USING RENEWABLE ENERGY SOURCES AS AN ALTERNATIVE TO ADAPT TO CLIMATE CHANGE

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Abstract

The aim of this paper is to document the interest in the research area regarding renewable energy sources, as a sustainable way of adapting to climate change. The study seeks to present a comparison between the alternative energy and the conventional energy and the impact on the mitigation of climate change. Moreover, by analyzing the key factors that characterize the energy sector from Romania and the European Union, the current situation is highlighted and the study could contribute to knowledge development or solving practical issues. Taking into consideration the interdependence between economic growth and energy consumption, stable access to electricity is of political, technical and monetary interest to both developed and developing countries. In this context, green energy sources can contribute, along with other means, to achieving a greener and more environmentally friendly society. For the literature review it was used the VOSViewer software that analyzes the bibliometric links between countries and authors. It can be stated that the highest production from green sources in Romania is obtained with the help of hydropower plants. However, wind and solar energy play an important role in the national energy structure.

Key words: *renewable energy, climate change, analysis*
JEL classification: *Q4 Alternative Energy Sources*

Introduction

The United Nations Framework Convention on Climate Change defines climate change as being attributed to anthropogenic activities that alter the composition of the Earth's atmosphere and create variations in climate, observable over time. Starting with 1850, the population expanded, and implicitly also the demand for fossil fuels: because of this phenomenon, the greenhouse gas emissions increased by 39% compared to the pre-industrial

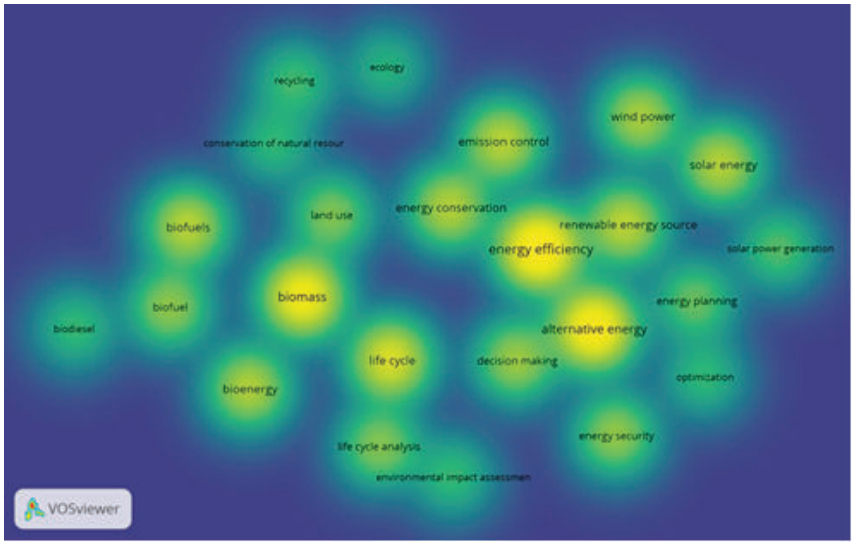
period (Fawzy, Osman, Doran & Rooney, 2020). Studies have shown that oil reserves will run out in approximately 45 years, natural gas reserves in approximately 149 years, and coal reserves in approximately 430 years, according to Worldometers.info, 2020. In this context, research into green energy and sustainability domain began in the 1990s, when the effects of climate change started to have a global footprint. It was found that, in addition to the negative impact on the environment, fossil fuels create geopolitical and military conflicts but also price fluctuations (Quaschning, 2019). Thus, following the analysis of the current situation in Romania, it was found that the most polluting sector in the economy is the energy sector (Dinca, Rousseaux &Badea, 2007) This paper aims to present the importance of the alternative energy sources, as a solution for the mitigation of climate change. For the literature review, it was used the VOSViewer soft to build and visualize various bibliometric links. There have been analyzed approximately 2000 documents from the field of renewable energy sources published between 2000-2019. In addition to this, the comparison between the conventional energy sources and the renewable energy sources intent to convince the readers that green energy is far more efficient and has a lower impact on the environment. In order to offer a more elaborate image of the matter in view, it has been analyzed a set of indicators that characterize the energy sector both from Romania and the European Union. The results of the study indicate the opportunities for developing green energy systems in Romania and the improvements that could be realised if these technologies would be applied.

