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Article

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THE CHALLENGES FOR GREEN ENERGY IN ROMANIA UNDER CURRENT ENERGY CRISIS

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Abstract

This paper aimed to evaluate the impact of the current EU energy crisis on Romania's policies to boost green energy as a solution to balance the national energy mix. Our methodological approach was a mixed one using both bibliometric analysis and qualitative analysis based on experts' interview. The bibliometric analysis has included 1085 research papers from the WOS database and indicates the main research focus at the international level in the green energy field. The second part of the study was based on 6 interviews with Romanian experts in the energy field (selected from a larger group according to their expertise of more than 10 years in fundamental research and their involvement in public policies and national strategies in the energy field). The interviews aimed to investigate the national opportunities to adopt green energy practices at affordable prices. Our research has highlighted that many of the international research trends investigated by researchers are similar to those indicated by the Romanian experts. Our main finding showed that although Romania has performed better than most European countries in increasing the renewable energy share in the national mix, there is still untapped potential in the field. However, Romania has several particularities, according to the interviews results, such as the national regulation, geographical potential, and the existing infrastructure. To fully develop green energy (according to the objectives of RePowerEU and Green Deal), Romania must better tailor its national policy, while providing a stable and predictable legal framework and increased subsidies for green energy.

Keywords: green energy, Romania, RePowerEU, Green Deal

JEL Classification: P18, P48, P49, Q4, Q42, Q48, Q49

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Introduction

Green energy (which for the purpose of this research includes renewable energy, but also nuclear energy considered far less polluting than fossil fuels energy) has presently become a very important topic on the EU agenda. The importance of green energy was highlighted by the adoption of the Green Deal, which has set ambitious targets for sustainable economic development throughout the EU. Green energy is now considered a key tool for reducing the carbon footprint of the EU's economy while combating climate change. Prior to the Green Deal adoption, green energy development was boosted through the 2020 Strategy and Romania was one of the countries that managed to substantially increase renewable energy development while surpassing all EU targets in the field. However, the current energy crisis unfolding across the EU under the shadow of the sanctions imposed on the Russian Federation has underlined that a larger share of green energy in the total EU's energy mix could be the key to achieving the EU's energy independence from Russia. Moreover, after the adoption, the topic of green energy became a central element of the EU strategy for energy security. Since Romania has great potential in the field, our research aims to identify how the goal of boosting green energy in Romania can be achieved, along with the main challenges and potential opportunities. Our research focusses on the analysis of Romania's green energy potential for several reasons. First, given the current energy crisis, Romania, as a member state, must contribute through smart and feasible solutions to balance the European energy mix by promoting renewable energy (in accordance with the objectives of the Green Deal, but also with those of RePowerEU). Secondly, the analysis of Romania's recent performance shows that it has consistently surpassed the EU's targets for renewable energy (established through the 2020 Strategy), highlighting this country's potential for further development of green energy in the national mix.

The purpose of our research was to highlight the potential of green energy to balance the national energy mix, given that, in the current economic climate marked by the existing energy crisis, Romania must find optimal solutions to reduce its dependence on fossil fuels, without jeopardising its energy security.

1. Review of the scientific literature

Launched in the middle of the pandemic's economic and social unprecedented challenges, the Green Deal seeks to lead to a zero-emission economy of the EU by 2050 (EC, 2020). To limit climate change and environmental degradation, the Green Deal will reshape the European Union into a competitive and resource-efficient economy, with the aim of decoupling economic growth from resource use. Although the Green Deal proposes a set of measures to ensure that climate, energy, and transport policies are in line with the 2030 target of 55% reduction in emissions, it also aims to make decarbonization a key objective for the long-term development.

Over the last decades, the European Union's energy policy has focused on several objectives, including energy security and environmental and climate protection (Bigerna et al., 2020). According to Siddi (2020), the experts acknowledged that the implementation of the European green agenda is mandatory, while Von Homeyer et al. (2022) show that the Green Deal remains at the core of the European Union's energy policy. However, this study shows

that its implementation involves significant financial resources to increase the share of energy from renewable sources (RES) and to increase energy efficiency. Also, according to Hass et al. (2021), the cooperation of European institutions with third countries is particularly important to support technology transfer.

