for some and disadvantages for others. Traditional energy sources are not evenly distributed, and this is a challenge for politicians and economists to meet the ever-increasing energy demand. Renewable energy sources bridge the gap between traditional understandings of growth and modern demands for environmental protection. They are a compromise between the past and the future. The purpose of the report is to synthesize the possibilities and limitations of the use of renewable energy in Bulgaria. The research used empirical methods such as analysis and survey. The results, as expected, confirm that in our country there are unused opportunities for the development of energy production from renewable sources. The conclusions show that the poorly regulated electricity market, regulatory restrictions, and the low incomes of Bulgarians are a deterrent to the more intensive use of renewable energy. Europe is amid the most severe energy crisis since the oil price shock of 1973. Since mid-2021, spot prices of natural gas have been on a steep rise, reaching levels of €100–200 MWh⁻¹ in 2022. This is about ten times the long-term pre-COVID-19 pandemic price levels of €15–20 MWh⁻¹. Specific events, such as Russia's invasion of Ukraine on 24 February 2022 and Russia's

* Corresponding author: nedelin.markov@trakia-uni.bg

announcement of closing the Nord Stream 1 pipeline on 19 August 2022, led prices to spike up to €227 and €339 MWh⁻¹, respectively. Meanwhile, the average gas price paid by German industry has increased sixfold when it peaked in September 2022, somewhat lagged and dampened by long-term contracts. Average German residential retail prices increased more than twofold between January and November 2022, before a political intervention substantially reduced households' energy bills in December 2022 [1].

The Bulgarian economy is characterized by high external energy dependence, as well as not particularly good resistance to international economic influences. For this reason, the prevailing situation had a negative impact both on the energy markets and on all production and trade chains. The international crisis came at a time when the exchange mechanisms for trading electricity for business users were being legally imposed and confirmed. In a not particularly stable market environment for electricity trade, accompanied by international political pressure, price values were registered that are a challenge to the entire Bulgarian economy. In fig. 1 presents information on the price of electricity and realized exchange volumes on the Bulgarian Independent Energy Exchange. The figure shows that during the summer months the price of traded electrical energy exceeds BGN 1.2 thousand for 1 MWh. Whole branches of the Bulgarian economy were faced with the real danger of stopping their activity. In an effort to regulate the price pressure, the Bulgarian government resorted to non-market measures and directly subsidized all excesses above BGN 250 per 1 MWh. This, in turn, stabilized the Bulgarian economy, but on the other hand, it led to a serious outflow of public resources from the Bulgarian budget system. In terms of electricity production, Bulgaria is a traditional producer and net exporter. The opening of the electricity market led to a high and non-competitive demand for the Bulgarian economy.

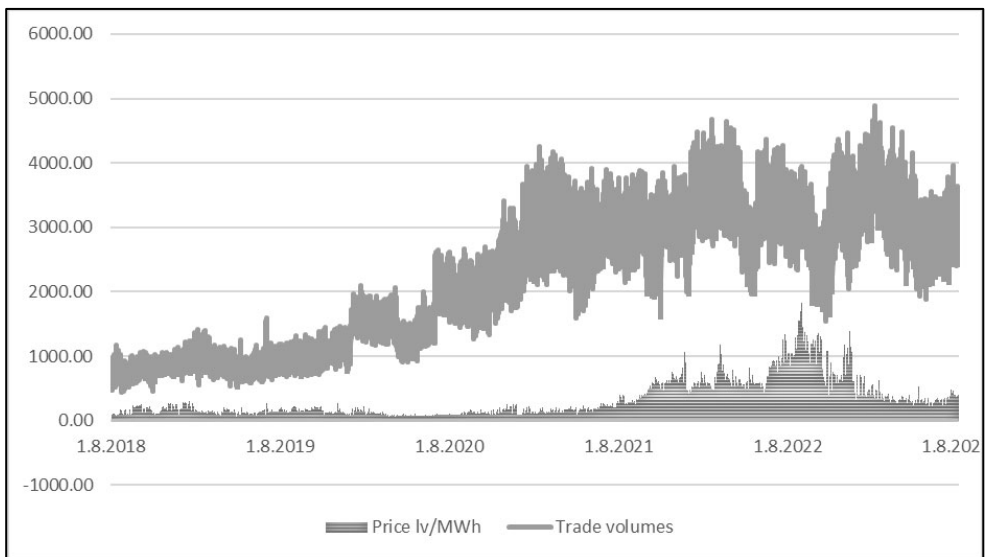


Fig. 1. Price of electric energy and number of transactions realized on the Bulgarian Independent Energy Exchange in the period 2018-2023.