1. Literature review

By using the VOSViewer software for the literature review, it was conducted a bibliometric analysis in the field of renewable energy. The analysis was made for approximately 2000 documents published between 2000-2019. The appearance of the keywords used by the authors illustrates the similarity between the terms (Chirescu, 2020). The result is determined based on the number of documents in which these words appear together.

Co-occurrence of authors' keywords

Fig.1

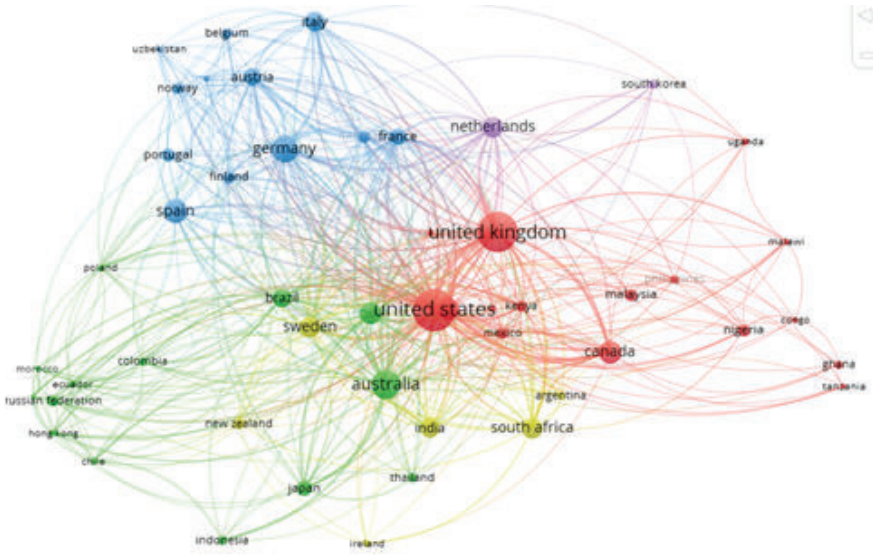


Source: own conceptualization based on Scopus database

According to the previous analysis, the most frequently used words by the authors in their scientific work from the field of renewable energy are: alternative energy, energy efficiency, biomass, bio-fuels, bio-energy, renewable energy, emission control, solar energy, wind energy, decision makers, conservation of natural resources or ecology. These concepts are, in fact, solutions to reduce the impact of climate change and to implement the principles of a sustainable economy. The analysis of collaborations between countries represents the cooperation of authors from several states for realising scientific papers in the field of green energy sources and climate change.

