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# Production of Electricity at the European Union Level vs. Romania

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**Abstract:** The purpose of this paper is to carry out a quantitative analysis of the electricity production at the level of the European Union (EU) and in Romania, in the period of 2011-2020. To address the current environmental concerns, the package "Fit for 55" proposes that by 2050, most of the energy production will have to come from renewable sources, but the question is whether this desideratum can indeed be achieved. Among the methods used in scientific research, the quantitative analysis was selected and applied in this paper, in order to carry out a detailed statistical analysis on the trend of increase or decrease in the electricity production from different energy resources, and then comparative analysis was performed, so as to draw relevant conclusions in this respect. Through this study, it can be found that, at the level of the European Union, the electricity production from renewable energy resources is increasing, while that from solid fossil fuels is decreasing. In Romania, the same trend of increase and decrease can be observed, except on a smaller scale. Accordingly, the greatest increase in electricity production was recorded from renewable energy resources, for both the EU and Romania, while the biggest decrease in electricity production from fossil fuels. In order to address the decarbonization of the energy system in Romania, the hypothesis that the decrease in total electricity production is due to the decrease in electricity production from solid fossil fuels was tested. However, this hypothesis was only partially confirmed, since the production of electricity from other energy resources, apart from renewable resources and natural gas, also experienced a similar downward trend.

**Keywords:** Economy; Energy; Production of electricity; Sustainable development goals; National recovery and resilience plan; Decarbonization

## 1. Introduction

What is electricity? To answer this question, we must start from an everyday reality. It can be said that in the XXI century, it is used in almost all types of activities, from household life to industrial production, and that the modern society cannot run without it. In fact, the phenomenon of electrification has been noted since antiquity - around BC 600, Thales of Milet made a series of observations regarding electricity [1].

This phenomenon has been studied over time, but the first grounded studies regarding this subject were carried out in the XVI century, when William Gilbert showed the distinction between electricity and magnetism. Another contribution he made in the field of magnetism and electricity is the explanation of the functioning of the compass by the fact that the Earth would be a huge magnet [2].

According to the chronological thread of events, the beginning of industrial use of electricity happened in the XIX century, when Thomas Alva Edison invented the light bulb and presented it to the general public [3]. Since then, the use of electricity has become essential.

Electricity can be produced as primary and secondary energy. Primary electricity is obtained from natural sources such as solar, wind, hydro, tidal or wave energy, while secondary electricity from nuclear fission heat of nuclear fuels, geothermal heat and solar thermal heat, and by burning primary fuels such as coal, natural gas, oil, renewables and waste. After the electricity is produced, it is distributed to final users through national or international transmission and distribution networks [4].

It is obvious that the electricity sector has undergone huge changes, at least in recent years. An eloquent example of this is the liberalization of the electricity market. All advanced economies unanimously advocate the

competitiveness, sustainability and reliability of this energy sector. In recent years, the energy sector has been in the spotlight due to several problems that had arisen along the way, such as price volatility, and disruptions in energy supply. Another prominent problem is the anthropogenic effects of energy use on the climate (those caused by man), and in particular, its substantial contribution to the increase in greenhouse gas emissions.

At the EU level, general concerns about global warming as well as the negative impact of greenhouse gases have increased significantly, and the effort to take more care in this area and to have a much more conscious behavior has resulted in the adoption of a series of official documents and regulations to support the counteraction of these negative phenomena. In December 2019, the "European Green Deal" was adopted [5], whereby the EU aims to be climate neutral in 2050. It provides an action plan to boost and raise awareness of resource efficiency by moving to a clean, circular economy, restore biodiversity and reduce pollution. Achieving this ambitious target will require actions by all sectors of the member states, namely making new investments in green technologies, ensuring cleaner, healthier and cheaper public/private transport, supporting innovation, and decarbonizing the energy sector. The "Fit for 55" package contains a set of proposals to review current legislation on climate, transport, energy and taxation as well as new legislative initiatives to align the EU legislation with climate objectives. Regulation no. 943/2019 on the internal market for electricity is another official document to support those established by the "European Green Deal", which entered into force on the 1st of January 2020 [6]. "The Clean Energy for all Europeans" package sets out the fundamental principles for an efficient electricity market and the clean energy transition.

