DECARBONIZATION OF THE ROMANIAN ENERGY SECTOR

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Abstract: Decarbonisation has the potential to significantly improve energy affordability and strengthen security of energy supply, a crucial objective given the impact of the war between Russia and Ukraine, which has put pressure on Europe's energy infrastructure. Although Romania is the second largest producer of natural gas in the European Union, its dependence on imports during peak consumption periods, such as winter, underlines the need for an effective security of supply strategy.

Keywords: greenhouse gas emissions, climate change, climate neutrality, policies, strategies

INTRODUCTION

Romania has committed itself to the field of climate change and climate neutrality, through a series of policies and initiatives at national and European level, with the aim of reducing greenhouse gas emissions and promoting sustainable development. It has also demonstrated a significant commitment to climate change since the early 1990s by ratifying the United Nations Framework Convention on Climate Change (UNFCCC) in 1994 and the Kyoto Protocol in 2001.

These actions were followed by an intensification of climate measures after the country's accession to the European Union in 2007, when clear targets for reducing greenhouse gas (GHG) emissions were set as part of the integration process in policies and regulations European.

Entering the European Union was a defining moment for our country, given that it was in the process of defining an ambitious set of measures to combat climate change. Another important step was the signing of the Paris Agreement (2015), whose measures included reducing GHG emissions, limiting global warming to 1.5°C compared to pre-industrial levels, and adopting directives and regulations to implement these goals at EU level Romania supports the EU objectives of reducing GHG emissions by at least 55% by 2030 compared to 1990 levels and achieving climate neutrality by 2050. These commitments are part of the European Green Deal (Green Deal), which aims to transform the European economy into a sustainable one.

The main target of the European Union is to achieve climate neutrality by 2050, and Romania, as a member state, must implement the necessary measures to comply with these commitments. In this context, strengthening governance and creating mechanisms and institutions dedicated to climate action are essential to ensure an effective and sustainable transition to a low-carbon future.

DECARBONISATION OF THE ENERGY SECTOR

A key aspect of decarbonisation is the expansion of electricity generation to support the electrification of key sectors such as transport, construction and industry. In this context, Romania must maintain its commitments to phase out coal and invest massively in low-carbon energy sources, such as solar and wind energy. These measures are necessary not only to reduce greenhouse gas (GHG) emissions, but also to support the transition to a more diversified and sustainable energy mix.

Fossil fuels still dominate the Romanian economy in terms of primary energy consumption and are still indispensable in the electricity production mix, as shown in Table 1 and Table 2.

Table 1: Gross internal consumption of primary energy (TWh)

Fuel	Gross internal consumption of primary energy
Coal	41,1
Natural gas	97,1
Oil	122,4
Biofuels	50,4
Hydro, wind, solar	24,5
Nuclear	32,8
Total	32,8

Source: *data Eurostat (2022)*

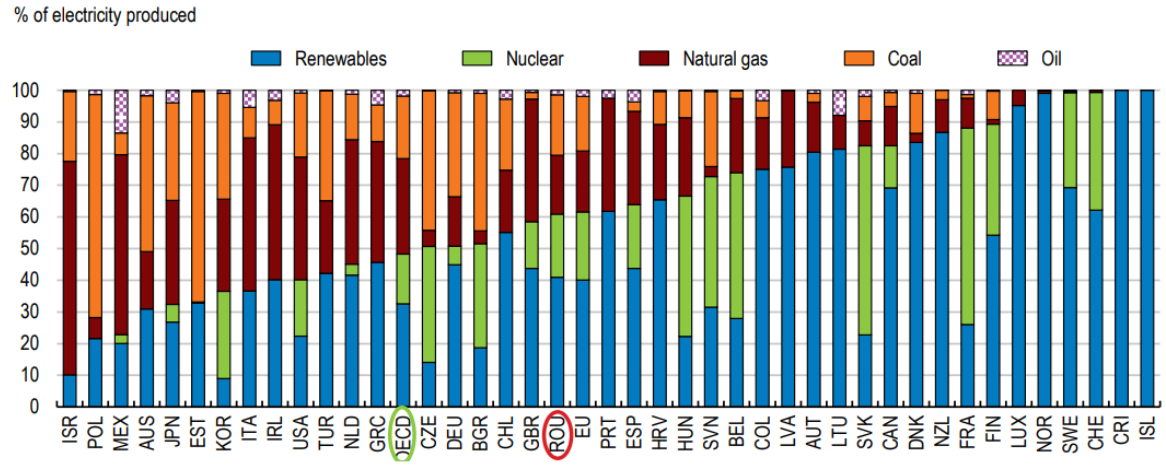
Table 2: Total electricity production (TWh) of Romania in 2022