Related to energy efficiency, experts say that environmental regulations in the energy market have a significant impact. According to a study published by Bigerna et al. (2020), it was found that different results have been achieved within EU countries in terms of the impact of environmental legislation on energy efficiency. The most important conclusion is that, in some countries, tougher legislation has led to a decrease in energy efficiency. Moreover, given the current economic environment, it should be underlined that access to affordable energy (one of the main Green Deal's objectives) will contribute to economic development and to increasing the well-being of the society (Zlaugotne et al., 2020; Adamowicz, 2022). Born amid the biggest EU energy crisis of the last years that was triggered by the numerous energy bans imposed on the Russian Federation, REPowerEU (European Commission, 2022) undoubtedly represents a very ambitious initiative. REPowerEU aims to achieve not only energy independence for all Member States, but also to boost the replacement of fossil fuels with clean energy sources, notably renewable energy. The goals assumed by the EU have been considered too ambitious by some analyses (Drăgoi et al., 2022), while other studies (Mathiesen et al., 2022) believe that REPowerEU may be a chance to achieve a more balanced energy mix across all Member States. RePower EU has three main goals: to accelerate clean energy transitions, to diversify energy sources, and to save energy. Many studies believe that the green transition proposed by REPowerEU can transform the entire EU energy system (Agnieszka, 2022). Others (Mathiesen et al., 2022) have pointed out that together with "Fit for 55", this initiative may initiate a significant change in the energy policies of the Member States to support green energy. Some studies (Kuzemko et al., 2022; Loewen, 2022) say that REPowerEU has a great potential for sustainable transformation in the energy field. There are studies that highlight the possible negative effects of the some of REPowerEU goals. Deng et al. (2022) have pointed out that although it has the potential to boost clean energy investment, REPowerEU may cause international divergence in the pace of the energy transition, with geopolitical tensions thus threatening the gains made so far in combating the global problem of climate change, while Lonergan et al., 2022 argue that open questions remain on how affordable and sustainable such green energy will be. Bonciu (2022) has revealed that the acceleration of the Hydrogen Strategy proposed by REPowerEU may create some significant challenges, while Rosenow (2022) has underlined that the investments proposed will need coordination on a very large scale across the EU for the replacement of fossil fuels in hard-to-electrify sectors. Stoykova and Martin (2022) argue that REPowerEU may boost new initiatives for a more balanced energy mix and even determine some Member States to adjust accordingly their National Recovery and Resilience Plans. Tertre and Savein (2022) have pointed out that achieving full energy independence of Russia is possible but will be costly, indicating that implementing the full potential to reach zero-dependence could require 300 billion euros cumulative from now to 2030 – which is beyond the "Fit for 55" proposal. Zanki (2022) has debated if the RePowerEU directions may contribute to overcoming the barriers for decarbonisation of multi-residential buildings.

As shown by the above analysed studies both Green Deal and RePowerEU may boost renewable energy, but for Romania the energy security also needs a greater development of nuclear energy. Moreover, many analyses have shown that Romania's energy mix could become cleaner if it added more nuclear energy. Tanțău et al. (2023) concluded that it is

necessary to invest more in actions to improve the process of designing credible and safe information, especially since the Russian – Ukrainian war will influence the future of the energy mix in the European Union. Although under the current geopolitical and economic framework the nuclear energy may be the secure and feasible solution, Cometto et al. (2019) underline that nuclear energy is often more expensive and impose several additional constraints on the energy system.

In view of these realities, the Romanian government must prioritise the development of the energy sector by focusing on hydropower and nuclear power to reduce dependence on fossil fuels (Rehman et al., 2022). Also, Pavela et al. (2016) state that while pollutant emissions are one of the most important aspects in power generation, the nuclear power is one of the few sources of energy with low emissions.