On the other hand, the Paris Agreement of 2015 provides for the global temperature increase to be kept below 2°C, while at the same time requires the reduction of greenhouse gas emissions [7]. But what are the means to achieve this? It can be seen that every day, fossil fuel is still maintaining its leading position while its weaknesses are being ignored [8]. This has prompted a transition towards clean energy in all sectors of the economy, including the electricity sector [9]. Without decarbonization, the global efforts to reduce the air temperature will not be effective [10]. In an optimistic scenario, it can be said that at the global level, a first step has been taken in this direction, by approving the Paris Agreement, according to which the vast majority of signatory countries have committed to increasing the share of renewable energy for the production of electricity in order to combat global warming [11]. But what will happen next remains to be seen, as the decarbonization of the electricity sector is still being discussed [12]. Even though in recent years, significant technological progress has been registered regarding the low-carbon resources for electricity production, the economic and operational characteristics of these resources and their abilities to meet the demand of electricity in a reliable way, vary from case to case [13, 14].

To move towards a low-carbon future, monitoring and measuring greenhouse gas emissions from electricity production is essential for any country [15]. Many studies have been done in this regard, one of them being the one conducted by Mohammadnejad et al. [16], which reached the conclusion that even in developing countries, such as Iran, the government had also been strengthening the availability of renewable energy recently, in order to ensure a safe and sustainable energy mix for the purpose of environmental protection. Thus, the share of renewable energy in total energy production must be increased. Another study conducted by Sohail et al. [17], also in developing countries, picked up another truth that the electricity generation sector has a significant potential in use of clean energy. Aryanpur and Shafiei [18] found that the reduction of greenhouse gas emissions in the field of energy can be achieved by developing the capacities to produce electricity from renewable sources, and that the intensity of emissions is directly proportional to the share of renewables in the total electricity production. Other studies, such as the one conducted by Kachoee et al. [19], highlighted a close relationship between electricity consumption and economic growth, and found that the dependence of power plants on fossil fuel resources still reflected an increasing trend. Also, studies were made to measure the potential of electricity production from renewable resources, which concluded that, even up to this point, no particular attention had been paid to this field and that new investments would be needed [20] to achieve a decrease in the share of solid fossil fuels in the energy mix. Reducing the share of solid fossil fuels is also part of the effort to achieve the Sustainable Development Goal 7 - Clean and affordable energy [21], as well as to prevent environmental degradation [22], which cannot be achieved without emission control [23].

From review of the above literature, the most important finding is that both at the global and at the EU level, the objectives of the environmental policy are oriented towards the development and application of some instruments to stimulate the concerns of economic entities and public authorities, for the prevention and limitation of ecological imbalances and for their support on increased actions on environmental protection. These instruments are intended to strengthen the positive link between development and the environment, and to break the negative link between economic growth and environmental degradation.

The importance and necessity of this paper lies in that it attempts to approach the decarbonization of the energy system in Romania, a milestone assumed within Component 6 – Energy in the National Recovery and Resilience Plan. This paper started withs a quantitative analysis of electricity production at the EU and national level, followed by a comparative analysis also carried out at the EU and national level. Through these analyses, a hypothesis, that is, the decrease in total electricity production is due to the decrease in electricity production from solid fossil fuels, was tested. After that, some relevant conclusions as well as future research proposals were made.

This paper is divided into five sections. The first section, entitled Introduction, presents relevant data about the regional context and the current situation of the research field, supported by scientific publications. The emphasis is placed on clearly defining the purpose and importance of this paper and detailing the specific hypothesis made, which was tested in the following sections. The second section, Methodology, presents the chosen scientific research methodology, as well as defines the set of collected data used and analyzed in this paper. In the third section, Results, the data collected are analyzed and processed. It is important to note that the processing of these quantitative data is intended to form pertinent and relevant conclusions for each research objective. The fourth section, Discussion, presents the interpretation of the results from the perspective of previous studies and the proposed hypothesis. It also provides the research results and their implications, in the widest possible context. In the last section, Conclusions, the main conclusions regarding the analyzed data are presented, emphasizing their significance and relevance, and the increasing or decreasing trends in electricity production at the level of the EU and Romania. Also, the similarities or differences between the EU and Romania are discussed. In addition, the directions for future research are proposed.

