# CONTRIBUTION OF RENEWABLE ENERGY TO CLIMATE CHANGE MITIGATION IN EU: THE CASE OF ROMANIA

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*Abstract: For the European Union, the advancement of renewable energy is a priority primarily due to climate change mitigation measures, but also because it can be easily identified and exploited while assuring the sustainable development across EU. Under the Green Deal ambitions UE aims to gradually reduce greenhouse gas emissions, especially carbon dioxide, to limit climate change and to achieve climate neutrality by 2050. Renewable energy plays a key role in this regard. In 2022, Romania had a significant share of energy from renewable sources. Also, forecasts indicate that Romania has onshore wind capacity that could generate twice as much electricity as current consumption. The following paper aims to carry out an analysis of Romania's progress in the field of renewables. The research is based on the challenges and opportunities for the development of renewable energy while also highlighting, the particularities of Romania in terms of the adoption of renewable energy practices and emphasizing the strengths and weaknesses that Romania has in this domain. Our main finding shows that while in Romania has been significant progress in terms of renewable energy, there is still untapped capacity in the field requiring for more actions from the Romanian authorities and business environment.*

*Keywords: EU, Romania, renewable energy, climate change mitigation, public policies, greenhouse gas emissions*

*JEL Classification: Q42, Q48, Q49*

## 1. Introduction

Within the framework of climate change mitigation, it is necessary to consider reducing greenhouse gas (GHG) emissions. The energy sector is the main source of greenhouse gas (GHG) emissions (Khan et al., 2014), and one of the mitigation strategies is to increase the production of renewable energy. The EU has identified the promotion of renewable energy as a priority, mainly due to the need to protect the environment. In addition, renewable energy can be easily identified and exploited while assuring the sustainable development across EU. As technology advances, renewable energy will become more affordable in terms of the cost of energy produced.

Despite ongoing discussions about the high costs associated with renewable energy (Carley et al., 2020), it remains an important element of the EU's energy policy. This is because it has the potential to address many of the challenges associated with meeting the EU's energy needs. Moreover, it can contribute to maintaining the EU's leadership in terms of innovation, high technologies and job creation. The large energy potential and availability make renewables an important factor for Member States to consider when shaping their energy mix (Fatima et al., 2021). The use of renewable energy sources offers the potential to develop a sustainable energy system, thereby addressing the EU's dependence on fossil fuels (Wolniak et al., 2022).

EU leaders have committed to gradually reduce greenhouse gas emissions, particularly carbon dioxide, in order to minimize climate change. Under the current economic and environmental challenges, the EU aims to achieve climate neutrality by 2050 (Perissi et al., 2022). The main source of greenhouse gas emissions, particularly carbon dioxide, is the production of electricity and heat, which contributes to global warming. Over the past century, the burning of fossil fuels has generated unprecedented levels of carbon dioxide emissions.

If no immediate action is taken, atmospheric carbon dioxide levels are expected to double over the next 50 years (Kabir et al., 2023), with immediate consequences such as melting glaciers and rising sea and ocean

levels. Accelerated global warming will lead to a range of extreme events, such as floods, droughts and other harmful consequences, such as increased mortality due to heat waves or loss of plant and animal species.

Renewable energies represent a strategic investment opportunity, as they offer a less harmful alternative to burning fossil fuels (Androniceanu et al., 2022). The latter has been linked to respiratory illnesses and fatal diseases such as cancer, as well as to numerous environmental issues, including greenhouse gas emissions, pollution and soil contamination. Renewable energy technologies, which are still under development, have the potential to reduce or even eliminate the release of carbon dioxide into the atmosphere (Mostafaeipour et al., 2022). Different types of renewable energy are being used to meet the needs of citizens, such as electricity, heating, cooling and transportation. The use of hydropower, wind power, and biomass to produce electricity is expected to increase significantly in the near future (Rahman et al., 2022).