2. Romania's energy mix

Romania has a diversified and balanced energy mix, largely based on internal energy resources. The diversity of Romania's energy mix has allowed to maintain the resilience of the national energy system and overcoming the problems arising due to extreme weather phenomena (Marinescu et al., 2022). Extreme temperatures are a region-specific element, and at those moments, the energy system is subject to vulnerabilities, having difficulty meeting the energy demand. Romania is among the 14 states in the European Union that still use nuclear energy. Now, the electricity produced through nuclear fission covers approximately 19% of Romania's energy production, and specialists estimate that the percentage will be about 28% in 2035, the moment when two additional units of the Cernavodă Power Plant will be put into operation (Lăzăroiu et al., 2020).

Long-term, the opportunity to build power plants using coal and natural gas will be given by the evolution of EU-ETS certificates prices, the need for a strategic reserve for the security of the national energy system, the increase in demand, the performance of capacities, and the possible increase of maintenance prices (Stoian, 2021).

In Romania, hydropower is the main source of clean energy (26%), which, together with wind, photovoltaic, and biomass, consists of approximately 45% of Romania's energy mix. However, since a large part of hydropower plants are 30-60 years old, important investments need to be made to increase their efficiency.

The share of wind energy in the national energy system is 17% and has constantly increased in recent years. Photovoltaic energy, its share in the national energy system is only 2%, but it should be considered that the balancing market is less affected by the production variations in photovoltaic plants, which have a more predictable operation than the wind ones (Ministry of Energy, 2022).

Biomass, including biogas, is also included in the category of renewable energy sources, which do not depend on meteorological variations. Given the economic potential, specialists estimate that their share will increase in the future (Voicu-Dorobanțu et al., 2021).

Due to the large-scale promotion of green energy and the policy of subsidising them, in Romania it is encouraged, for the population, to assume the quality of "prosumer". This term defines the person who is, at the same time, a consumer and producer of electricity using renewable energies (for example, through solar energy as a result of the installation of

photovoltaic panels). A prosumer uses the energy it needs and the surplus it sent to the electrical network, being compensated by the supplier to whom has an energy contract.

3. Research methodology

Our methodological approach is based on a large investigation of the literature review using the bibliometric research which aims to underline the importance of green energy in achieving energy security, but also on the experts' interviews, since this method of qualitative research is best suited to reveal the main challenges that Romania is facing in the current economic environment while having the potential to unveil the best solutions and policies in the field.

The authors considered that the bibliometric data resulting from the Romanian research sources would have generated poor results to be relevant in the context of this article, given the reduced number of specialised studies published in Romania on the subject of green energy. In this regard, the theoretical information obtained from the literature review was completed by the information gathered from the professional expertise of Romanian experts in the field. Thus, the chosen research mix is the most appropriate for highlighting the main challenges facing Romania in the current economic climate and identifying the best public policy measures in the field of green energy. Additionally, the results of the two parts of the study allow for a more comprehensive description of the topic addressed in the article.

Our study presents the particularities of Romania as a country that started to adopt green energy practices with a focus on its strengths and opportunities. We choose to study Romania, as this country has constantly met the EU target for renewable energy while enforcing a strong incentive policy in the field. In this regard, we conducted an exploratory study based on interviews and found the opinion of experts on this topic. The results of the exploratory study were linked with the major findings of bibliometric research, to underline the connection between the latest trends in international academic research and the Romanian perspective on the investigated topic. In this regard, we applied a mix of bibliometric and interviews analysis, which outlines the connection between the worldwide approach and the national one. The mix methods design was chosen with the purpose of a better and deeper understanding of green and renewable energy issues in the view of the academic professionals, with a focus on the actual European context and some specific particularities of Romania. The results of the bibliometric analysis highlighted keywords and themes of interest presented in the clusters-tables. These were the basis of the design of the interviews with Romanian experts to obtain in-depth results related to the themes identified in the bibliometric analysis correlated with the particularities and challenges of the green energy market in Romania. The research design is presented in Table no. 1 and is based on the study published by Bowen et al. (2023) including two main phases: the bibliometric analysis and the exploratory study based on interviews.