The analysis of collaboration between countries

Fig.2

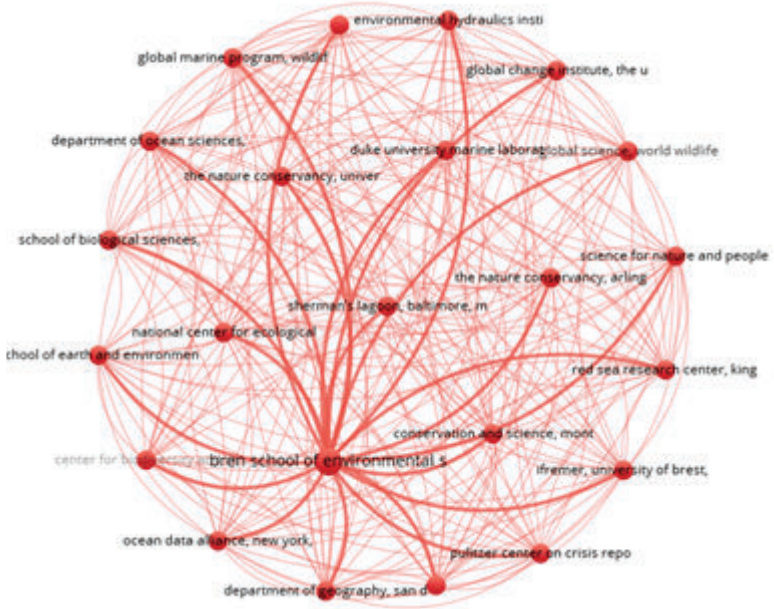


Source: own conceptualization based on Scopus database

The country with the most collaboration between authors for realising scientific papers is the USA with 216 published documents and 48 collaboration links with other states, followed by the United Kingdom with 194 published documents and 42 collaboration links with other states. Germany has subsequently published 88 papers and is collaborating with 29 authors from other countries. Spain has published 68 documents and has 26 collaborative links, followed by Canada with 61 documents and 27 collaborative links. Last but not least, Italy has published 48 papers and collaborated with 23 foreign authors to carry out scientific papers. In Austria, 36 papers were published and 24 different authors collaborated. This analysis is important to observe which are the best developed states in terms of research and development. Thus, the fact that the authors of several states collaborate in the elaboration of research works, ensures complexity and homogeneity in terms of data character. The analysis of collaborations between organizations illustrates the organizations that have collaborated with each other to carry out scientific work in the field of alternative energy.

The analysis of collaborations between organizations

Fig.3



Source: own conceptualization based on Scopus database

According to the analysis, Bren School of Environmental Science is the organization that has published the most articles, respectively 2 and has 22 collaborative relationships with other organizations for the development of scientific papers. All other organizations have published a document and have 22 collaborative links with other organizations. Thus, among these can be listed School of Biological Sciences, Science for Nature and People, Ocean Data Alliance or School of Earth and Environment. In order to complete the Literature Review and to offer a more complex picture regarding the importance of using renewable energy sources as an alternative to adapt to climate change, several articles in this field have been consulted and also the European Green Deal, as it is the most important strategy on this domain. Energy and energy independence have been some of the most widely debated issues over the past few years. The European Union countries rely mostly on the import of gas and energy and as past experience has shown, this dependence can be harmful in the case of a conflict or increase in price. In this context, Agenda 2030 plays an important role for the transition to the green energy. Moreover, in numerous countries, the energy sector has become of great interest. Apart from the already mentioned energy independence there is also

a need to find solutions for sustainable development and to tackle the impact of fossil fuels on the environment (Paun, 2017). In this context, Romania is considered to have both technological and geographical potential to develop clean energy production systems. According to the European Commission, in 2015, Romania demonstrated a high renewable energy potential, especially in the biomass and hydro sectors (Lupu et al, 2016). Taking into account that climate change and the environmental degradation are an existential threat to Europe and to the world, the European Commission intervenes through the European Green Deal, a strategy that will transform the EU into a modern, competitive and resource-efficient economy, The European Green Deal aims to dissociate economic growth from resource utilization, to become climate neutral and to become inclusive. In this context, the European Green Deal takes action on multiple fields like Climate, Energy, Agriculture, Industry, Environment and Oceans, Transport, Finance & Regional development, Research & Development. According to the European Commission, Energy production and use generates over 75% of the EU's greenhouse gas emissions. For the decarbonisation of the EU energy system The European Green Pact focuses on 3 key principles: providing the EU with secure, affordable energy, developing a fully integrated, interconnected and digitized European energy market and prioritizing energy efficiency, improving the energy performance of our buildings and developing an energy sector based largely on renewable sources (European Commission, 2021).

2. Methodology, data, results and discussions

2.1 Green energy vs Brown energy

This chapter presents a comparative analysis of the two models used for energy production, namely renewable energy (green) vs. conventional energy (brown). The aim of this analysis is to highlight the main benefits of using alternative energy and the impact on the mitigation of climate change.

Alternative energy vs Conventional energy

Table 1.