Fuel	Gross internal consumption of primary energy
Water	13,98
Aeolian	7,00
Solar PV	1,99
Biofuels	0,65
Nuclear	11,09
Coal	10,37
Oil	1,11
Natural gas	9,33
Total	55,51

Source: *data Eurostat (2022)*

Table 1 and Table 2 contain data showing that national electricity production covers less than 20% of gross domestic primary energy consumption. The percentage will probably exceed 50% by 2050. A quarter of Romania's GHG emissions (which come from energy) come from the own production of the energy industries, the rest from the burning of fossil fuels from other sectors. Romania's dependence on coal and natural gas for electricity has decreased in the last ten years, however, it remains high (40% of electricity generation). (Figure 1).

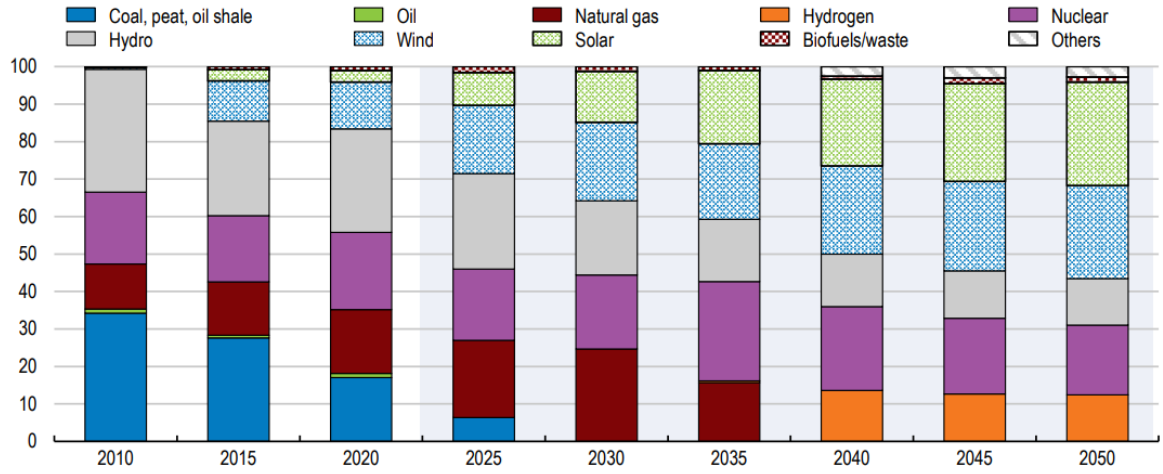
Figura 1: Producerea de energie electrică după sursa de energie