The bibliometric analysis was conducted on research papers (articles and proceedings) included in the Web of Science database (WOS). We resumed our research on the documents included in WOS, as it is recognised as one of the most important bibliometric databases worldwide, having the highest research relevance. We excluded from our search review articles as we considered them not relevant for our interrogation. The results were analysed using VosViewer software, an open-access tool for bibliometric research used internationally. We defined our search in the WOS database on 10 keywords in the title of

the paper, as explained in Table no. 1. The investigation was conducted on 1085 papers. Our search results revealed the keyword occurrence analysis (based on the authors' keywords) and the coauthorship description (based on the country and institution affiliation).

Table no. 1. Research design

Research Phase	Purpose /output	Description of the method
Research Phase I Secondary Data	<p>i) identify the period of publications in the field of green energy. Output: Analysis of the publication</p> <p>ii) identify the main research subtopics. Output: Keywords Occurrence analysis</p> <p>iii) illustrate the profile of the research teams Output: The analysis of affiliation</p>	<p>Method used: The bibliometric, using VosViewer software.</p> <p>Overview: 1085 research papers published in English until February 2023 (Web of Science).</p> <p>Inclusion criteria: papers that have in title one of the following keywords: green energy, REPowerEU, energies policy, renewable, energy mix, photovoltaic, wind energy, biomass, hydro-energy, nuclear energy</p>
Research Phase II Interviews	<p>i) conduct the experts interview Output: Map of the interview data</p> <p>ii) centralised all experts' answers and recommendation Output: Synthesis of relevant policy recommendation</p>	<p>Method used: exploratory study based on semi-structured interview</p> <p>Overview: 6 interviews with reference specialists in the energy field from Romania (February 2023)</p> <p>Inclusion criteria: experts who contributed to developing studies on energy and drafting documents for national decision-makers.</p>

The second part of our study consists of interview analyses and aims to identify the main particularities of Romanian green energy. We interviewed six experts with more than 10 years of experience in the field. The purpose of this part of the study was to discover the particularities of adopting green energy practices in Romania and to identify the opportunities and strengths that Romania could explore to gain clean energy for its citizens at low prices.

The interviews took place in February 2023 and were semi-structured. The interview guide included 10 questions: 2 questions of identification and 8 questions about green energy practices in Romania. After the respondents agreed to take part in the study, we sent them the interview guide via email and reconfirmed each question by phone. The results were interpreted manually by collecting and analysing all the answers using the comparison method.

4. Results and discussions

This part illustrates the results of our research, showing the research trend at the international level in the field of green energy and focussing on the particularities of Romania derived from the exploratory study based on interviews.

4.1 Secondary data

To determine the international trend in green energy research, we investigated the research papers published in the WOS database. The main purpose of this stage of our paper is to identify the time span of the publications in the field of green energy (i).

The search results in the WOS database after the selection criteria returned 1085 documents, 98% being research articles (1063 documents), and 2% being proceedings papers (22 documents). The research papers were published between 2012 and 2023, peaking in 2021, when 16% of the total articles were published. Most of the papers were published in journals of established international publishing houses. Elsevier Publishing House has the highest number of publications - 66% of the total, followed by Wiley, which published 5% of the total and IEEE - 4% of the total.

To identify the main research subtopics of the published research papers (ii), we developed the occurrence analysis of the items in author keywords with an occurrence over 7. The analysis includes 4 clusters (Table no. 2). The first cluster contains 20 items. It represents the most used item in the analysed papers' title, renewable energy (occurrence = 202). Other items that belong to the first cluster with a high occurrence are CO2 emissions (55), ecological footprint (19), and nuclear energy (14). The second cluster consists of the second main item used in the tile, mainly biomass (occurrence = 88). Other items that belong to this cluster with a high occurrence are energy storage (22), biochar (19), supercapacitors (22). The third cluster contains 16 items from the efficiency sphere. The main item that is used in the title of the papers is economic growth (occurrence = 56), followed by renewable energy consumption (51), financial development (24), carbon emissions (24) and energy transition (18). The fourth cluster includes 13 items from the green energy types. The main item used in the title is China (occurrence = 27) followed by wind energy (23), Pakistan (12), optimization (12), and solar energy (11).

