ECONOMIC IMPLICATIONS OF THE ENERGY TRANSITION: A THEORETICAL APPROACH

ALINA NIȚESCU, OANA DOBRE-BARON *

ABSTRACT: *The energy transition represents an essential process in the current context of climate change and the need to reduce dependence on fossil fuels, having significant economic implications at the global, European, and national level. This work captures a series of ecological, economic and social aspects deriving from the transition to renewable energy, also presenting the main policies and instruments that facilitate a balanced and fair transition. Although, in the short term, the energy transition may entail economic and social costs, in the long term the benefits are multiple, and are reflected in sustainable economic growth, technological innovation, and the creation of sustainable jobs.*

KEY WORDS: *energy transition, renewable energy, sustainability, investment, innovation, green jobs, sustainable economic growth.*

JEL CLASSIFICATIONS: *Q42, Q43, Q48.*

1. INTRODUCTION

The energy transition is the process by which energy production and consumption systems evolve from fossil fuel-based models to sustainable solutions with low or zero carbon emissions. Decarbonisation of the energy sector is essential in the context of the acceleration of climate change, generated mainly by the increase in the concentration of greenhouse gases.

On a global scale, international goals aim to reduce emissions, protect the environment and strengthen the resilience of societies in the face of climate effects. The energy transition thus becomes a common effort and a fundamental condition for a sustainable future, both in Europe and around the world.

Rising global temperatures, extreme weather events and biodiversity loss have led the international community (United Nations, 2025) to act through joint policies

* *Assoc. Prof., Ph.D., University of Petrosani, Romania, alinanitescu@upet.ro*
Assoc. Prof., Ph.D., University of Petrosani, Romania, oanabaron@upet.ro

and agreements, such as the Paris Agreement (United Nations, 2015), which sets the goal of limiting global warming to 1.5°C above pre-industrial levels.

At the European level, the European Green Deal is the EU's strategic response to this climate crisis. Through the ambitious goal of climate neutrality by 2050, the Union aims to transform the energy system, accelerate investments in renewable energy, improve energy efficiency and significantly reduce carbon emissions. At the same time, the transition must be fair, ensuring support for affected regions and citizens.

However, the energy transition should not only be seen as a response to climate change, but also a major opportunity for economic development, especially in the context where "the European Commission understands decarbonisation and green innovation as a driver for economic development" (European Environmental Bureau, 2025). By shifting towards renewables and decarbonising the energy sector, economies can become more competitive, more resilient, and more independent from the volatility of fossil fuel markets. Investments in green technologies drive innovation, create jobs in emerging industries, and reduce long-term energy costs. Likewise, the modernization of energy infrastructure and the digitization of production and distribution systems contribute to increasing efficiency, attracting private investments, and strengthening energy security. Thus, the energy transition becomes an essential driver of sustainable economic growth and industrial transformation in Europe and globally.