Sursa: *date International Energy Agency (IEA, 2022)*

Currently, electricity represents approximately 15% of Romania's final energy consumption, and the government plays a significant role in the control and management of the energy sector, including in terms of production capacities and the technological mix of installations. The national strategy for the decarbonisation of electricity production focuses on the gradual reduction of dependence on coal, but also on the expansion of electricity generation capacity by about a third compared to the level of 2020. In this sense, renewable energy sources such as photovoltaics and wind turbines, will play an increasingly important role.
Investments in the nuclear field are also a priority, with the expansion of the Cernavoda nuclear complex and the installation of the first small modular nuclear reactor in the European Union. In parallel, Romania is investing in offshore natural gas deposits, which will contribute to the diversification of supply sources. Coordination between investments in clean energy and phasing out of fossil fuels will be essential to avoid possible price increases and ensure a stable and affordable energy supply.
The 2022 legislation, which stipulates the complete phase-out of coal by 2032, underlines Romania's commitment to achieving emissions reduction targets and supporting the transition to a cleaner and more sustainable energy system. Coal-fired power generation declined significantly between 2012 and 2022, gradually being replaced by greener sources such as natural gas, solar and wind power (Figure 2). However, coal continues to have a significant share in the energy mix, being responsible for nearly a fifth of total energy production and, at the same time, the largest contributor to GHG emissions in the energy sector.
Thus, the transition to a decarbonized energy system represents an important step for Romania, not only from the perspective of reducing carbon emissions, but also to ensure sustainable long-term energy security.

Figure 2: Coal energy production in Romania



Sursa: *date International Energy Agency (IEA, 2022)*

The energy crisis had a significant impact on government policies in Romania, and the adopted measures reflect the urgent need to ensure energy security in a context of transition to cleaner energy sources. The closure of some coal plants (due to rising energy prices) has been delayed until October 2023, despite previous commitments to reduce dependence on the fuel. The decision risks delaying Romania's transition to a more sustainable energy system,

considering that many of the EU states are already more advanced in the decarbonization process.
To compensate for the gradual elimination of coal-based power generation, Romania intends to expand natural gas production capacity, in parallel with the development of renewable energy sources. The government plans to double natural gas production capacity by 2026-2027, and a significant part of this growth will be supported by European funds. These new gas plants will be compatible with the use of hydrogen, a low-emissions technology, although there are uncertainties about its costs and competitiveness.
At the same time, Romania must take into account the global objectives of reducing greenhouse gas emissions, which require a decrease in the demand for fossil fuels before 2030. The continued exploration and development of new natural gas projects could enter contradiction with international climate commitments, and Romania should adopt a more cautious approach in granting new licenses for oil and gas.

PROPOSALS FOR ACCELERATING THE ENERGY TRANSITION IN ROMANIA

Another important aspect of the energy transition in Romania is the electrification of the economy, an essential process for reducing dependence on fossil fuels. Electrification of the economic sector will contribute to the increase in demand for electricity, especially in key sectors such as transport, buildings and industry. Measures such as the promotion of electric vehicles, the electrification of rail transport, the use of heat pumps in buildings and the production of electric heat in industry will boost the demand for electricity and support the transition to a cleaner and more sustainable energy system.
Romania faces a major dilemma: on the one hand, it must ensure energy stability and security, and on the other, it must align itself with global climate goals and the transition to clean energy sources. Implementing an integrated strategy that combines renewable energy sources, electrification of the economy and a gradual reduction of dependence on fossil fuels is necessary for long-term success.
In order to cope with the increasing demand for energy, it is necessary to adapt the transmission and distribution networks and to support the integration of renewable energy sources (such as solar and wind energy). These energy sources, being variable, require infrastructures to manage them efficiently, and the development of prosumers (that produce and consume energy) plays a significant role in this regard.
The main goal of the transition is to reduce carbon emissions by replacing fossil energy sources with renewables (such as solar and wind) and carbon-free nuclear power. Electricity plays an important role in this decarbonisation process, and the electrification of economic sectors (transport, industry, buildings) is essential to reduce dependence on fossil fuels.
Also, the energy production capacities from renewable sources (photovoltaic and wind) must be expanded, considering their decisive role in the decarbonization of the energy sector. Romania already has a solid base of prosumers, and their number is constantly growing, which reflects a global trend of decentralization of energy production.
Nuclear energy remains an important element of the energy mix, due to its ability to produce energy without carbon emissions. Romania is already developing two nuclear units at Cernavodă and is exploring the possibility of implementing low-power nuclear reactors (SMRs), which can contribute to reducing emissions and diversifying energy sources.
The production of green hydrogen is an important component of the energy transition. Green hydrogen can be used in industries that are difficult to decarbonize (such as steel production or the chemical industry) and can represent a solution for storing and transporting energy in a more flexible form through Power-to-X technology.
Overall, the transition to a low-carbon energy system requires not only the expansion and modernization of infrastructure, but also the adoption of innovative technologies and a