In recent years, the transportation sector has become a major contributor to increasing greenhouse gas emissions (Kazancoglu et al., 2021). One effective strategy to reduce these emissions is to replace gasoline and diesel with biofuels, such as biogas, bioethanol and biodiesel. These biofuels emit about a third less carbon dioxide than fossil fuels. Directive (EU) 2023/2413 of the European Parliament and of the Council of 18 October 2023 amending Directive (EU) 2018/2001, Regulation (EU) 2018/1999 and Directive 98/70/EC as regards the promotion of energy from renewable sources recognizes the development of renewable energies as a key element of its energy policy. In order to achieve their renewable energy targets, Member States must adopt national plans, develop support schemes and conclude agreements with third countries. Other issues relate to the exchange of renewable energy and cooperation in renewable electricity projects.

## 2. Literature review

The Renewable Energy Directive is the EU's binding framework for the development of clean technologies, facilitating cooperation between Member States in achieving this goal. As can be seen from the recent literature (Nagaj et al., 2024; Muscio et al., 2023), the EU is at the forefront of renewable energy in the development and deployment of cutting-edge technologies.

As part of the Green Deal, renewable energy sources represent a critical element of the energy transition, as it can contribute to reducing the Union's dependence on other energy suppliers. In light of this, the share of renewables in the energy mix is under constant review. The Renewable Energy Directive was revised at the end of 2023. It sets a target of at least 42.5% by 2030, with a goal of reaching 45%. In July 2021, the Commission proposed a revision of the Directive with the aim of reaching 40% (instead of 32%) as part of the "Fit for 55" package. Less than a year later, at the start of the Russian invasion of Ukraine, the Commission proposed raising the target to 45% in 2030. An interim target of 42.5% was agreed on March 30, 2023.

The revised directive builds on previous directives and introduces new measures to ensure that all renewable energy development options are utilized. This is key to reaching the 2050 climate neutrality target. The literature (Kettner et al., 2020; Teixeira et al., 2022; Mhatre et al., 2021) shows that in addition to increasing the share of renewable energy targets, a strong policy framework will facilitate the electrification of various sectors. New targets will be set for renewables in heating and cooling, transportation, industry and other sectors.

Although all Member States can produce renewable energy, certain geographic regions have the potential to produce a greater amount (Hoicka et al., 2021). For example, some countries have rivers that can produce a much larger amount of hydropower, while sunny countries can produce more solar energy. The EU is trying to promote renewable energy projects by removing administrative barriers in the licensing processes, i.e. the authorization procedures for renewable energy projects. In some EU countries, licensing processes are an obstacle for these projects (Inês et al., 2020). Considering this, in May 2022, the European Commission issued recommendations on speeding up authorization procedures for renewable energy projects and facilitating power purchase agreements Also, the Renewable Energy Directive includes provisions that facilitate the licensing process, taking into account citizens' concerns and respecting environmental standards.

In order to facilitate the development of renewable energy projects, the European Commission has set up a financing mechanism. According to experts (Taghizadeh-Hesary et al., 2020), the main objective of this mechanism is to encourage member states to collaborate in the promotion and development of renewable energies. With the support of this mechanism, countries will be able to achieve their individual and collective objectives more easily. These national support schemes can help EU countries develop renewable energies and implement various policies, while providing investors with greater certainty. In light of the ambitious targets set out in the Green Deal and REPowerEU, it is clear that national support systems remain a critical component in

facilitating increased investment. As the literature (Boscán et al., 2020; González et al., 2022) demonstrates, these actions must be executed with caution to avoid disrupting the energy market and resulting in higher prices for households and businesses.

The literature (Leiren et al., 2020; Ortega-Izquierdo et al., 2020) also shows that wind energy has played a key role in the European Union's efforts to reach the 2050 climate neutrality targets. Wind energy production, along with other industries, serves as a critical foundation for the transition towards climate neutrality. At the same time, it contributes to economic growth and job creation in the EU.

The Commission has adopted two wind energy initiatives that form a package to promote the development and deployment of wind energy in the EU. The Wind Energy Action Plan is based on 15 actions to be implemented by public and private actors.

Numerous studies (Hassan et al., 2024; Liu et al., 2024; Spiru, 2023) have indicated that solar energy plays an important role in both the clean energy transition and the REPowerEU plan. Solar technologies convert sunlight into energy, either electricity or solar power. Solar energy is the fastest growing energy source in the EU because it is affordable, clean and flexible. The cost of solar energy fell by 82% between 2010 and 2020, making it the most competitive in the EU. The European Commission has adopted the EU Solar Strategy, which is part of the EU REPowerEU Plan. This strategy identifies the barriers and challenges currently facing the solar sector and outlines measures to overcome them.