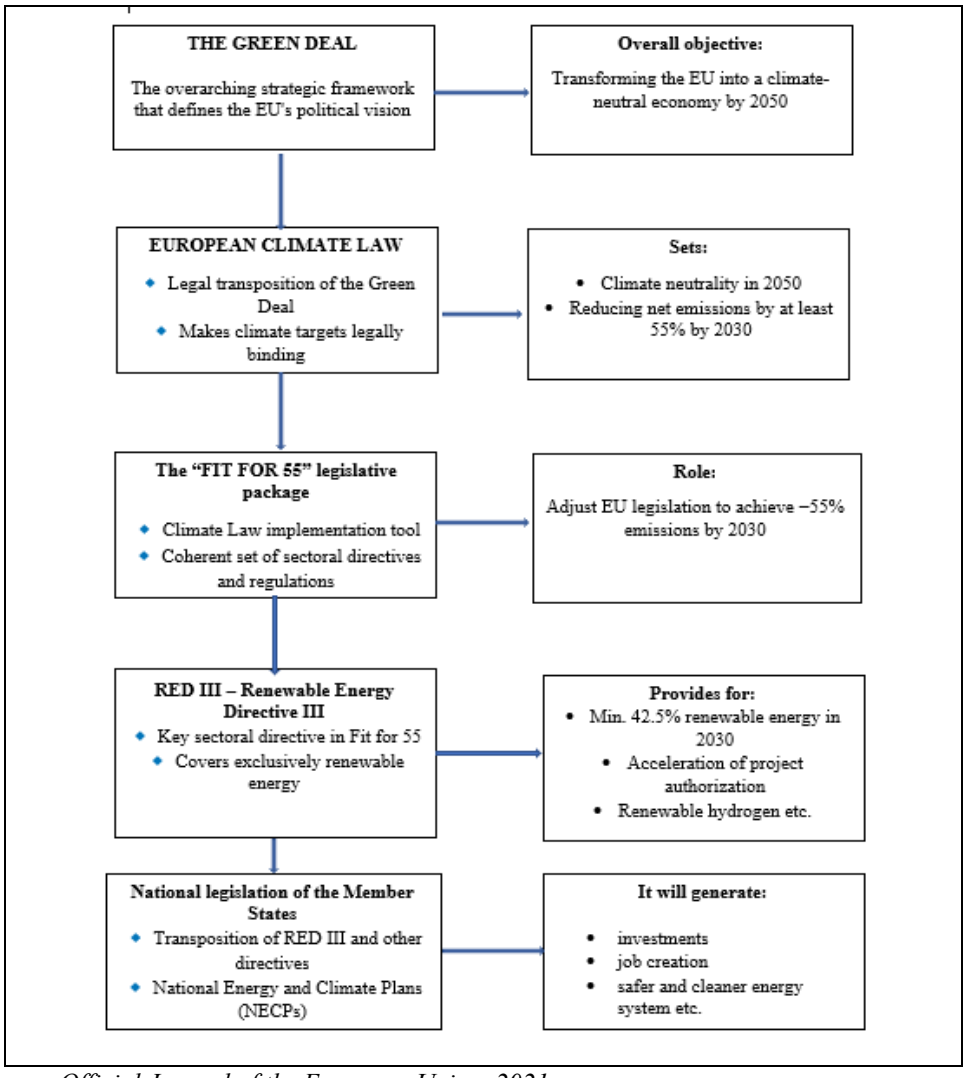
2. PROGRAMS AND INSTRUMENTS TO ACCELERATE THE ENERGY TRANSITION AT THE EUROPEAN AND NATIONAL LEVEL

The Green Deal represents the most ambitious legislative and strategic project of the European Union in recent decades. It not only sets climate targets, but reconfigures the entire European energy system, driving the transition to clean technologies, energy efficiency and independence from fossil fuels.

The climate neutrality objectives provided by the Green Deal have been transposed into legislation through the European Climate Law (European Commission, 2025c), which stipulates as a legal obligation that by 2050 the EU member states reach the objective of zero greenhouse gases (GHG) - net zero greenhouse gas (GHG) emissions. At the same time, a series of intermediate targets have been set to achieve this objective, such as reducing net greenhouse gas emissions by at least 55% compared to 1990 levels by 2030. In this regard, in 2023 the legislative package "Prepare for 55" was adopted - a comprehensive set of legislative proposals (some revised and some new) that pay increased attention to the need for the transition to renewable energy and increasing energy efficiency (European Commission, 2023).

As part of the "Fit for 55" package, RED III (Renewable Energy Directive III) (Official Journal of the European Union, 2021) was adopted - a new legislative framework which establishes that, by 2030, at least 42.5% of the total energy consumption of the European Union should come from renewable sources, with an indicative target of 45%, especially since the energy sector currently contributes more than 75% of the total greenhouse gas emissions in the EU (Figure 1).

In essence, RED III is the directive by which the European Union accelerates the energy transition and increases the share of energy from renewable sources until 2030, in the context of the energy crisis and climate objectives, through: rapid expansion of solar, wind, hydro and biomass energy; simplifying and shortening authorization procedures for green projects; the introduction of renewable energy acceleration zones – designated areas for the rapid development of renewable energy projects.