Table no. 2. Author Keywords Occurrence

Cluster	Keywords	Occurrence
Cluster I	renewable energy	202
	CO2 emissions	55
	ecological footprint	19
	nuclear energy	14
Cluster II	biomass	88
	energy storage	22
	<i>biochar</i>	19
	supercapacitors	22
Cluster III	economic growth	56
	renewable energy consumption	51
	financial development	24
	carbon emissions	24

Cluster	Keywords	Occurrence
Cluster IV	<i>China</i>	27
	wind energy	23
	<i>Pakistan</i>	12
	optimization	12
	solar energy	11

Note: For each cluster, the authors chose the four most relevant keywords based on their occurrence

To illustrate the profile of the research teams in terms of affiliation (country/institution), we build the co-authorship network considering the authors' country (Table no. 3) and institution of affiliation (Table no. 4). The analysis of the country affiliation illustrates two clusters, the first one which has as its main item China (479 documents), followed by Turkey (100), Pakistan (88), and Australia (64) and the second one, which has as main item USA (218) followed by England (87), Germany (74) and Canada (54).

Table no. 3. Main author affiliations by country

Cluster	Affiliation (country)	Occurrence
Cluster I	<i>China</i>	479
	Turkey	100
	<i>Pakistan</i>	88
	<i>Australia</i>	64
Cluster II	<i>SUA</i>	218
	England	87
	<i>Germany</i>	74
	<i>Canada</i>	54

Note: Minimum number of documents per country/institution is 5

The institutional analysis (Table no. 4) shows that Beijing Institute of Technology is the leading institution in terms of research papers production in the field of green energy (China, 44 documents), followed by the Chinese Academy of Sciences (China, 43 papers), Tsinghua University (China, 23 documents), ILMA University (Pakistan, 17 documents) and Cag University (Turkey, 17 documents).

Table no. 4. Main author affiliations by institution

Affiliation (institution/country)	No. of documents
Beijing Institute of Technology (China)	44
The Chinese Academy of Sciences (China)	43
Tsinghua University (China)	23
ILMA University (Pakistan)	17
Cag University (Turkey)	17

Note: Minimum number of documents per country/institution is 5

4.2 Interview data

After receiving all the completed interviews, we synthetised a series of main drivers, but also important challenges for the development of green energy in Romania (presented in Figure no. 1).