Indicators	Renewable energy	Conventional energy
Examples	Solar, wind, biomass	Coal, oil, natural gas
Source	The natural environment	Concentrated stock
Natural state	Solar radiation, wind kinetic energy, fermentation of food waste (dynamic state)	Extracted from the ground (static state)
Supply life	Infinite	Finite
Cost at source	Free	Continuously increasing
Variation and control	Fluctuating, it is recommended to use complementary sources (solar, wind)	Constant

Utilised location	Part of society, a favorable setting in the landscape, eco-friendly	Peripheral land, polluted area, opulent construction and infrastructure
Connections with other industries	Agriculture, transport	It is mainly based on the mechanical, industrial part
Context	Favorable for both rural and urban areas, areas that do not have access to electricity	Urban areas
Dependency	Systems characterized by self-sufficiency (elements of nature)	External input dependent systems (coal, oil)
Safety	It respects safety measures, does not pollute the natural environment and does not affect human health; ecosystems can be damaged as a result of the installation process and during the life of the equipment; local hazards may occur	Surely insofar as the operation of the technology is known; It pollutes a lot, it affects human health, the natural environment
Pollution and degradation of the natural environment	Impairment of biodiversity and ecosystem stability through the installation of equipment, diversion of watercourses, land preparation, proper functioning	Pollutant emissions, habitat degradation, affect human health, climate change, desertification
Estetics, visual impact	Landscape disturbances can occur, but they fit much better in both rural and urban areas than large power plants.	Opulent buildings, unpleasant visual impact - industrial and polluted area

Source: own conceptualization based on Twidell and Weir (2015)

As it can be observed from the analysis above, renewable energy has considerably more advantages than brown energy. Thus, it is obtained from the natural environment, it is infinite, it is free (it has no cost at source), it can have connections with all branches of the economy, for example agriculture - machinery, transport - biofuel, or production - green energy. Alternative energy production systems can ensure their self-sufficiency, unlike power plants, which need external inputs such as coal or oil. In terms of safety, both technologies are safe in the sense that people, if they know how to use the infrastructure, cannot be injured. However, the environmental cost is very high for conventional energy. Pollutant emissions occur both in the air and in the water, ecosystems are affected, desertification takes place, and the effects of climate change are reflected on human health (Michaelides, 2012). In terms of visual impact, it is obvious that wind turbines have a lower visual impact than power plants. Therefore, in addition to reducing the level of pollution by using green energy sources, the stability of local ecosystems is also ensured.

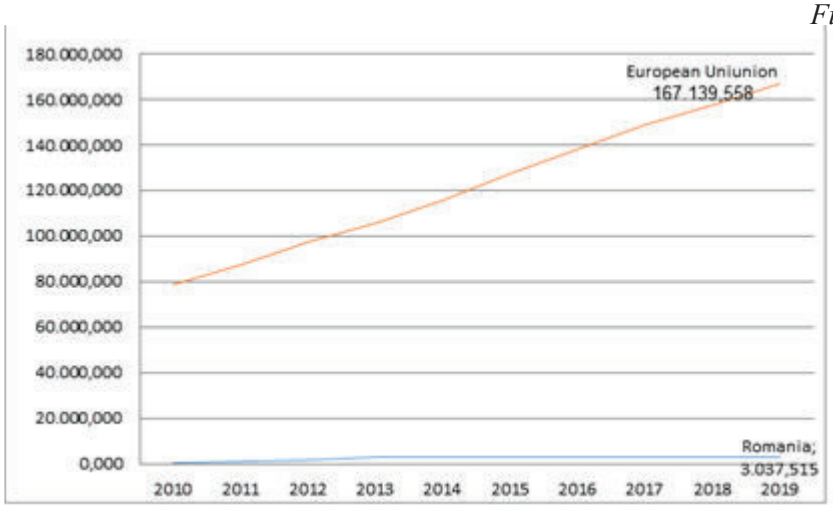
This makes a decisive contribution to reducing the loss of plant and animal species and to improving systemic services.

2.2. Analysis of the main indicators of the energy sector in Romania and in the European Union

In this chapter were analyzed the main indicators that characterize the energy sector, in order to perform a comparative analysis between the situation registered in Romania and the European Union during 2010-2019.