## 2. Methodology

The purpose of this paper is to perform a comparative analysis regarding the production of electricity in the EU and in Romania, between 2011-2020. It also attempts to draw some conclusions regarding the similarities or differences found in the comparative analysis. In this paper, the official data, i.e. the statistical data, at the level of the EU and of Romania, were collected from the EUROSTAT database. In order to draw some relevant and pertinent conclusions, these official statistical data were then processed. In addition to highlighting the similarities and differences found, this paper also presented the increasing or decreasing trends of the electricity production, during the period under analysis. A hypothesis, that is, the decrease in the total production of electricity is due to the decrease in the production of electricity from solid fossil fuels, was also tested.

But why is this indicator – electricity production chosen? Because electricity is the result of transformation or processing of some energy resources, or in other words, it is produced in power plants, as a primary or secondary product. Electricity production represents the total amount of electricity produced, which is generically called gross electricity production. It is known that in the process of electricity production, these power plants need to consume part of the produced electricity for their own use. If we subtract this energy consumption for own use from the gross electricity production, we can obtain the net electricity production. Then the electricity is transmitted and distributed through the transmission and distribution networks to the final users, where it is "transformed into heat in boilers or heat pumps, stored by pumped storage or traded (exported or imported) [4]."

Taking into account the fact that the energy sector is extremely important in the economy of any country, choosing this sector as the object of this study may provide possible scenarios for future scientific research, and also inform or support the relevant decision-makers in making well founded and realistic decisions on the decarbonization of the energy sector in Romania. The research method used in this paper is quantitative analysis, which is for the purpose of gaining better understanding of electricity production, and of course, supporting other scientific research in this energy sector.

## 3. Results

In this section, the indicator - gross electricity production - was analyzed through the quantitative analysis method. First, the quantitative analysis was carried out at the level of the EU, as presented in Figure 1. It can be seen that the electricity production from different resources exhibited different trends during the period of 2011 - 2020. The only type of resource with increasing electricity production was renewable energy. For the other electricity resources, namely solid fossil fuels and nuclear energy, an accelerated downward trend can be identified. Oil was almost stagnated, with relatively stable electricity production throughout the period under analysis. For natural gas, there was a decrease until 2014, and after that, there was an increase until 2020. Thus, it can be concluded that, in the last decade (2011-2020), at the level of the EU, solid fossil fuels and nuclear energy saw a downward trend, that oil showed stagnation, and that natural gas experienced a downward trend until 2014 and then an upward trend until 2020. The most pronounced decrease was recorded by solid fossil fuels, followed by nuclear energy, and renewable energy registered the highest growth.

In order to identify the maximum values of increase or the minimum values of decrease, this paper analyzed the statistical data collected at the level of the EU, as presented in Figure 2. With the year 2011 as the starting point, it can be found that the electricity resources decreased at the end of the period analyzed, except renewable resources and natural gas. The largest decrease in electricity resources was recorded in 2020, when almost all electricity resources saw a decrease, compared to those in previous years. The largest decrease recorded was in solid fossil fuels, and the lowest level appeared in 2020.

Then, a quantitative analysis was performed on the production of electricity in Romania, as presented in Figure 3, from which, the trends of increase or decrease in the electricity production from different resources during the

period of 2011-2020 can be seen. It is obvious that the only type of resource with increasing electricity production was renewable energy. At the opposite pole were solid fossil fuels, for which an accelerated downward trend can be identified. Other electricity resources saw stagnation or a slight growth. For example, oil and nuclear energy experienced stagnation while natural gas registered a decreasing trend until 2014, followed by a slight increase. Thus, it can be concluded that in the last decade (2011-2020) in Romania, for solid fossil fuels, there was an accelerated downward trend, that oil and nuclear energy showed stagnation, and that natural gas experienced a slightly upward trend until 2013, a downward trend until 2014, a slight upward trend again until 2018, another decrease until 2019, and after that an increase again until 2020. The sharpest decrease was recorded by solid fossil fuels and the most pronounced growth, by renewable sources.