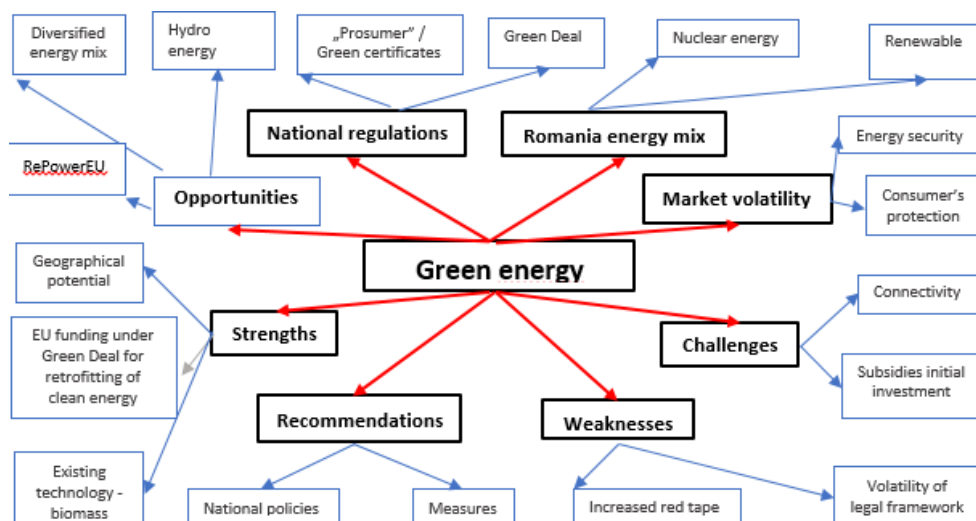


Figure no. 1. Map of the interview data

Renewable energy represents the focus, as resulted from the interview data. This is connected to some other related aspects, such as the strengths, weaknesses, challenges, opportunities, recommendations, market volatility, national regulations, and Romania's energy mix. A notable aspect is linked to the European Green Deal and REPowerEU Plan and how Romania could take advantage of the national **opportunities** of producing energy by: „obtaining clean coal fuels (underground coal gasification), but also carbon capture and storage can give coal a new chance in energy production” (Respondent A). Accessing European grant facilities for investment in projects regarding the production of green energy represents an asset: „While both the Green Deal and RePowerEU bring important opportunities for diversifying the national energy mix, there are other opportunities for Romania to increase security of energy supply related to the construction of LNG (liquefied natural gas) terminals, given that the Black Sea ports offer opportunities in this area” (Respondent D). RE, shows that „the requirements imposed by the policies and strategies adopted under the European Green Deal for phasing out polluting fossil resources in a relatively short period of time cannot be met without urgent completing the hydro and nuclear projects which have started some time ago, but there are severe financial constraints”.

Romania's **strengths** for the development of green energy are another theme that was emphasised in the interview data. The country has a great potential for producing different types of green energy due to its geographical variety, the EU funding under the Green Deal for retrofitting clean energy production and existing Romanian patented biomass technology. Some major types of favourable green energy were identified: „Romania has regions with good potential for wind energy production, on the Black Sea coast and in the mountain areas; for solar energy production in the lowland region, with a high degree of sunlight, including

the land taken out of agricultural use by ash dumps resulting from the burning of coal in thermal power stations” (Respondent A). Also, there is a good perspective for producing energy from different renewable sources: „Photovoltaic panels on non-arable green areas and on buildings in rural/urban areas; wind turbines installed between photovoltaic panels, in remote mountain areas or off-shore on the seaside coast; geothermal energy that can be used both by ground-to-water heat pumps and by hot water in the ground in certain regions of the country. Collectable wood waste and green hydrogen from water hydrolysis are other sources of green energy that can lead Romania to energy autonomy with extremely low GHG emissions” (Respondent B). Furthermore, for Respondent D, another source of clean but currently underused energy is biomass and waste: „there are technologies to recover energy through anaerobic biological treatment of this waste, including a technology for which Romania holds the patent - Eco-Hornet; the initial investment in this technology is not large and it also has a low environmental impact”. For Respondent F, the sources are relatively balanced but disproportionately harnessed: „there is hydro, wind, solar, geothermal and biomass potential. While the hydro potential is exploited at a significant level (65%), but in plants older than 30 years, wind and solar are underexploited, geothermal resources are less significant and with potential for development especially for heating in rural areas”.

Maintaining connectivity between the energy producer and consumer and generating subsidies for initial investment represents the two major aspects of the **challenges** theme. At the national level, implementing the policy to stimulate green energy investments is mainly obstructed by: „unclear legislation, too often changed and lack of enforcement rules” (RB). The increased cost of producing renewable electricity is also taken into account, correlated with a heavy dependence on natural factors (wind, water, solar energy), thus using new technologies: „it takes time and in the short term does not meet the requirements of serving increased energy demand in the current political context” (Respondent A). Respondent F approach places „lack of investment priorities and delays in the development and adoption of a coherent national energy strategy”, followed by „delays in upgrading the electricity grid to accommodate decentralised energy production” as central issues to be problematic for a sustainable development of the national green energy strategy. Necessary steps to follow as possible solutions for smart approach to investment strategies are: „first of all, the projects that are financed from EU funds must be implemented, and secondly, the National Environment Fund must be replenished by channelling all potentially available financial resources from the Romanian economy” (Respondent C).