Source: Bulgarian Independent Energy Exchange, <https://ibex.bg/> [2]

Along with the rise in electricity, there was also a price shock in the natural gas trade. Almost all of Europe was dependent on gas supplies from Russian producers. Due to irrational political decisions, Russian gas was almost completely removed from the gas mix of Europe. The lack of real volumes of piped gas from Russia were replaced by imports of liquefied gas of various origins. Eastern Europe was not technically ready for such a change.

As a result, the LNG terminals in Greece and Turkey have become of high strategic importance.

All this led to price peaks, which at times coincided with the rise in the price of electricity. Figure 2 shows the change in the price of natural gas on the Amsterdam stock exchange.

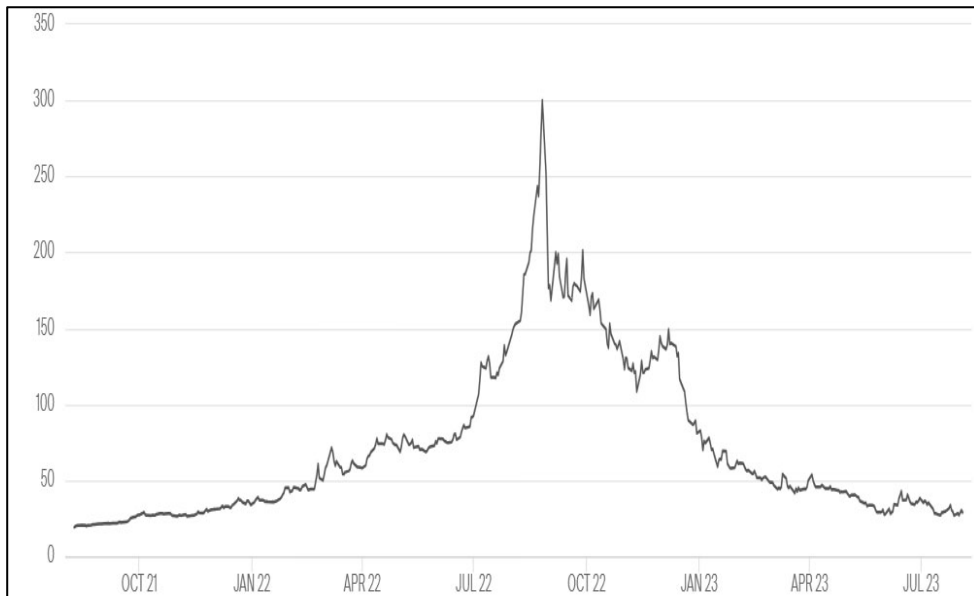


Fig. 2. Natural gas index price in the period 2018-2023 on the Amsterdam Stock Exchange. Source: Dutch TTF Natural Gas Futures, <https://www.ice.com/> [3]

The upheavals in the markets of energy raw materials, as well as their unfavorable consequences on the Bulgarian economy, brought the conversation about the origin of electric energy back to the fore. Investors in electricity generation, Bulgarian businesses and end-users should answer the following important questions:

1. Which power generation will ensure energy independence and long-term sustainability?
2. How will the challenges of climate change and consequent regulatory environmental constraints be met?
3. What is the affordable price of electricity, so as to ensure the competitiveness of the Bulgarian economy?

2 Analysis

All these questions remain without a clear answer, especially since they are related to decisions that have a horizon between 30 and 50 years. Preferential purchasing of energy and various forms of subsidies are of great importance for the development of renewable sources in Bulgaria. Green energy subsidies have had a positive impact historically, but their importance should not be overstated. Controversial some authors subsidies could even have a negative impact on the structure of electricity production, noting the importance of legal regulation.