Source: Official Journal of the European Union, 2021

Figure 1. The legislative framework for the energy transition

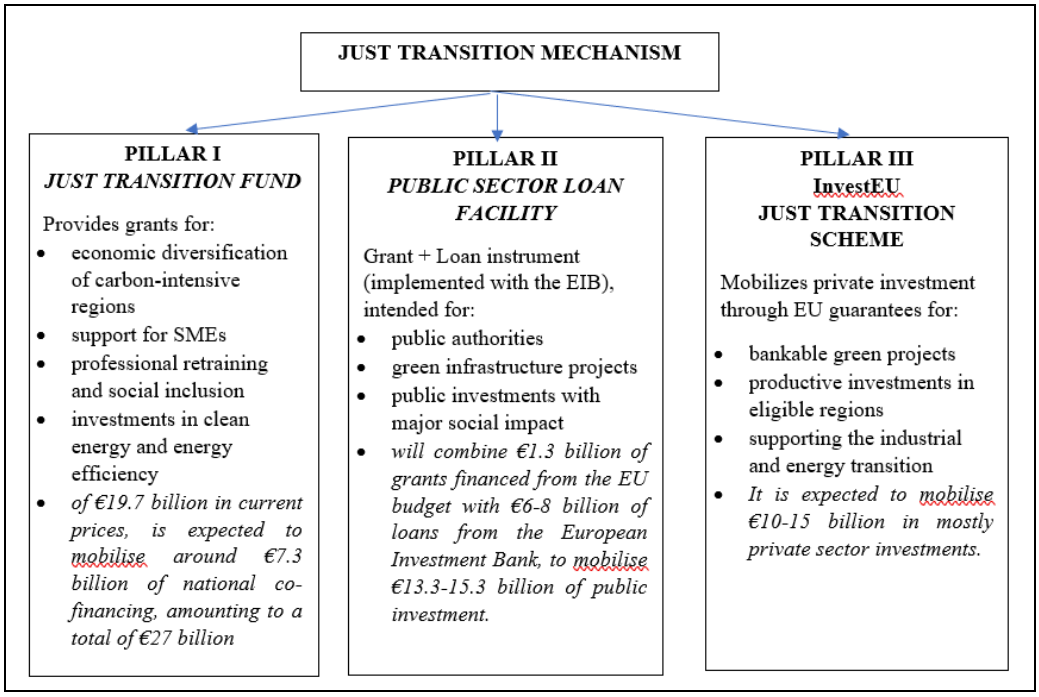
The transposition of RED III and the other directives into the national legislation of EU member countries will generate a series of effects, such as:

- *energy security.* Increasing domestic production of renewable energy will reduce dependence on fossil fuel imports and exposure to price volatility on international markets, an aspect that has become critical in the context of recent energy crises.
- *positive economic impact*. There will be increased investment in green technologies, energy infrastructure and innovation, which will contribute to job creation and strengthening the competitiveness of European industry. At the same time, the directive offers legislative predictability to investors, through clear rules and accelerated authorization procedures.
- *modernization of the energy system***.** The directive promotes electrification, the integration of renewable hydrogen, energy storage and the digitization of networks, facilitating the transition from a centralized system based on fossil fuels to a flexible and decentralized one.
- *increasing sustainability*, ensuring that the green transition takes place without affecting biodiversity and natural ecosystems. Thus, the directive seeks a balance between climate objectives, environmental protection and economic development.

Legislation derived from the Green Deal – including the European Climate Law, the Fit for 55 package and sectoral directives such as RED III – creates an integrated system of public policies, where climate objectives, energy security, and economic competitiveness are addressed simultaneously. This integrated approach ensures coherence between European and national levels and provides long-term predictability for authorities, investors, and industry.

The European Union makes available to the member states a series of financial instruments dedicated to accelerating the energy transition, in accordance with the climate and economic development objectives. Among these, we mention the Recovery and Resilience Mechanism (RRM), originally created to help member states recover from the COVID-19 pandemic. It is the EU's main financial instrument that provides loans and grants to member countries in order to ensure the transition to a green and digital economy. The funding was based on the National Recovery and Resilience Plans made by each individual state, and an important criterion according to which the plans were evaluated was the effective contribution to the green and digital transition (national plans must allocate at least 37% of the budget for climate and biodiversity and at least another 20% for digital measures) (European Council, 2025a). At the same time, as an additional financing component, the REPowerEU plan, was integrated into the RRM and aims to create the conditions for the gradual elimination of dependence on fossil fuels from Russia. "REPowerEU helps the EU: save energy, diversify energy supply sources, produce clean energy" (European Commission, 2025b).