The increased red tape was one aspect of the **weaknesses** theme, as outlined in Figure no. 1, as well as the volatility of the legal framework. The “Prosumer” programme and the implementation difficulties represent the main topic addressed. Several respondents talked about increased red tapes in terms of long delays in approval and accreditation for physical entities, with high levels of bureaucracy, and increased costs for individuals. As such, Respondent D mentioned that although: “The Prosumer programme can bring net benefits - they can market the electricity they produce to suppliers and are exempt from all tax obligations related to the amount of electricity produced and used for self-consumption - its implementation is not easy for regular consumers”. Similarly, long terms for dissemination, poor financing facilities for the initial investment, and affordable connection to the local grid represent some milestones to complete the gaps from the actual legal framework.

Therefore, *“the programme has the potential to significantly reduce the energy bills of any consumer place where green energy is produced. To achieve this, incentives are needed through low purchase costs for specific installations and competitive prices for “feeding” green energy into the National Energy System (NES) produced by potential users of green technologies at the green energy production sites”* (Respondent C).

Recommendations for prosumers on clean energy was a notable theme for the interview data. This relates to measures that prosumers need to take in order to be able to access the programme, but at the same time, refers to national policies that central authorities have to adopt. Firstly, *“a feasibility study should be carried out to carefully analyse the potential of the area where the project is to be implemented for one form of energy or another (photovoltaic or wind”, followed by “a realistic cost-benefit analysis highlighting the potential direct benefits of implementing the project”* (Respondent C). For Respondent F this means organising the prosumers in non-governmental associations: *“to increase the capacity to negotiate and implement projects”*. Secondly, as Respondent E remarks: *“Prosumers need to be better organised to benefit from European funds and bank financing and to be able to distribute surplus energy profitably. They should also find technically advantageous solutions to store energy for peak loads or to prevent negative effects related to grid operation”*.

Regarding **market volatility**, the importance of energy security was emphasised (Respondent A), while the need for consumer protection was also highlighted (Respondent D). Supporting the idea of subsidies, Respondent C underlines the role of *“a stronger financial incentive from the state authorities”*, and Respondent E points out that *“breaking the integrated energy system and aligning with Western European prices have big consequences on the markets”* and that is why investments must be increased for producers and perhaps even for distributors.

The national regulations theme is related to the costs that Prosumers must face for the transition to green energy production and consumption. The codes related to this theme are green certificates and the European Green Deal initiative. Most respondents identified the increase in the price of green certificates as a potential problem. For Respondent A, *“Unpredictable growth in the benchmark price of emission allowances can have a decisive impact on the profitability of fossil fuel power producers (with the highest level of pollution), as the increase in the price of green certificates could lead to their insolvency. It is possible that due to the highly speculative nature of this market, the price level is likely to register surprising values”*. For example, in the view of RC the initiative of green certificates has not achieved the purpose for which they were created *“mainly because the price of electricity that consumers pay for has not decreased, but, on the contrary, has increased through the introduction of green certificates in the energy bill”*. On the other hand, at the regulatory level, there was a lack of unitary perspective which led to the failure to achieve its main objectives: *“the policy of stimulating RES investments proved to be incoherent”* (Respondent F) and *“the volatility of the legal framework, repeated changes, and a lack of predictability for investors have hindered the long-term development of renewable energy investments. Therefore, it would be necessary to create a national strategy for renewable energy development, long-term licensing, including specific regulations at local and national level, establishing subsidies, and encouraging the formation of national associations”* (Respondent D).