Therefore, subsidies for clean energy should likewise be maintained at a reasonable level. Environmental restrictions, according to studies, have a favorable impact in fostering green growth. **The** government should also continue to strengthen relevant laws and regulations to ensure that laws, rules, and policies incorporate economic incentives while also taking

mandatory requirements into consideration. Besides, a reliable monitoring mechanism is also essential. [4].

In recent time, the growing demand arising from increased economic activities and population increase in addition to the drive to mitigate the effects of global warming has led to advances in alternate energy sources. In the advance economies such as the United States, the pressure from both the domestic actors and intergovernmental agencies is largely responsible for the increased development of cleaner energy sources. [5]

A key point in the solution of the complex task is the extent to which there is investment interest in the development of balancing capacities that would provide a solid energy base for the national economy and Bulgarian citizens. Unfortunately, all major projects in balancing capacities have failed spectacularly. The project for a nuclear power plant in Belene is nearing its final completion, and the potential modernization of the existing plant in Kozloduy has not even started as a concept project at all. At the same time, the fate of coal-fired power plants is becoming increasingly unclear due to pressure from the European Union and increasingly high environmental requirements for their operation. Greenhouse gases, including CO₂ emissions create more and more environmental problems. The wave of the global fervor for industrialization has come with its attendant effect of increasing CO₂ emissions which consequently, causes natural reactions in the form of environmental pollution, global warming and climate change [6].

The 2022 energy crisis has given coal plants a new boost, but European administrators are not backing down from the EU's environmental targets. In all this chaos, investment interest in renewable energy sources has grown again. In the table 1 presents information on the installed power generation capacities from renewable energy sources.

Table 1. Installed capacities and gross electricity production for the period 2015-2022. Source: Electricity operator of Bulgaria, <https://www.eso.bg/>

	2017		2018		2019		2020		2021		2022	
	Installed capacities MW	Gross electricity production TWh	Installed capacities MW	Gross electricity production TWh	Installed capacities MW	Gross electricity production TWh	Installed capacities MW	Gross electricity production TWh	Installed capacities MW	Gross electricity production TWh	Installed capacities MW	Gross electricity production TWh
Hydroelectric plant	3204	3,5	3208	5,4	3211	3,4	3213	3,4	3213	5,1	3214	3,8
Wind turbines	701	1,5	700	1,3	701	1,5	701	1,5	705	1,4	705	1,5
Photovoltaic power plants	1046	1,4	1052	1,4	1059	1,3	1121	1,5	1246	1,5	1726	2,0
Biogas power plants	77	0,4	77	0,3	77	0,4	79	0,4	79	0,3	77	0,3

From the table it is clear that the installed capacities for the production of energy from water and wind keep the same level. Investment in solar power plants shows growth that is smooth until 2020 and dynamic in 2022. In 2022, the capacity of solar power plants will increase by almost 40%. This growth coincides with electricity price shocks. The high final cost of electricity and increasingly accessible technologies lead to similar growth. The following question can be reasonably asked here. To what extent a similar type of technology satisfies the users of the Bulgarian energy market. In fig. 3 presents information on the traded volumes on any date of the summer season - 02.08.2023 in the segment "Within the day".