Hydropower is the most established and reliable form of renewable energy (Opperman et al., 2023; Siri et al., 2020) and has been around for more than a century. It currently accounts for the second largest share of electricity generated globally (Jadoon et al., 2020). Moreover, hydropower can bring additional benefits to EU energy systems, such as flexibility and storage (Nautiyal et al., 2020). These services are essential for maintaining stability in the energy sector.

Heating and cooling accounts for about half of the EU's energy consumption (Bertelsen et al., 2020). The EU Strategy on Heating and Cooling, published in 2016, was a great first step in understanding the amount of energy used for heating and cooling in buildings and industry. It also identified tools that the heating and cooling sector can use to contribute to the EU's 2050 climate neutrality target.

## 3. Methodology

The research methodology has a mixed design based on both a comprehensive literature review and a quantitative analysis of renewable energy indicators in Romania (using the latest Eurostat data). This mix of research is the best way to identify the main challenges of Romania in the development of renewable energy. In addition, we will also analyze the particularities of Romania in terms of the adoption of renewable energy practices, emphasizing the strengths and weaknesses that Romania has in this domain.

In light of these considerations, the following sections of the paper will present an overview of renewable energy issues in the literature, an analysis of Romania's indicators in this sector and an analysis of the strong and weak points of Romania in relation to the development of energy from renewable sources in the country.

Therefore, the aim of the research is to outline the trends at Romanian level of the particularities of the renewable energy sector that policy makers should consider when pursuing the implementation of new development directions in the field.

The main limitation of the research is the absence at the time of elaboration of this paper of data for the year 2023. Having this in mind, it can be considered a possible extension of the research when these data will be available.

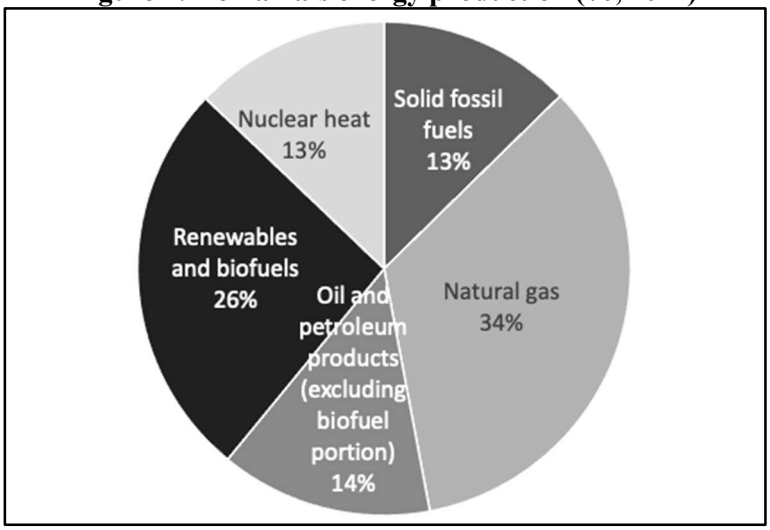
## 4. Statistical analysis of the main renewable energy indicators of Romania

### 4.1. EU energy production

The EU has a wide range of energy sources, including solid fuels, natural gas, oil, nuclear energy and renewable energy sources such as hydro, wind and solar.

Renewable energy played a significant role in EU energy production in 2022, the last year for which we have available data (43 % of total EU energy production). Nuclear energy had a significant share (28 %), followed by solid fuels (19 %), natural gas (6 %) and crude oil (3 %).