Another key instrument aimed at mitigating the socio-economic impact of the transition to climate neutrality, by supporting vulnerable regions and communities affected by decarbonisation, in order to ensure a fair, inclusive and sustainable transformation, is the Just Transition Mechanism, which is structured on three complementary pillars (European Commission, 2019), as seen in Figure 2.



Source: European Commission, 2019

Figure 2. Just Transition Mechanism

The three pillars combine grants, loans, and guarantees, ensuring an integrated approach that mitigates the socio-economic impact of decarbonisation and facilitates the sustainable structural transformation of vulnerable regions.

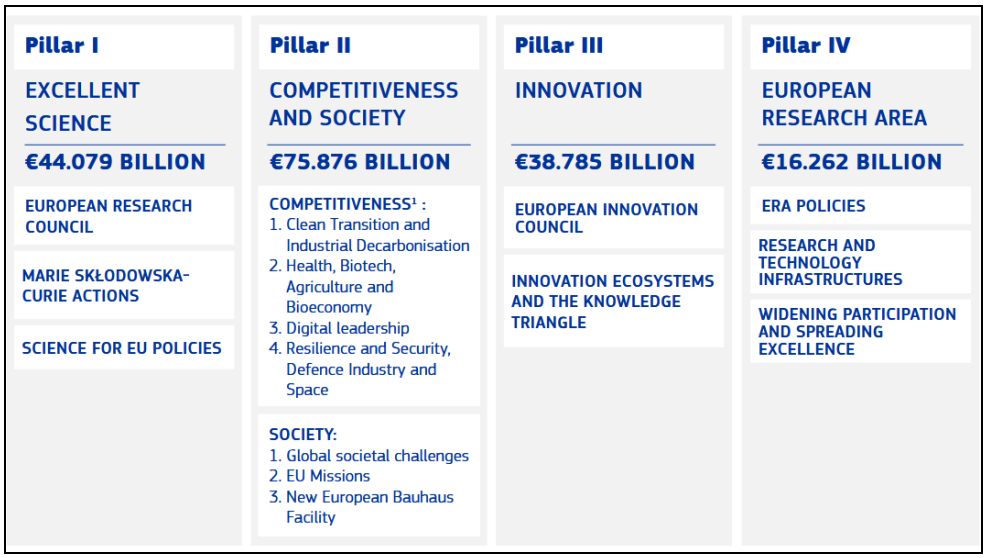
Another important program is Horizon Europe for research and innovation, which is the scientific pillar of the transition to clean energies, funding the development, testing and demonstration of the technologies needed to decarbonize Europe's energy and economic systems. The indicative funding amount for Horizon Europe for the period 2021-2027 is EUR 93.5 billion (European Commission, 2025a).

In the context of the transition to clean energies, the ambitious research and innovation Horizon Europe:

- supports fundamental and applied research in areas such as advanced solar and wind energy, energy storage, green hydrogen, smart grids and carbon capture;
- integrates the systemic dimension of the energy transition, simultaneously addressing technological, economic, social and governance aspects;
- contribute to the implementation of the European Green Deal, aligning the research agenda with the objectives of climate neutrality and energy security;
- ensures the continuity of the innovation chain, preparing projects for scaling and further investments through instruments such as InvestEU or the Innovation Fund.

"On 16 July 2025, the European Commission put forward its proposal for the Horizon Europe Framework Programme (2028–2034). With a proposed €175 billion budget, the programme will boost Europe’s productivity and competitiveness, while

also improving the well-being of millions of people across the continent." (Figure 3) (European Commission, 2025a).



Source: European Commission: Directorate-General for Research and Innovation, 2025

Figure 3. Horizon Europe Proposed Budget (2028-2034)

Overall, Horizon Europe acts as an innovation engine of the clean energy transition, creating the scientific and technological basis for the sustainable transformation of the European energy system.

We believe that, together, all the programs and financing instruments presented constitute an integrated architecture of the energy transition, in which technological innovation (Horizon Europe), rapid implementation and reforms (RRM), and socio-territorial equity (Just Transition) are interdependent, and converge towards the objective of climate neutrality of the European Union.

For the member states, the adoption and transposition of European legislation presuppose deep reforms, both administrative and economic, but at the same time generate significant opportunities: modernizing the energy infrastructure, attracting investments, creating jobs and reducing dependence on fossil fuel imports. Although the process involves short-term costs and challenges, the medium- and long-term benefits are structural and sustainable.