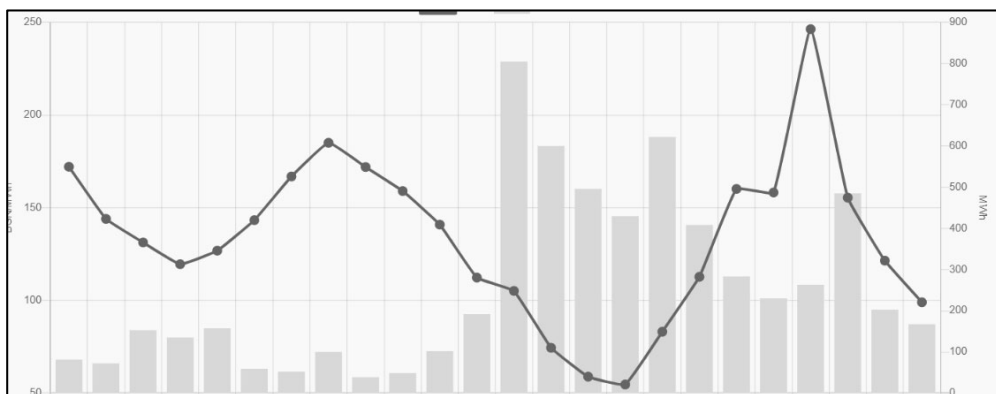


Fig. 3. Traded volumes of electricity on the Bulgarian Independent Energy Exchange on August 2, 2023.

Source: Bulgarian Independent Energy Exchange, <https://ibex.bg/>

It can be seen from the figure that the prices of traded energy rise until around 08:00 on the working day, after which the prices start to fall, which is the result of the excess non-energy supply. This excess coincides with the active part of the day when the solar plants operate. In fig. 4 presents the graph for trading on a random working winter day - 25.01.2023 in the "Intraday" segment.



Fig. 4. Traded volumes of electricity on the Bulgarian Independent Energy Exchange on January 25, 2023.

Source: Bulgarian Independent Energy Exchange, <https://ibex.bg/>

From the figure, the opposite trend is visible. As a result of the higher demand for electrical energy and the limited production of energy from renewable energy sources (including from the sun), the price of energy remains high almost throughout the day. In fig. 5 the two figures are superimposed.

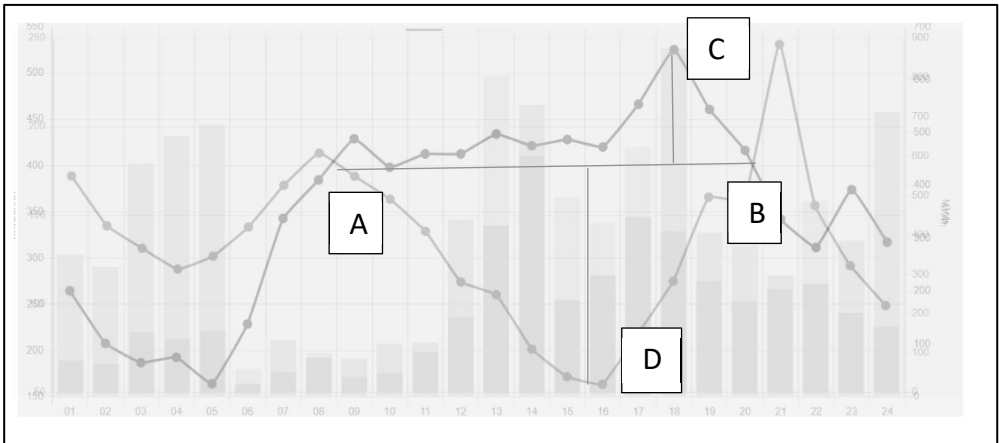


Fig. 5. Electricity prices on a random winter and summer day

It is clear from the figure that seasonal imbalances exist in the Bulgarian energy market, which prevent an objective assessment of how effective the installation of renewable energy production capacities is. These imbalances are confined in a polygon, which is formed by two peculiar triangles. This polygon represents the so-called Zone of energy dependence. The straight AB represents that price at which the price difference in the two seasons is equalized, and the two heights represent the deviations between the actual prices and the potentially equalized (AB). To reduce the faces of the two triangles, it is necessary to reduce the segment AB or to reduce the two heights. The reduction of the segment AB is related to the daily life of Bulgarian citizens, the duration of the production process, etc. Not that it is impossible, but influencing such facts is difficult. However, it is more achievable to limit the differences in the supply of electricity between winter and summer.