**Figure 1: Romania's energy production (%, 2022)**



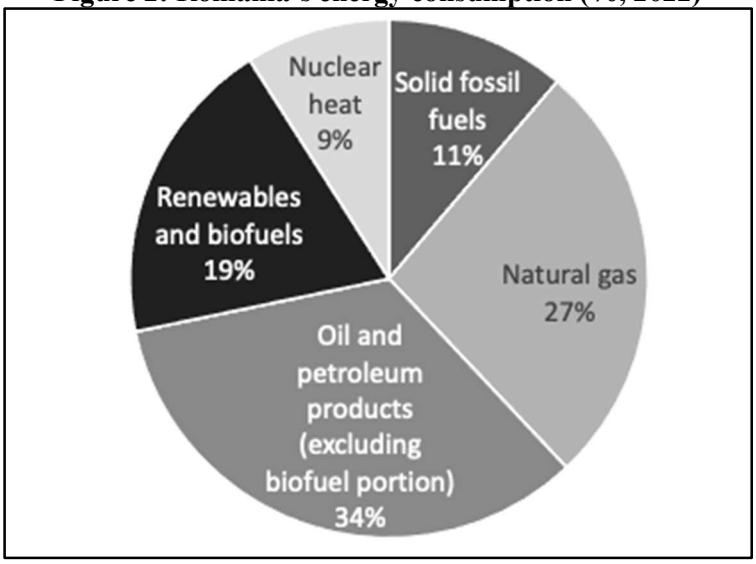

Source: Author according to Eurostat, 2024.

With regard to Romania, we can see in Figure 1 that in 2022 (the last year in which we have available data) the energy produced using renewable sources has the second largest share (26%), being surpassed only by that produced by power plants using natural gas. We also mention that 13% of the total energy was produced using oil and petroleum products, 13% using nuclear fuel and 13% using solid fossil fuels.

## 4.2. Energy consumption

It is estimated that in 2022, 67% of the total available energy in the EU will be consumed by end users (final energy consumption) such as EU citizens, industry and transport. The 33% remained is mainly lost in the generation and distribution of electricity used to support energy production processes or consumed for non-energy purposes.

**Figure 2: Romania's energy consumption (%, 2022)**




Source: Author according to Eurostat, 2024.

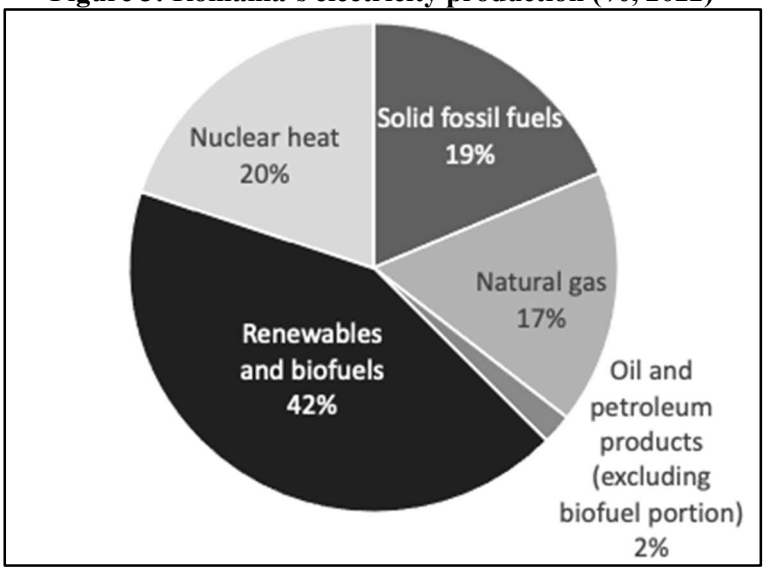
Figure 2 shows that 19% of the total consumption in Romania was produced by renewable sources, this consumption being exceeded by the consumption of natural gas (27%) and of oil and petroleum products. Below the share of renewable consumption were nuclear heat (9%) and solid fossil fuels (11%). A number of potential explanations can be advanced for the relatively low consumption of renewable energy. These include a lack of predictability, adverse weather conditions, lower efficiency, higher capital costs and geographical limitations.

## 4.3. Electricity production

In 2022, electricity accounted for 23 % of the final energy consumed in the EU, from a variety of sources. Renewable energy and fossil fuels were the main sources of electricity generation (both 39 %), with nuclear power plants accounting for 22 %.

Among renewable energy sources, wind turbines accounted for the largest share of electricity generation, with 15 %. Hydroelectric, solar and biofuel plants also contributed significantly with shares of 10, 8 and 5 % respectively.