Romania, an EU member state, aligns itself with European efforts, being "firmly committed to achieving the energy transition, making possible the development of the national economy through energy sources with low carbon emissions and clean, safe and accessible technologies for energy consumers. Renewable energy sources, energy efficiency, natural gas mixed with hydrogen, nuclear energy and CCUS technologies (carbon capture, use and storage) play an important role in the implementation of the energy transition process" (Guvernul României, 2025c).

Romania's Energy Strategy 2025-2035, with the perspective of 2050, represents the national strategic framework which guide the medium and long-term development of the energy sector by diversifying the production mix, expanding capacities from renewable and nuclear sources, using natural gas as a transition resource and modernizing the infrastructure, in order to ensure energy security, economic competitiveness and progressive decarbonization. The document stipulates, among other things, that "the share of renewable energy sources in the final gross energy consumption will reach 44% in 2035, respectively 73% in 2050. The targets will be met, mainly, by increasing the installed capacity of energy production from wind, solar, hydropower and geothermal sources, the use of green gases (biomethane, hydrogen, synthetic methane, etc.), as well as by the partial electrification of the systems of heating and cooling." (Guvernul României, 2024).

Another programmatic document through which Romania defines its objectives and measures until 2030 for reducing greenhouse gas emissions, increasing the share of renewable energies, improving energy efficiency and strengthening energy security, in accordance with European Union policies, is the National Integrated Energy and Climate Change Plan (Guvernul României, 2025b). It provides a series of objectives such as: a target of at least 38% renewable energy in final consumption by 2030; phasing out coal (by 2032 – with possible adjustments); increasing energy efficiency; reducing emissions in all sectors, etc.

The energy transition is also supported with the help of the National Recovery and Resilience Plan which, by allocating funds for investments and reforms, accelerates the decarbonisation of the energy system, especially by developing the capacities to produce energy from renewable sources, promoting prosumers, expanding energy storage solutions, increasing the energy efficiency of buildings and modernizing energy transport and distribution networks. "Romania's Recovery and Resilience Plan is a strategic document that establishes the investment priorities and reforms necessary for recovery and sustainable growth, linked to the green and digital transition envisaged by the European Commission." (Guvernul României, 2025a).

Regions and communities dependent on carbon-intensive industries are supported through the Just Transition Program 2021-2027 (European Commission, C(2022) which finances economic reconversion, the creation of sustainable jobs, the reskilling of the workforce and the development of alternative economic activities, so that the decarbonization process is socially and economically equitable. In Romania, areas in Dolj, Gorj, Hunedoara, Mureș, Prahova and Galați counties are targeted. Although the Just Transition Fund does not directly finance the energy transition, it contributes to creating the economic-social conditions for decoupling from polluting industries and ensuring a fair energy transition, ensuring that decarbonization does not generate economic exclusion, but real development opportunities for the most affected regions.

Romania's national policies in the field of energy and climate establish the legislative and strategic framework through which the state transposes the European objectives into concrete measures, aimed at decarbonizing the economy, increasing the share of renewable energies and ensuring energy security in the medium and long term.

3. ECONOMICAL IMPLICATIONS OF THE TRANSITION TO CLEAN ENERGIES

The need to transition to renewable energy is supported by the need to protect the environment, the long-term economic advantages and the increase in energy security, which is not only a global responsibility, but also an essential investment in the future of humanity. "Renewable energy development not only changes the mix of energy sources powering the world's economies, but also creates jobs, builds economic value and enhances human well-being" (International Renewable Energy Agency, 2024).

From an ecological point of view, in terms of environmental protection we must remember that energy from renewable sources has lower carbon dioxide emissions than fossil fuels and comes from free and abundant natural resources. Moreover, accelerating the transition to renewable energy will decrease greenhouse gas emissions, having a positive impact on air quality and, implicitly, on people's health. The main types of energy from renewable sources are: wind energy, solar energy, hydroelectric energy, tidal energy, geothermal energy, heat pumps, biofuels, the renewable part of waste (European Council, 2025b).

From an economic point of view, the transition to renewable energy sources involves a series of major investments with positive effects both on GDP, employment, and related economic sectors.