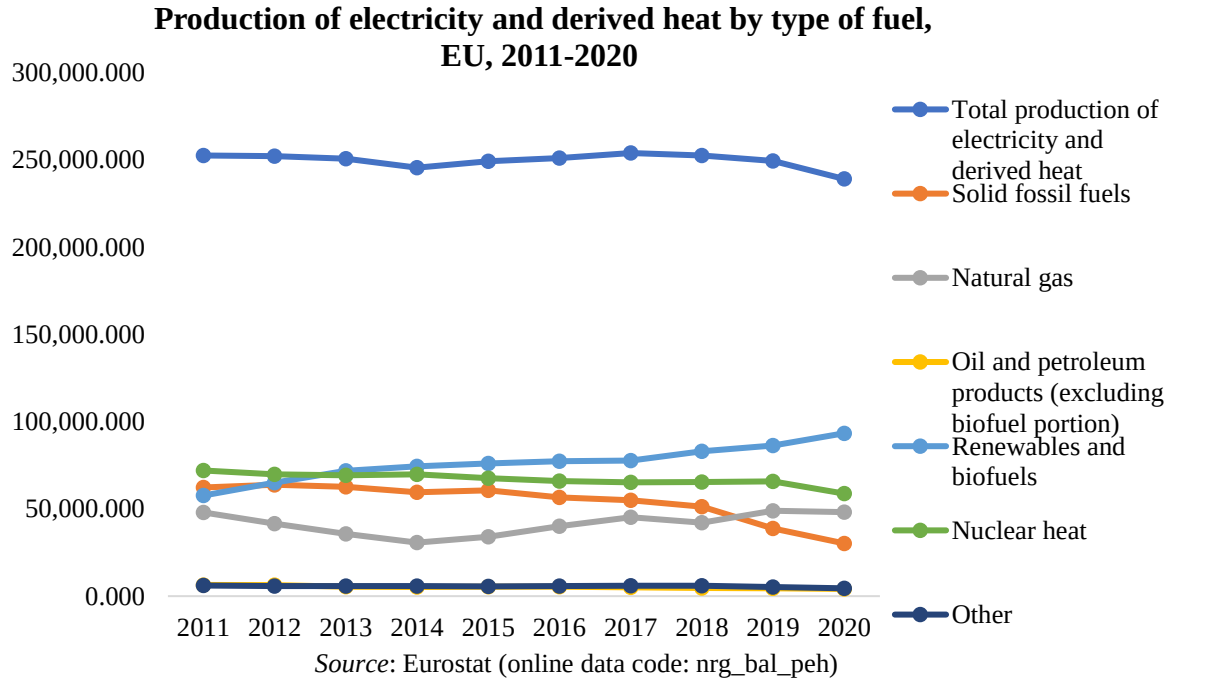


**Figure 1.** Production of electricity and derived heat by type of fuel, EU, 2011-2020
Note: Data processing by author based on official amounts published by Eurostat