**Figure 3: Romania's electricity production (%, 2022)**




Source: Author according to Eurostat, 2024.

In Romania, most of the electricity produced was from renewable sources (42%), followed by nuclear fuel (20%), solid fuel (19%) and natural gas (17%). At the other end of the spectrum are coal and petroleum products (Figure 3).

# 5. Romania's strengths and weaknesses in terms of renewable energy

## 5.1. Strong points

***Five counties with a potential of 98.9 GW***

When evaluating wind energy, two key technical considerations are wind power generation potential and the Full Load Hours (FLH) indicator, which represents the total number of hours of operation or energy production per year. For onshore wind turbines, a value of more than 2,000 FLH is generally considered a positive indicator. Accordingly, the typical operating life of an onshore wind turbine is estimated to be between 2,000 and 2,300 FLH, while offshore turbines are expected to operate for approximately 3,000 FLH. However, it should be noted that offshore turbines tend to be more expensive to maintain and operate.

The following five counties have been identified as having high potential for the development of wind energy projects: Braila, Constanta, Galati, Tulcea, and Ilomita. The total gross technical potential for wind energy in these five provinces is of 98.9 GW, equivalent to 249.2 TWh. If additional land use restrictions are applied and a rather conservative area allocation assumption is made, the technical potential is reduced by half, 48.1 GW or 122.6 TWh, respectively.

The conclusion is that even the lowest figure in terms of production potential is twice the electricity consumption of the whole of Romania today. This shows that it is possible to exploit onshore wind potential in a way that takes into account all important aspects (bird migration routes, protected natural areas, agricultural regeneration) and yet allows for a significant increase in generation.

***Photovoltaics, an additional 2,000 MW in 2024***

In 2023, more than 1,000 MW of solar panels were installed and investments were estimated at around 1 billion euros. The development of PV capacity is expected to gain momentum in 2024, with Romania's installed capacity expected to reach 4 GW.

As a result, by 2024, Romania could have an installed capacity of 2,000 new megawatts from PV panels alone, equivalent to the output of three nuclear reactors in Cernavodă. The pace of development and investment in this area is accelerating, despite Romania's relative inexperience in the field.

For comparison, Romania's installed PV capacity is expected to reach 4 GW by 2024, while Germany has already reached nearly 70 GW. This is a relatively modest figure, but it illustrates the significant development potential of this sector in Romania. Large energy companies, investment funds, and PV park developers are expected to be the main investors in Romania's solar industry. The sector is expected to experience significant growth because of the EU's sustainability policy and climate commitments.

***Offshore Wind Energy Law***

In April 2024, the Chamber of Deputies approved the offshore wind energy law (Law no. 121 / April 30th 2024). Romania has an offshore wind potential of 76 GW of installed capacity, providing an attractive opportunity for the development of this type of renewable energy. The Ministry of Energy will initiate a study to prepare procedures for granting concessions, exploration, construction and operation of offshore wind farms.

The study will also identify the offshore oceans to be leased by the Ministry of Energy, taking into account wind potential, the evacuation potential of offshore wind power and restrictions imposed by the Marine Spatial Plan, including those related to biodiversity and environmental protection. The results of the study will be submitted to the government by June 30, 2025, at which time the offshore wind limits and subsequent implementing laws will be approved. The Ministry of Energy will then initiate a competitive process for awarding concession contracts.

***European funds***

Romania's Modernization Fund and Recovery and Resilience Plan have facilitated support schemes for renewable energy investors and calls for new power generation in line with Romania's decarbonization plan. Romania has made 2 billion euros available for the renewable energy sector, 2 billion euros for investment in power transmission and distribution, and 400 million euros for new high-efficiency cogeneration units. In addition, funds worth 590 million euros have been made available for the reconstruction of thermal networks. With the planned investments, Romania will add 10,000 MW of green energy by 2030.