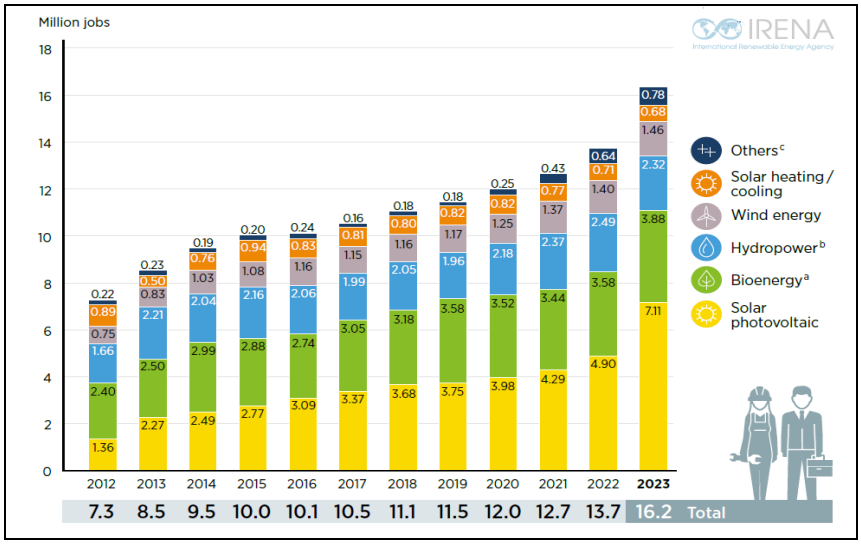
A United Nation study shows that "in 2024, $2 trillion went into clean energy – $800 billion more than fossil fuels and up almost 70 per cent in ten years. In 2023 alone, clean energy sectors drove 10 per cent of global GDP growth" (The European House Ambrosetti, Enel Foundation, 2019).

The Deloitte study on renewable energy in Romania shows that "each billion invested in renewable energy sources (RES) will bring an added value to the Romanian economy of EUR 2.17 billion and EUR 2.09 billion, respectively, and that each EUR invested in RES in the relevant sectors will generate EUR 4.4 in the Gross Domestic Product" (Deloitte, 2019).

These statements demonstrate the ability of the green energy sectors to generate added value and become a central engine of economic growth (Niță et. al., 2025), which in the future, will no longer depend exclusively on subsidies but become cost competitive and attractive for private capital.

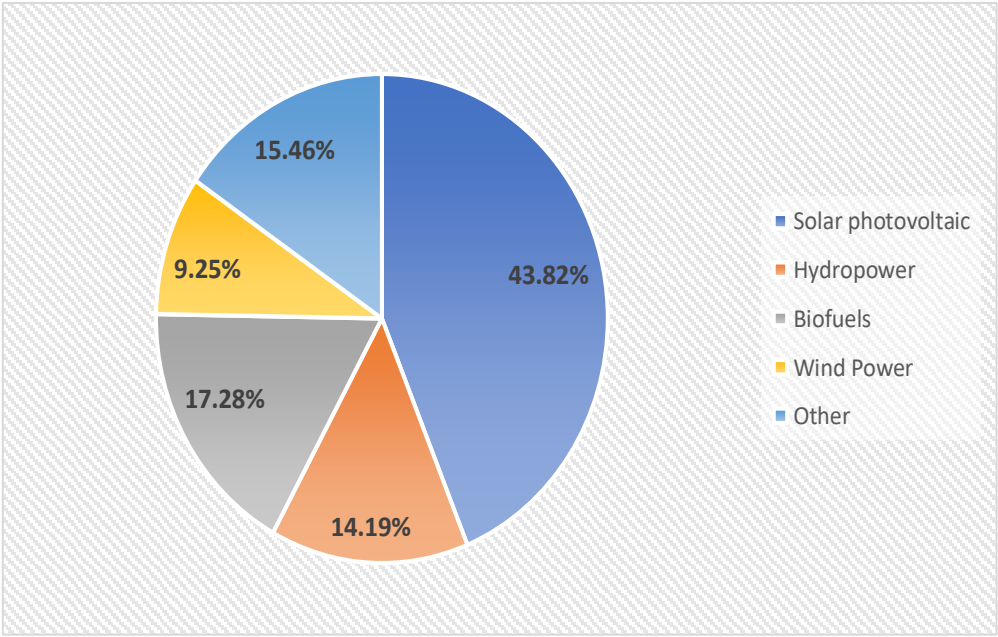
Moving towards a green economy also involves the creation of new jobs both in the energy sector and in related sectors. Worldwide, according to the IRENA study, "16.2 million global renewable energy jobs were created in 2023, up from 13.7 million in 2022" (International Renewable Energy Agency, 2024) (Figure 4).