Finally, green energy and especially renewable energy have strong inputs at the national level and a variety of ways to be produced in Romania. The theme of Energy Mix in Romania has

2 codes related to nuclear energy and the category of all other new technologies involved in producing clean energy. *“The general opinion of the experts interviewed is that nuclear energy has an increased potential to contribute to the energy mix in Romania with a low pollution effect, thus creating opportunities for “overcoming the imminent energy crisis in the EU” (Respondent D). Also, nuclear energy is a feasible solution for periods when renewable plants are not operational (Respondent F).*

According to our research, the topics of interest related to green energies in the international specialised literature highlight the importance of public policies and subsidies for stimulating investments in the field and are similar to those reported by Romanian experts. Besides the topics in the studied articles, the experts also pointed out the importance of supporting innovation and research, given that for some new technologies, Romania currently holds several patents that can be exploited. Contrary to the articles written by foreign experts, the interviews indicated that for a balanced national mix, fossil fuels should not be totally excluded, given that some green energies are dependent on weather conditions (solar and wind energy), while technological innovation associated with other energies (biomass) may be subject to market failures.

Conclusions

The present study shows that green energy is a main international research subject and the interest in this subject increased substantially in 2021. Although the present geopolitical challenges affect the EU member states, the most interested institutions in researching this topic are from China. This shows that Chinese experts are looking for the latest moves in the energy sector and want to be seen as the main drivers in knowledge generation. The bibliometric analysis allows us to determine a general profile of the green energy field. The occurrence analysis indicates that the focus on research is related to renewable energy and biomass. The individual types of energy are also important in research, but are less included as main keywords.

Our main findings show that although hydropower remains Romania’s main green energy source accounting for 26% of national energy mix, there is an important untapped potential for the other clean energies (wind, photovoltaic, and biomass), while nuclear energy should also be considered as a potential trigger for the country’s energy security. The experts’ interviews show that while both Green Deal and REPowerEU present important opportunities to boost green energy development in Romania, major challenges remain in terms of both energy grid connection and public incentives for investors. While the past public policies (such as the green certificate scheme and other national subsidies granted for renewable energy) have boosted green energy development, the current energy crisis underlines the need for further incentives in the field. Green energy is closely linked to technological development and innovation; both being submitted to market failure hence the public support remains crucial for ensuring further development in the field. The current initiatives (such as Prosumator compensation scheme) may be useful in increasing the green energy share in Romania’s energy mix, but they need to be correlated with a more predictable regulation framework to prevent the investment exodus while ensuring the grid connectivity.

The article lends support to policymakers in establishing energy strategies that boost Romania's integration into the Energy Union by ensuring sustainability (sustainable, low-

carbon and climate-neutral economy), security (diversifying the energy mix and reducing dependence on energy imports) and competitiveness (stimulating growth in the number of energy suppliers and ensuring affordable energy prices). The analysis identifies the significant challenges to green energy supply, opportunities, and medium- and long-term priorities for Romania.

In terms of scientific contribution, the study added value derived from the interdisciplinary research methodology used, i.e., the use of social research tools (questionnaires) in parallel with qualitative research and bibliometric analysis of literature and EU documents in the field of green energy.

The bibliometric analysis allows us to establish a general profile of the field of interest in “green” energy. The map of links between keywords associated with “green” energy indicates that most research focuses on renewable energy and biomass. Individual types of energy are also crucial in the research. Also, the results of the bibliometric analysis show that the main topics of interest in international green energy research, i.e., types of green energy, technologies, and economic implications of the transition from an energy based on traditional resources to clean energy, coincide with the characteristics of the evolution of the green energy field in Romania, as it results from the description made by the experts included in the research.

Our study also has some limitations, which require future investigations. First, the findings are based on bibliometric research of the papers from a single database written in English. In this way, the documents written in Romanian were not considered. We intend to expand our research with the study of the national papers written in the national language, as Romania is a country that has established research institutions and authorities in the field of energy that publish on regularly base research papers in the national language. Another limitation of our research is that we did not include industry reports, books, and book chapters at this stage and referred only to academic articles. The third weakness of our paper is that the second part of the research is based on the results of interviewing only six experts in the field. We intend to expand the number of experts and include representatives of the national bodies in our study to have a more comprehensive image of the legislative framework.

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