***National Integrated Energy and Climate Change Plan***

The National Integrated Energy and Climate Change Plan 2021-2030 describes Romania's commitment to reach a total of 30.7% of energy from renewable energy sources in the overall final energy consumption mix by 2030. This is in line with Romania's decarbonization target as an EU member state. To achieve this, the plan identifies the need to increase the installed capacity of wind and photovoltaic power plants and increase the number of consumers. To achieve this, Romania should have an installed capacity of 5.1 GW in solar technology and 5.3 GW in wind technology by 2030. In addition, the country aims to install an additional 6.9 GW of renewable energy between 2021 and 2030.

## 4.2. Weak points

***Frequent changes in legislation***

Frequent and significant amendments to energy legislation are a major obstacle to advancing renewable energy projects. Enacting comprehensive, transparent and permanent legislation can be a compelling argument to attract investments (international, national or even local) in this field. Considering the great potential and the ability to take into account relevant regional constraints and influence electricity prices in the medium to long term, wind energy development in Romania seems to be a logical and relatively risk-free course of action.

However, in order to be able to see this development, it would be useful to have a framework that organizes and defines, both at the level of strategic objectives and concrete actions, how to develop the wind energy sector in Romania.

***Lack of a related legislative framework***

It may be useful to consider legislative means to avoid the development of potentially speculative investments, and a related legislative framework to avoid long grid connection times. According to an analysis by the National Energy Regulatory Agency and the Competition Council, there are still financial challenges in securing financing for grid reinforcement works to take over the electricity that will be produced by the new units. In addition, there appears to be some uncertainty among electricity distribution network operators regarding the interpretation and application of the provisions of the current regulatory framework.

Finally, the lengthy approval process, lack of cadastral plans, delays in issuing government decisions and ministerial orders, and long construction period are some of the challenges identified by the National Energy Regulatory Agency (NERA) and the Competition Council that may hinder the connection of new production capacities to the National Energy System (NES).

***Long approval deadlines***

The European Union has taken the initiative to establish a framework to accelerate the deployment of renewable electricity through Regulation (EU) 2022/2577 of December 22, 2022. It introduces a series of

measures aimed at significantly reducing the EU's dependence on fossil fuels and combating the climate crisis by accelerating the transition to renewable energy sources.

To achieve this goal, the Regulation obliges Member States to ensure that the permitting process for renewable electricity projects is completed within specific deadlines. These deadlines include three months for the permitting process for the installation of co-located wind, solar and energy storage assets and six months for the permitting process for refurbishment projects, including all relevant environmental assessments. In addition, if the refurbishment involves an increase of up to 15% of the plant's capacity, the connection to the grid will be authorized within three months. However, these deadlines are not respected in Romania for various reasons.

The wide variation in the time required to process delivery requests can be attributed to the time required for users to complete the documentation accompanying the delivery request, which can range from a few days to six months. In addition, the long time required to draft, finalize, and correct processing studies, as well as the time it takes for users to choose one of the delivery solutions approved by the operators, contribute to the observed differences.

The time required to process applications is also heavily influenced by the level of training and engagement of the consultants selected by the applicants. For the period 2019-2022, the average time to process connection requests submitted to the national operator was about nine months, ranging from 5 months to 13 months. The high volume of connection requests has led to the need for grid upgrades to ensure the technical conditions for power production at power plants. These upgrades require long lead times and can affect the operating time of power generation capacities, depending on the region where the power plant is located.

To eliminate or limit the potentially speculative nature of obtaining Technical Connection Approvals (TCA) for new generation facilities, producer associations have proposed the introduction of an obligation to pay a deposit of 10% of the connection fee, which must be deposited within a maximum of three months of the issuance of the TCA, under penalty of expiration. In this regard, producer associations have suggested that when a connection contract is concluded, the deposit can be deposited as an advance payment for the work to be carried out. If the work is not completed, the deposit is returned to the beneficiary at the end of the delivery contract. The proposals made by the producer associations apply to capacities with an installed capacity of more than 10 MW.

***Slow digitization***

One of the main issues identified was the lack of a centralized IT system for renewable energy project developers. While some online platforms have been created in recent years to facilitate the submission of applications and supporting documents at various stages of licensing, there has been limited digitization of interactions with authorities such as the National Energy Regulatory Agency or the Environment Fund Administration. In addition, the lack of transparency and communication also affects the possibility for renewable electricity generation project developers to submit complaints and inquiries regarding the administrative procedures for issuing various types of permits and certificates.