Analysis of wind energy production in Romania and in the European Union during 2010-2019. On the left side there is the measurement unit, expressed as thousands of MW

Fig.4

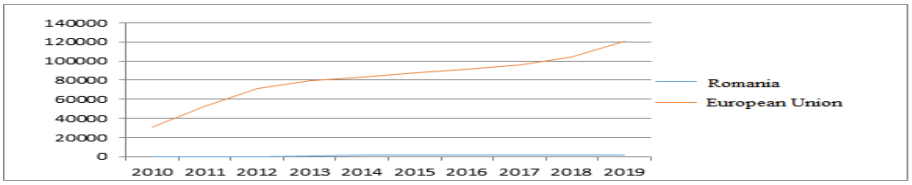


Source: own conceptualization

According to the graph, the production of wind energy, both in Romania and in the European Union, experienced an upward trend in the analyzed period. Thus, in the period 2010-2019, the installed capacity for wind energy sources increased approximately 7 times, reaching about 3,000 MW production capacities. Regarding the data recorded at the level of the European Union, the installed power doubled. Of the total wind energy produced at European level, Romania contributes with 1.81%. The figure below shows the evolution of installed power for solar energy sources in Romania and the European Union in the period 2010-2019.

Analysis of solar energy production in Romania and in the European Union during 2010-2019. On the left side there is the measurement unit, expressed as thousands of MW

Fig.5

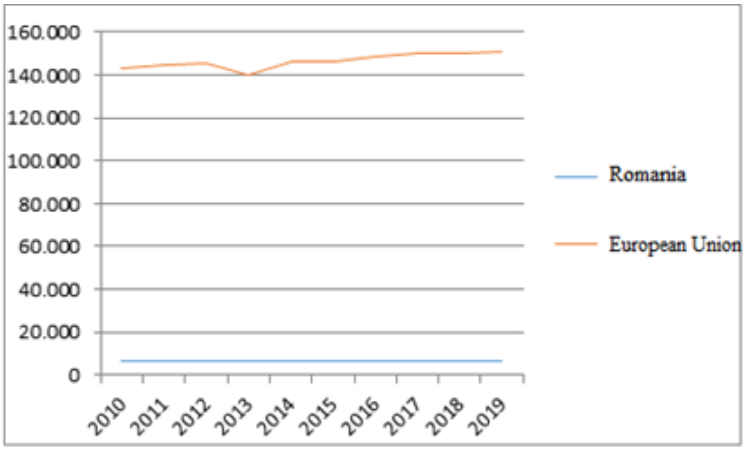


Source: own conceptualization

During this period, solar energy production increased both nationally and at European level, but to a different extent. Compared to the base period, more precisely the year 2010, the installed power for solar energy in Romania increased by 1,397.7 MW production capacity. On the other hand, production capacity in the European Union increased 4 times in the same period. Thus, a discrepancy can be found between the energy consumption model at national level and the one registered at European level. Following the analysis of the production capacity of hydropower plants in Romania and in the European Union, there is a slower evolution compared to other renewable energy sources.

Analysis of hydropower production in Romania and the European Union during 2010-2019. On the left side there is the measurement unit, expressed as thousands of MW