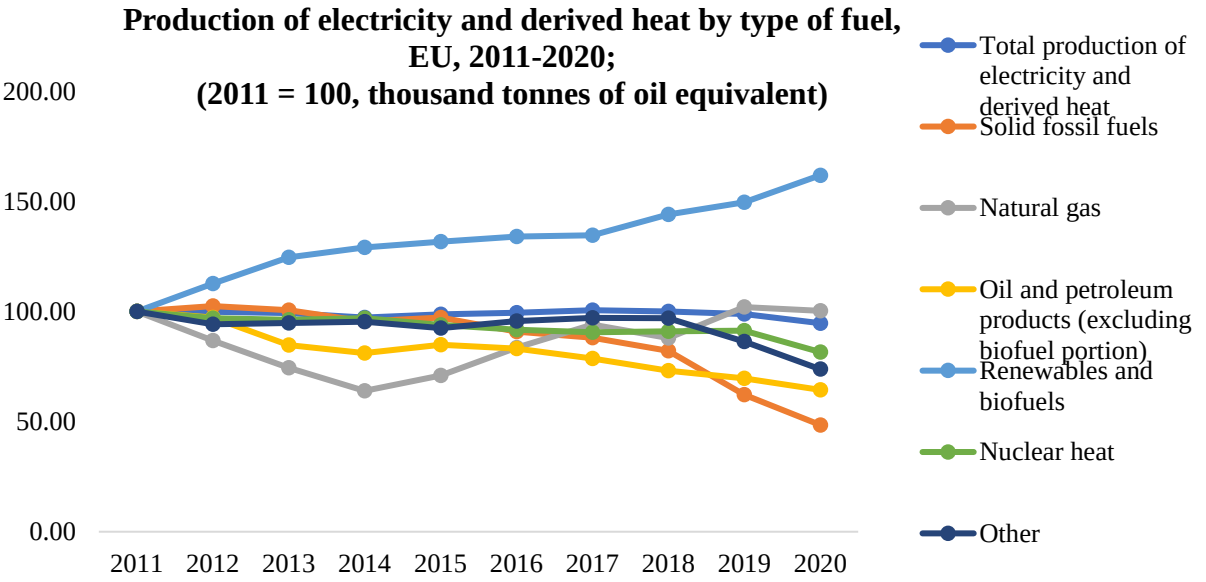


**Figure 2.** Production of electricity and derived heat by type of fuel, EU, 2011-2020 (2011=100, thousand tonnes of oil equivalent)
Note: Data processing by author based on official amounts published by Eurostat

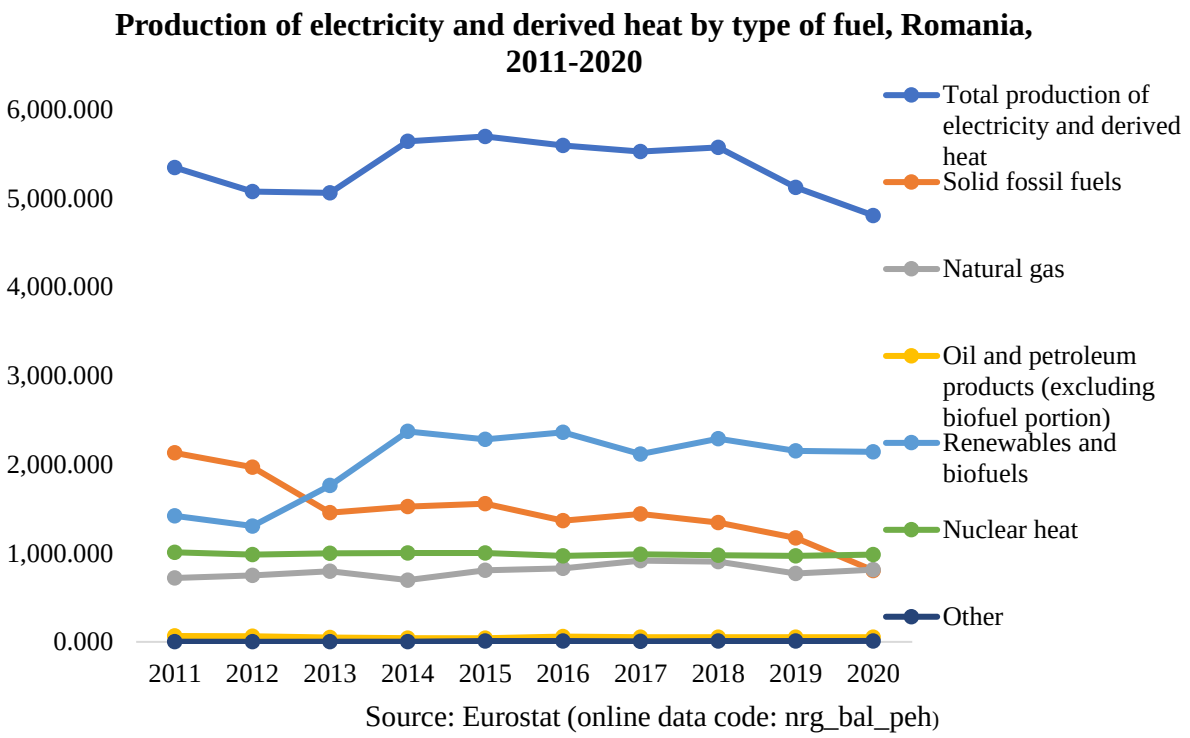


**Figure 3.** Production of electricity and derived heat by type of fuel, Romania, 2011-2020
Note: Data processing by the author based on official amounts published by Eurostat