This is also an important factor contributing to the authorities' lack of adherence to the legal deadlines for processing complaints. Moreover, due to the lack of transparency, in practice only those who are directly involved in the capacity project plan and are aware of the relevant details can make valid complaints.

***Failing to harness renewable potential***

The technical potential of wind energy sources in Romania has been estimated at 10.23 terawatt-hours (TWh) per year. Currently, only 60% of this potential is being exploited due to the limited capacity of the national power grid to absorb unpredictable and discontinuous sources of production. Thus, any expansion of wind power must be implemented in parallel with other developments to ensure the provision of system balancing services.

Regarding the distribution of solar electricity generation across the country, there is a relatively even distribution of values ranging from 1,100 to 1,450 kWh/m2/year. Utilizing the potential of solar energy to generate electricity via photovoltaic panels allows for the installation of a total capacity of 4,000 MWh, with an annual output of 4.8 terawatt-hours of energy.

***Bureaucracy***

In Romania, several institutions are involved in the licensing process for renewable energy projects, leading to a duplication of licensing procedures that unnecessarily prolongs the whole process and discourages potential investors. In addition, the lack of experience of grid operator staff regarding renewable energy projects is a major obstacle to obtaining renewable energy licenses. In addition, there is an urgent need to measure, monitor and optimize various performance indicators.

One way to measure this is to look at how long it takes for the relevant authorities to authorize the project. This can vary greatly from project to project due to the lack of a standardized process. Other performance

indicators that could be improved are the rate of project approvals, the rate of approvals/permits being challenged in court and the rate of court cases filed.

## 6. Conclusion

The European Union prioritizes the promotion of renewable energy to mitigate climate change, leveraging the large energy potential and availability of these sources. Renewable energy helps reduce the EU's dependence on fossil fuels, aiding in the transition to a sustainable energy system and supporting the EU's goal of achieving climate neutrality by 2050. This commitment is part of the broader Green Deal ambitions, which aim to limit climate change and promote sustainable economic development.

In Romania, the exploitation of onshore wind energy is highlighted as a key opportunity. In Romania the wind and photovoltaic energy can be harnessed without compromising important environmental aspects such as bird migration routes, protected natural areas, and agricultural regeneration. This approach facilitates a significant increase in renewable energy generation, contributing to Romania's substantial progress in this sector

Regarding the opportunities associated with the European funds in the field of renewable energy, it is important to note that support schemes for new investors has been developed and calls for new energy production capacities have been launched in line with the decarbonization plan undertaken by Romania.

When discussing Romania's weaknesses in the field of renewable energy, it can be observed that major and frequent changes in energy legislation present a significant barrier to the development of renewable projects. However, establishing detailed, transparent, and long-lasting legislation can be a favorable argument for attracting investment, as it provides a stable and predictable framework necessary to develop renewable energy projects.

In Romania, however, the approval deadlines are not respected, and there are numerous reasons for this non-compliance. The transmission system operator (TSO) asserts that the significant discrepancies in the time required to process connection applications are attributable to the time taken by users to complete the documentation attached to the connection application and the time taken by users to select one of the connection solutions approved by operators. Moreover, the absence of a centralized information system for renewable energy project developers represents a significant obstacle. While online platforms have been established in recent years for the submission of applications and supporting documents required at the various permitting stages, the digitization of interactions with the relevant authorities has not yet been achieved.

The technical potential of Romania in terms of wind power sources has been estimated at approximately 10.23 terawatt-hours (TWh) per year. However, only 60% of this potential is currently being exploited, due to the limitations of the National Energy Strategy (NES) in accommodating unpredictable discontinuous production sources. In Romania, numerous institutions are involved in the authorization process for renewable energy projects, which results in repetitive licensing procedures that unnecessarily prolong the entire process and discourage potential investors.

In conclusion, our main finding is that there has been significant progress in terms of renewable energy in Romania, which performs well on the analyzed indicators. Moreover, estimates indicate that Romania has a renewable energy capacity that could allow to generate a much larger amount of renewable energy than we do now. However, this can only be achieved with a better understanding of long-term objectives and a proactive involvement of all decision-makers.

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