Fig.6

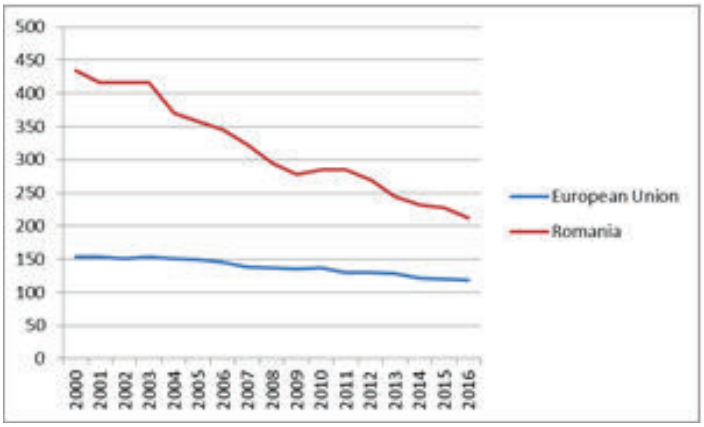


Source: own conceptualization

In Romania, the installed production capacity reached 6,686 MW in 2019, which means that during the specified period it increased by 3.2%. The growth registered at European level is not considerable either, respectively 5% in 2019 compared to 2010. Another important indicator for the analysis of the situation in the energy sector is Energy intensity. Energy intensity is an indicator that measures energy consumption in relation to the national economy.

Energy intensity in Romania and in the European Union between 2000-2016. On the left side there is the measurement unit, expressed as kgep/1000 Euro

Fig.7

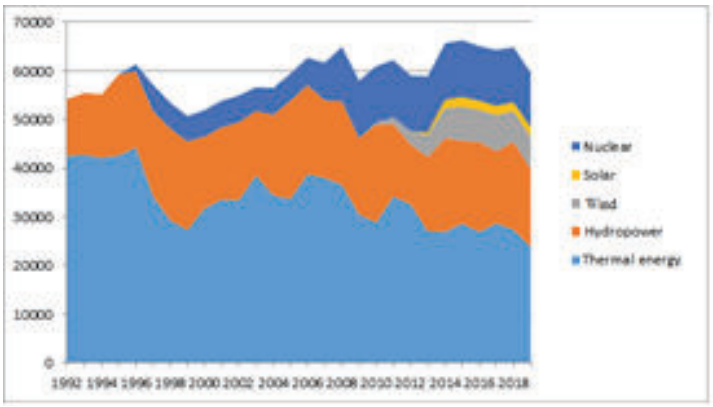


Source: own conceptualization

It is noted that, at both European and national level, energy intensity is on a downward trend. In the European Union, energy intensity decreased by 22.63% in the analyzed period, while the decrease registered in Romania was more than double, respectively 51%. In order to mitigate climate change, action must be taken in a timely and responsible manner so as to reduce the negative effects on the natural environment and also mankind. In this sense, the aim is not to increase energy use, but to increase energy efficiency. In other words, for Romania to be productive from the energy sector point of view, energy intensity must be reduced. The following graph shows the evolution of electricity production in Romania by categories of power plants, between 1992-2018.

The evolution of electricity production in Romania by categories of power plants between 1992-2018. On the left side there is the measurement unit, expressed as thousands of MW