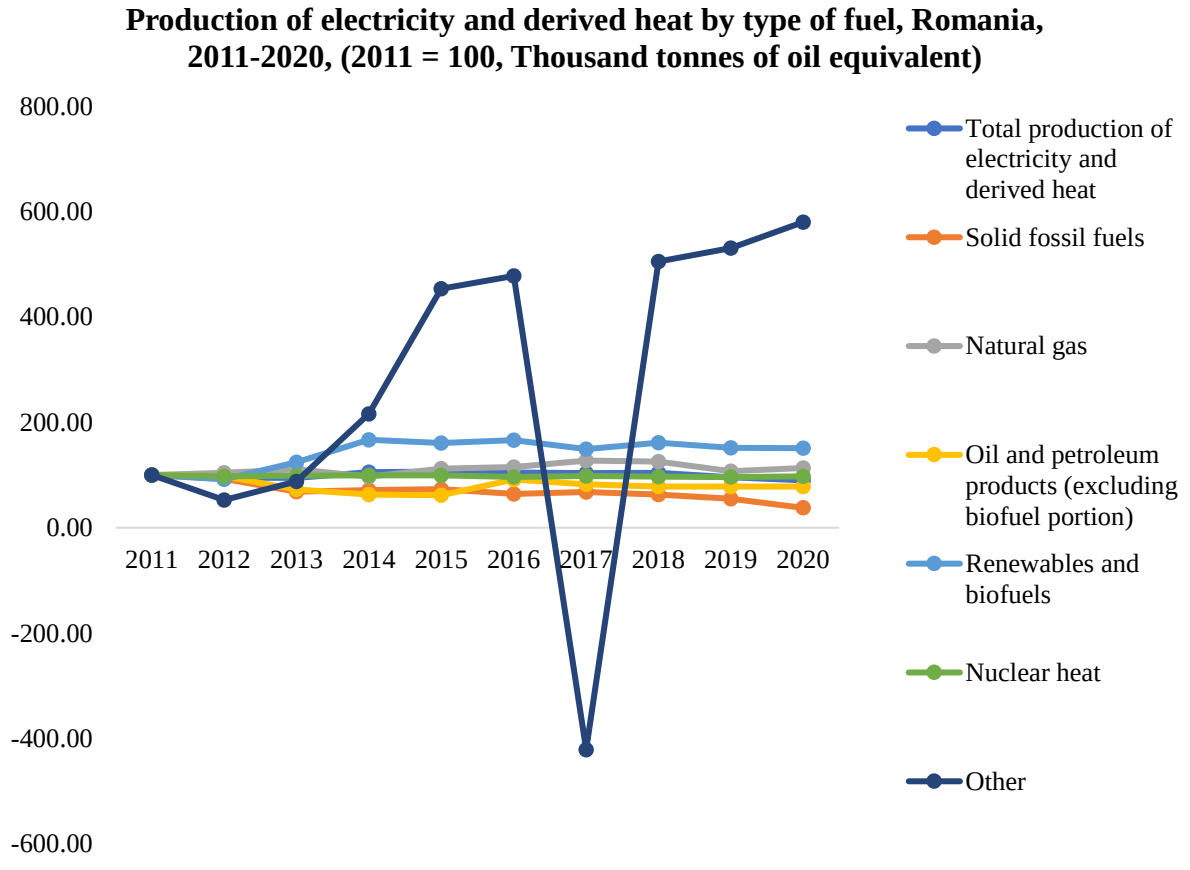


**Figure 4.** Production of electricity and derived heat by type of fuel, Romania, 2011-2020
Note: Data processing by the author based on official amounts published by Eurostat

In order to identify the maximum values of increase or the minimum values of decrease, this paper analyzed the statistical data collected in Romania, as presented in Figure 4. With the year 2011 as the starting point, it can be found that all electricity resources decreased at the end of the period analyzed, except renewable resources. The largest decrease was recorded by solid fossil fuels, which reached the minimum level in 2020. The largest increase was recorded by renewable sources, which reached the maximum level in 2014.