diversification of energy sources. Romania, through its projects in the field of nuclear and renewable energy, aims to contribute significantly to the achievement of global climate goals.
In addition to electrification, carbon capture and storage (CCS) solutions are essential for reducing industrial emissions from sectors that generate emissions that cannot be avoided. The manufacture of cement, lime or chemicals are relevant examples, as their manufacturing processes involve CO2 emissions that cannot easily be eliminated by electrification. Large-scale deployment of CO2 capture and transport infrastructure is essential to achieve emissions reduction targets.
Implementing these solutions requires significant investment in research, infrastructure, and regulation, but they could contribute substantially to diversifying and decarbonizing the global energy mix. In parallel with electrification, these technologies can be part of a more integrated, sustainable and resilient energy system.

THE NATIONAL INTEGRATED ENERGY-CLIMATE PLAN (PNIESC)

The National Integrated Energy and Climate Change Plan (PNIESC) anticipates a significant transition in Romania's renewable energy mix by 2030, with a dominant role of biomass, but also with a considerable increase in solar and wind energy sources. Here are the main points highlighted in that scenario:
1. Biomass remains the most important type of renewable fuel until 2030, but its share in gross final consumption of renewable energy will decrease significantly from 56% in 2022 to 34% in 2030. This reflects the transition to more efficient sources and less polluting, such as solar and wind energy.
2. Solar energy will experience significant growth, with an estimated installed capacity of 8.2 GW by 2030 and 33.3 GW by 2050. Its share of gross final renewable energy consumption will reach 15% in 2030, which which represents a considerable change from the current situation.
3. Wind energy will follow a similar trend, with a capacity of 7.3 GW estimated for 2030 and 21.3 GW for 2050. Its share in total renewable energy will reach 14% in 2030, a significant advance from the current level.
4. Hydropower will remain stable with an installed capacity of around 6.9 GW in both 2030 and 2050, and its share of gross final renewable energy consumption will decrease from 22% in 2022 to 14% in 2030. This reflects both the limit of hydropower expansion capacity and the growth of other renewable energy sources.
There are also changes in proportions between renewable sources, as solar and wind power increase, the share of biomass and hydropower will decrease in the final gross consumption of renewable energy. These changes will contribute to a diversification of the energy mix and support the achievement of climate and sustainability objectives.

CONCLUSIONS

The integration of renewable energy sources into national power systems is a major challenge, but also an opportunity, especially considering the proportional increase of variable sources such as solar and wind energy. In this context, electricity storage capacity becomes essential, and battery storage is an important tool for grid stabilization.
Battery storage allows the system to absorb excess energy from renewable sources when production exceeds demand and release that energy when demand exceeds production. This process contributes to the real-time balancing of energy production and consumption, frequency and voltage regulation, and ensuring a stable network. Given the variability of renewable energy sources such as photovoltaic and wind farms, storage becomes a critical component to ensure system continuity and reliability.

The increase in storage capacity is supported by falling battery prices, a favorable factor for investment in this technology. Battery production is dominated by China, and lower costs have made these investments more attractive and affordable. Furthermore, storage capacities not only support grid stability, but also help reduce energy losses and manage reactive power more efficiently.

In this context, the PNIESC (Integrated National Plan for Energy and Climate Change) revised the objectives regarding battery storage, proposing a significant increase in installed capacity by 2030, from 240 MW/480 MWh to 1,200 MW/2,300 MWh. This is a clear signal that Romania wants to strengthen its energy infrastructure to support the integration of renewable sources.

For Romania, accelerating the transition to a low-carbon economy and adapting to climate change are necessary, not only to fulfill international commitments, but also to ensure the country's economic and social sustainability.

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