Fig.8

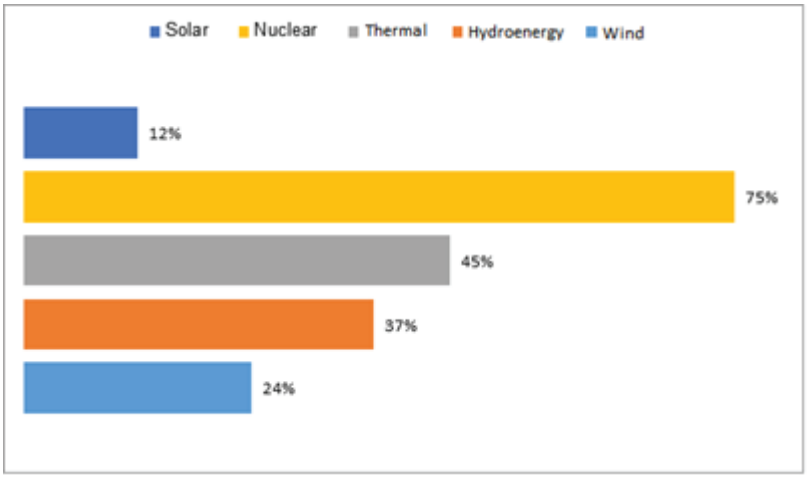


Source: own conceptualization

In the period 1992-2018, the electricity in Romania was produced by several types of power plants: thermoelectric, hydroelectric, wind, solar and nuclear. The highest energy production is obtained through thermal power plants. They reached their peak in 1996, according to the graphic representation. Hydropower plants are another important source of electricity production, which reached the highest point around 1996. The presence of wind energy has also been observed since 2009; its share in total energy production increased during 2009-2017, after which it declines. It can be said that the energy produced by photovoltaic panels is less used in Romania. It came into view in 2012 and starts to develop until 2018, when no data was found. As far as nuclear power plants are concerned, they have also been supplying a significant amount of energy since 1995. This analysis was made in order to have a clearer picture on the evolution of electricity production by types of plants in Romania and to be able to draw some conclusions related to the energy consumption model. Thereby, although at the moment Romania is mainly using conventional energy sources, it has a huge potential to develop clean technologies that can ensure energy security (Owusu and Sarkodie 2016). The graph below refers to the global use of electricity capacity by type of energy, at the level of year 2020.

The global use of electricity capacity by type of energy in 2020

Fig.9



Source: own conceptualization

It can be observed that nuclear energy is used to the greatest extent and is close to reaching the maximum possible level of use, with a percentage of 75% of the maximum possible capacity already in operation. Also, the thermal energy capacity is used in proportion of 45%. With regard to renewable energy sources, it is noted that they are used less than conventional sources. For example, hydropower production capacity is 37%, which means that there is untapped potential of about 63%. Wind power generation capacity is used in proportion of 24%, leaving an untapped potential of 76%. The highest untapped potential is attributed to solar energy, with a capacity used of only 12%. Therefore, there is potential for development in this area and it is recommended to make the transition to a sustainable economy as soon as possible.

Conclusions

The aim of this paper is to document the interest in the research area regarding renewable energy sources, as a sustainable way of adapting to climate change. The study seeks to present a comparison between the alternative energy and the conventional energy and the impact on the mitigation of climate change. Moreover, by analyzing the key factors that characterize the energy sector from Romania and the European Union, the current situation is highlighted and the study could contribute to knowledge development and

solving practical issues. It can be stated that the highest production from green energy sources in Romania is produced by hydropower plants. However, wind and solar energy play an important role in the national energy structure. Thereby, the use of renewable energy sources is the most appropriate solution for the global energy system, as all three dimensions are taken into account: economic, social and environmental. In Romania, the installed production capacity for hydropower reached 6,686 MW in 2019, which means that during the specified period it increased by 3.2%. It is noted that, at both European and national level, energy intensity is on a downward trend. In the European Union, energy intensity decreased by 22.63% in the analyzed period, while the decrease registered in Romania was more than double, respectively 51%. By implementing green energy systems, new jobs will be created, which will positively influence the employment rate, the unemployment rate and the poverty rate. In terms of environmental impact, first and foremost, greenhouse gas emissions will be reduced, ecosystems will be protected and stabilized, and biodiversity will be conserved. The landscape will not be altered by large power plants and access to energy can be provided to both urban and rural residents. Last but not least, a very important aspect, which the vast majority of the population and global power does not take into account, is that, in addition to the fact that alternative energy sources are a direct mechanism for adapting to climate change, by implementing these systems, future environmental costs are reduced. In order to adapt to climate change and reduce greenhouse gas emissions, it is recommended to increase the installed capacity of renewable energy sources both at national and European level, to decarbonise the EU energy system, to carry out insulation work on both public buildings, as well as residential ones and making investments in the research-development-innovation sector. The main objectives of the European Commission regarding the energy sector include interconnection of energy systems and better integration of renewable energy sources in the network, promoting innovative technologies and modern infrastructure, boosting energy efficiency and green product design and harnessing the full potential of Europe's offshore wind energy. This study aims to highlight the current situation in regards to the energy sector from Romania, in comparison to the European Union so that researchers or other interested parties could contribute to knowledge development and solving practical issues. The main barrier in conducting this study was the lack of information, in terms of scientific papers that present Romania's energy sector and the transition to the renewable energy sources. It will be therefore necessary to increase efforts to disseminate information on the importance of renewable energy sources in mitigating climate change, so that more people could get interested on this subject.

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