We see sustained and continued growth in employment in the renewable energy sector globally over the period 2012–2023, with total jobs doubling from 7.3 million to 16.2 million, driven mainly by the rapid expansion of the solar PV sector, which accounts for the largest share of employment, followed by bioenergy, while wind, hydro and other renewable technologies are increasing moderate but constant, confirming the central role of the energy transition in the dynamics of the global labor market.



Source: International Renewable Energy Agency, 2024, p. 19

Figure 4. Evolution of global renewable energy employment by technology, 2012-2023



Source: International Renewable Energy Agency, 2024, p. 19

Figure 5. Share of jobs created on renewable energy sources, 2023

At the level of 2023, the largest share in the total number of jobs created globally in the field of renewable energy was in the solar photovoltaic sector, followed by Biofuels and Hydropower (Figure 5).

This trend of job growth in green energy fields is noticeable, for example, in the case of Romania, where "more than 100,000 new green employment will be created by the year 2050 in the Romania Neutral scenario", but also in the case of Germany, where "green technology represents 15% of German economic production, creating 1.5 million jobs" (Federal Ministry for Economic Affairs and Climate Action, 2022). At the same time, according to the Just E-volution study at the level of the European Union, the energy transition could generate an increase in industrial production between +113 billion Euros and +145 billion Euros, and in the case of Romania between +1 billion to +3 billion Euros, until 2030. At the same time, it is estimated that in the European Union, the energy transition generates a final net impact on employment between +997,000 and +1.4 million employees by 2030, while in Romania, the net effect extends from +30,000 to over +52,000 employees (Official Journal of the European Union, 2023).

4. CONCLUSIONS

The transition to renewable energy sources represents one of the most profound structural transformations of the contemporary economy, with multiple economic implications, both in the short and long term. The energy transition is not only a climate necessity, but also an essential vector of global economic development, with the potential to redefine the structure of investments, the competitiveness of states and the trajectory of long-term economic growth.

In the short and medium term, the energy transition requires significant financial efforts, associated with investments in infrastructure, new technologies, network modernization and support measures for sectors and regions affected by the decline of fossil fuel-based industries. These costs can put pressure on public budgets, energy prices and the competitiveness of certain industries, especially in economies with aging energy infrastructure or a high degree of dependence on conventional sources. However, in the long term, the economic impact of the transition to renewable energies is predominantly positive. Increasing investment in green energy stimulates economic activity, technological innovation and the development of new value chains, contributing to the creation of jobs and the diversification of the productive base. In addition, reducing dependence on fossil fuel imports increases energy security and stabilizes the trade balance, reducing economies' vulnerability to external shocks and volatility in international energy prices. Also, the indirect economic benefits of the energy transition, such as reduced pollution costs and improved public health, have a positive impact on labor productivity and public spending in the long term. Thus, the energy transition contributes not only to the achievement of climate objectives, but also to the strengthening of economic and social resilience.

In conclusion, the economic impact of the transition to renewable energies is complex and dependent on how public policies are designed and implemented. A well-managed transition, supported by coherent investment, professional retraining policies and social protection mechanisms, can turn initial challenges into opportunities for sustainable economic development, positioning economies on a long-term competitive and sustainable growth trajectory.

REFERENCES:

[1]. Deloitte (2019) *Energia regenerabilă în România: Potențial de dezvoltare la orizontul anului 2030*. Available at: https://rwea.ro/wp-content/uploads/2021/03/20190307_RES_Roadmap_2030.pdf

[2]. European Commission (2019) *The Just Transition Mechanism: making sure no one is left behind*. Available at: https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/finance-and-green-deal/just-transition-mechanism_en

[3]. European Commission (2022) 9125 final/2.12.2022. Available at: https://mfe.gov.ro/wp-content/uploads/2022/12/6fe2fccf9139171821fba5e867dc3c13.pdf