3 Conclusions

This would be achieved through the following measures:

1. Investing in the production of energy from RES should be accompanied by investing in storage capacities. Electrical energy has one major weakness that humanity has struggled to overcome, namely that electricity is difficult to accumulate on a large scale. As technology and materials develop, batteries are becoming more usable and more affordable for storing large amounts of energy. Every single unit of installed capacity for the production of energy from RES must go with a clear plan for storing the energy in batteries, which will offer the energy at exactly the most suitable moment for the market. In addition, studies are being conducted on the possibilities of accumulating sunlight and its later utilization. Photoswitches are organic or organometallic chromophores that undergo a reversible chemical transformation upon absorption of light. In other words, such a photoswitch acts as a battery that captures solar energy, stores it as chemical potential and releases it on demand as heat. This process is known as molecular solar thermal energy storage or a molecular solar thermal battery. Unlike the more established conventional solar thermal storage, which uses sunlight to heat, melt or vaporize material, molecular solar thermal energy storage does not require thermal insulation to prevent discharge but relies on the kinetic activation barrier separating the two isomers. Unlike solar-to-chemical energy conversion by photosplitting of H₂O or photoreduction of CO₂, which comprise open-system cycles, photoswitches are thermodynamically closed storage media.[8].

2. The development of alternative storage plants is an important decision. We should not forget that nature has given us natural accumulators that can convert energy according to the

needs of the market. Such an accumulator is, for example, water. In the built "Chaira" pumped-storage hydropower plant, a volume of water is used, which passes through a pump-generator cycle. When there is an excess of electrical energy, the water is pumped into a higher reservoir by electric pumps, and when energy is needed, the water is discharged into the lower reservoir by driving generator turbines that produce electricity. The increasing penetration of renewable energy sources in the power system has highlighted the benefits of being able to store energy in a more efficient manner, and the need of holding additional operating reserves to manage the system under more demanding conditions due to the inherent uncertainty and variability of wind and solar power. Pumped hydroelectric energy storage (PHES) is by far the most established technology for energy storage at a large-scale. [9]

3. Hydrogen may prove to be the missing link between the producers of electricity and those who consume it. Electrolyzers for hydrogen production consume a lot of electrical energy. Hydrogen produced by water electrolysis coupled with renewable energy—the so-called green hydrogen—is a promising alternative to fossil fuels. It does not emit CO₂ and almost no air pollution when used, thus offering a solution to decarbonize industrial processes and economic sectors. [10]

4. The development of balancing capacities is important. The transition to completely green energy is impossible. Energy production from RES has a strong seasonality. In a country like Bulgaria, which has a well-defined moderate and transitional - continental climate, it is necessary to maintain generating capacities that work with traditional energy resources. In this regard, the debate on the development of new nuclear capacities is important. Since the planning and implementation of such investments has a long-term horizon, coal plants should not be dismissed hastily. The operation of coal-fired power plants is becoming increasingly complex due to rising carbon prices and environmental constraints. However, coal plants are the last insurance for the Bulgarian economy.

References

1. O. Ruhnau, C. Stiewe, J. Muessel, *Nature Energy* **8**, 621–628 (2023)
2. Independent Bulgarian Energy Exchange, Data: Markets – Prices and Volumes, [Online] <https://ibex.bg/>
3. Dutch TTF Natural Gas Futures, Statistics, [Online] <https://www.ice.com/>
4. X. Wang, Z. Zhang, Z. Guo, C. Su, L. Sun, *J. Clean. Prod.* **398**, 136626 (2023)
5. A. Alola, S. Akadiri, *Renewable Energy* **169**, 221-230 (2021)
6. F. Adedoyin, I. Ozturk, I. Abubakar, T. Kumeke, O. Folarin, F. Bekun, *J Environ Manage.* **266**, 110628 (2020)
7. Operator of Bulgarian electricity system, Statistical book, [Online] <https://www.eso.bg/>
8. C. Sun, C. Wang, R. Boulatov, *Chemistry Europe* **3**, 6, 268-283 (2019)
9. J. Pérez-Díaz, M. Chazarra, J. García-González, G. Cavazzini, A. Stoppato, *Renew. Sust. Energ. Rev.* **44**, 767-784 (2015)
10. A. Santos, M. Cebola, M. F. Santos, *Energies* **14**, 11, 3193 (2021)