## 4. Discussion

Previous studies from specialized literature [19, 20] clearly established the fact that, in the energy sector, decarbonization can be addressed by eliminating solid fossil fuels from the electricity resources. However, the elimination of solid fossil fuels will only be possible by introducing new production capacities or by increasing production from other resources, in order to maintain electricity production. Another important aspect to note is that the elimination of these resources, namely solid fossil fuels, can only be carried out in stages, without jeopardizing the supply of electricity to the entire country. Regarding imports, a firm decision was taken at the EU level during the informal meeting of heads of state or government, in Versailles, by adopting the Declaration of Versailles [24], which provides for the commitment of the member states of the EU regarding the management of the crisis situation generated by Russia's aggression against Ukraine, as well as some measures to reduce energy dependencies.

This study shows us that, in recent years, the production of electricity from renewable sources has registered an upward trend both at the EU and the national level. This presupposes, first of all, the existence of new electricity production capacities. Drăcea et al. [25] showed that all the Member States of the EU are making serious efforts to increase the share of renewable resources in energy consumption. Through the previous studies listed, it can be seen that not only at the European level, but also at the global level, a perspective is emerging regarding the production of electricity from renewable resources [17]. Thus, the results obtained in this study are similar to those obtained by other research, regarding the possibility of eliminating solid fossil fuels by introducing new production capacities from other resources, such as renewable energy resources, in order to reduce greenhouse gas emissions.

Although numerous investments have been made in new production capacities from renewable sources, both at EU and national level, the downward trend of electricity production from solid fossil fuels is still not sufficient to achieve the ambitious objectives set at the EU level by the "European Green Deal". Therefore, further investments will be needed for new electricity production capacities from renewable sources.

## 5. Conclusions

This study discussed the topic that recently people have been more and more concerned about - the production of electricity. It started with a quantitative analysis of electricity production at European and national level, followed by a comparative analysis carried out at both European and national level. Through these analyses, the hypothesis was tested, that is, the decrease in the total electricity production is due to the decrease in the production of electricity from solid fossil fuels.

However, the hypothesis can only be partially confirmed, since electricity production from other energy resources, apart from renewable resources and natural gas, also experienced a downward trend in the period under analysis. Therefore, it cannot be said that the decline in the total production of electricity is solely due to the decline in electricity production from solid fossil fuels. Another thing to note is that in 2020, the impact of the crisis caused by the COVID-19 pandemic also led to a substantial decrease in the total production of electricity, as the electricity consumption and demand decreased.

At the level of Romania, to address the decarbonization of the energy system, an extremely important aspect to remember is that eliminating coal from the energy mix will create a capacity deficit, and that to cover it, investments in new production capacities will be necessary. At those mines where the exploitation activities will be closed, any environmental damages must be remedied. And later, they can be included in the tourist routes, provided that they respect the legal provisions in force regarding the safety of visitors. The personnel who lose their jobs as a result of the closure of these mines, will benefit from social protection measures as well as measures to combat unemployment under the conditions provided by law and the clauses of the applicable collective or individual labor contracts. The decarbonization of the energy sector in Romania will be achieved by phasing out the lignite and coal from the energy mix in production of electricity, which is part of the reform proposed in the National Recovery and Resilience Plan.

Future research may involve analysis of these measures contained in the Government's Emergency Ordinance no. 108/2022 regarding the decarbonization of the energy sector.

Also, others who are interested in the decarbonization of the energy sector in Romania may take this study as a reference and process the results obtained here or continue this study by taking other additional elements into account.

## Data Availability

The data used to support the research findings are available from the corresponding author upon request.

## Conflicts of Interest

The authors declare no conflict of interest.

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