[4]. European Commission (2023) *Commission welcomes completion of key 'Fit for 55' legislation, putting EU on track to exceed 2030 targets*. Available at: https://ec.europa.eu/commission/presscorner/detail/en/ip_23_4754

[5]. European Commission (2025) *Horizon Europe*. Available at: https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe_en

[6]. European Commission (2025) *REPowerEU, Energie sigură și durabilă pentru Europa, la prețuri accesibile*. Available at: https://commission.europa.eu/topics/energy/repowereu_ro

[7]. European Commission (2025) *European Climate Law*. Available at: https://climate.ec.europa.eu/eu-action/european-climate-law_en

[8]. European Commission: Directorate-General for Research and Innovation (2025) *Europe's budget – Horizon Europe (2028-2034)*, Publications Office of the European Union. https://data.europa.eu/doi/10.2777/8979807

[9]. European Council (2025) *Mecanismul de redresare și reziliență*. Available at: https://www.consilium.europa.eu/ro/policies/rrf/#0

[10]. European Council (2025) *Pachetul „Pregătiți pentru 55": cum intenționează UE să impulsioneze utilizarea energiei din surse regenerabile*. Available at: https://www.consilium.europa.eu/ro/infographics/fit-for-55-how-the-eu-plans-to-boost-renewable-energy/

[11]. European Environmental Bureau (2025) *The European Green Deal (EGD) Knowledge Brief*. Available at: https://eeb.org/wp-content/uploads/2025/05/The-European-Green-Deal-Knowledge-Brief.pdf

[12]. Federal Ministry for Economic Affairs and Climate Action (2022) *An overview of the socio-economic impacts of the energy transition*. Available at: https://www.esp.org.vn/wp-content/uploads/eng-socio11-2-1.pdf

[13]. Guvernul României (2023) *Long term strategy of Romania*. Available at: https://mmediu.ro/app/webroot/uploads/files/Long%20Term%20Strategy%20of%20Romania.pdf

[14]. Guvernul României (2024) *Strategia Energetică a României 2025–2035*. Available at: https://energie.gov.ro/wp-content/uploads/2024/11/Strategia-Energetica-a-Romaniei-2025-2035-cu-perspectiva-anului-2050_23_10_2024_vf.pdf

[15]. Guvernul României (2025) *Planul Național de Redresare și Reziliență*. Available at: https://proiecte.pnrr.gov.ro/#/home

[16]. Guvernul României (2025) *Planul național integrat în domeniul energiei și schimbărilor climatice 2021-2030 Actualizare*. Available at: https://energie.gov.ro/wp-content/uploads/2025/10/PNIESC-2021-2030-actualizat_14.10.2025.pdf

[17]. Guvernul României (2025) *Tranziția energetică în România*. Available at: https://gov.ro/ro/tranzitia-energetica-in-romania

[18]. International Renewable Energy Agency (2024) *Renewable Energy and Jobs Annual Review 2024*. Available at: https://www.irena.org/Publications/2024/Oct/Renewable-energy-and-jobs-Annual-review-2024

[19]. Niță, D.; Stoicuța, N.; Nițescu, A.; Isac, C.; Dobre-Baron, O. (2025) *The impact of the transition to a green economy on Romania's economic growth*. Energy, Sustainability and Society, 15(1), 19. https://doi.org/10.1186/s13705-025-00520-4

[20]. Official Journal of the European Union (2021) *Regulation (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021 establishing the framework for achieving climate neutrality*. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32021R1119&from=EN

[21]. Official Journal of the European Union (2023) *DIRECTIVE (EU) 2023/2413 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 18 October 2023*. Available at: https://eur-lex.europa.eu/eli/dir/2023/2413/oj/eng

[22]. The European House Ambrosetti, Enel Foundation (2019) *Just E-volution 2030. The socio-economic impacts of energy transition in Europe*. Available at: https://www.enelfoundation.org/content/dam/enel-foundation/topics/2019/09/just-e-volution-2030/Just%20E-volution%202030_Full%20Report%20-%20Printing%20Version.pdf

[23]. United Nations (2015) *Paris Agreement*. Available at: https://unfccc.int/sites/default/files/english_paris_agreement.pdf

[24]. United Nation (2025) *Renewable energy – powering a safer and prosperous future.* Available at: https://www.un.org/en/climatechange/raising-ambition/renewable-energy