

European Union Energy Policy and the Green Energy Transition: A Comparative Economic Analysis of Romania, Poland, Germany, and Spain

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Abstract

Energy security, decarbonisation, and transition costs are all central components of the European Union's sustainability strategy. Even though from a policy perspective the transition to green energy is mostly linear, its economic outcomes differ significantly across member states, generating uneven risks and regulatory challenges. This paper aims to examine how EU policy instruments, particularly the European Green Deal and REPowerEU, generate different economic effects in distinctive national contexts using a comparative framework. The study focuses on four distinct transition models: Romania and Poland as Central and Eastern European economies with structural constraints and Germany and Spain as more advanced adopters of renewable energy. The analysis covers the period 2018–2023 and integrates key indicators such as renewable energy share, gross domestic product growth, and energy prices. The findings indicate that EU policies produce different economic outcomes across countries, depending on nation-specific factors, including energy mix, institutional capacity, and policy stability. Spain emerges as the most balanced case, while Romania records strong results that are partly explained by structural advantages, namely pre-existing hydropower capacity. Germany's transition appears more cost-intensive, whereas Poland remains burdened by fossil fuel dependence and slower adaptation to transition goals. These differences highlight the varying economic risks associated with the transition and the uneven effectiveness of regulatory frameworks across member states. This study contributes to the literature by linking EU policy instruments with economic outcomes in a comparative perspective, highlighting how national structural differences shape the effectiveness of the green energy transition. The findings suggest the need for differentiated policy approaches within the European Union and provide insights for improving regulatory design and managing transition-related risks. At the same time, the study provides a foundation for future research on energy transition pathways, as it is tailored to national economic structures in order to improve both the efficiency and economic sustainability of the transition.

Keywords

European Union energy policy; green energy transition; comparative analysis; renewable energy economics; energy policy effectiveness; sustainable economic development

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Introduction

Sustainable development and climate change mitigation have become the central focus of the European Union's (EU) efforts to enhance energy security and ensure sustainable economic growth. Policy frameworks such as the European Green Deal and REPowerEU establish a common strategic direction for decarbonisation and the expansion of renewable energy across member states. While these initiatives aim to create a unified transition pathway, their economic effects are not uniform, as national economies differ significantly in terms of energy structure, institutional capacity, and level of development.

The existing literature highlights that the effectiveness of green energy policies is strongly conditioned by country-specific factors. Advanced economies such as Germany and Spain have demonstrated the capacity to translate policy support into tangible economic and environmental benefits through stable regulatory environments and sustained investment in renewable energy technologies (Silva et al., 2024). In contrast, Central and Eastern European countries, including Romania and Poland, face structural constraints that reduce the efficiency of the transition process. These challenges include dependence on fossil fuels, limited infrastructure, and inconsistent policy implementation (Santa et al., 2025). Moreover, in several Eastern European contexts, expenses related to renewable energy are often perceived as a short-term burden on public budgets, associated with higher energy prices and significant infrastructure adjustments. This perception can limit political commitment to long-term transition strategies. These disparities suggest that the economic outcomes of EU policies are mediated by national contexts rather than determined solely by EU-level frameworks.

Despite the growing body of research on renewable energy and economic performance, there remains a lack of comparative studies that explicitly link EU policy instruments to differentiated economic outcomes across member states. Most existing research focuses either on energy indicators or on policy design, without integrating these dimensions into a coherent analytical framework. Comparative studies also emphasize that the effectiveness of energy transition policies varies significantly across European economies depending on institutional quality, energy dependency, and economic structure (Ćetković & Buzogány, 2016). Addressing this gap is essential for understanding how common EU strategies generate diverse national trajectories.

This article examines the impact of EU energy policy instruments on the economic outcomes of the green energy transition across different development models. Using a comparative approach, the study focuses on four countries—Romania, Poland, Germany, and Spain—representing distinct economic and institutional contexts. The analysis covers the period 2018–2023 and evaluates key indicators, including renewable energy share, gross domestic product growth and energy prices. By linking policy frameworks with economic performance, the study provides insights into the effectiveness of the green energy transition and supports the development of more tailored policy approaches within the European Union.

2. Review of the scientific literature

The European Union (EU) has set ambitious targets for the energy transition, requiring strong commitment from its member states, each of which plays a distinct role as a producer, importer, or transit country. As part of its efforts to combat climate change, the EU has progressively developed a comprehensive policy framework to support the transition toward a low-carbon economy (European Parliament, 2024). Central to this strategy are initiatives such as the European Green Deal and REPowerEU, which aim to reduce greenhouse gas emissions, increase the share of renewable energy, and enhance energy security (European Commission, 2022). These frameworks provide financial mechanisms, regulatory instruments, and strategic objectives designed to align member states with common decarbonisation goals.

The implementation of these policies varies across countries due to differences in institutional capacity and national priorities. Research shows that while EU-level policies establish a coordinated direction, their effectiveness and pace of convergence depend on national adaptation and enforcement (Leuffen et al., 2022). Countries with stable regulatory environments and consistent policy support tend to achieve better outcomes in renewable energy deployment and economic performance. In contrast, poorly coordinated policy frameworks may reduce the effectiveness of EU initiatives, leading to uneven progress across the Union.

Moreover, policy instruments such as subsidies, feed-in tariffs, and EU funding mechanisms play a crucial role in shaping investment behaviour in the energy sector. Empirical studies indicate that well-designed policy mixes can accelerate the adoption of renewable technologies and stimulate economic development, whereas inconsistent or frequently changing regulations may discourage investment and slow down the transition process (Giwah et al., 2020). These findings highlight the importance of policy stability and institutional effectiveness in achieving the objectives of the green energy transition.

The relationship between the transition to renewable energy and economic performance has been widely examined in the literature. Research suggests that the shift toward green energy generates both opportunities and challenges. On the one hand, it supports positive economic outcomes, including increased investment, innovation, job creation, and improved energy security (Cantarero, 2020). On the other hand, the transition involves significant short-term costs related to infrastructure development, technological adaptation, institutional reforms, and social acceptance.

Energy prices represent a key transmission channel through which the transition affects the broader economy. Increased investment in renewable energy has been associated with higher short-term energy costs, particularly during the initial phases of the transition, when infrastructure development and market adjustments are most intensive. This can directly affect both businesses and households, influencing public perception and willingness to adopt new technologies. In the long term, however, renewable energy can contribute to price stability and reduce dependence on imported fossil fuels (Aslanturk, 2020). This dual effect highlights the complexity of evaluating the economic implications of the transition.

The effectiveness of green investments is closely linked to the structure of national economies. Countries with diversified energy portfolios and well-developed financial systems are better equipped to absorb transition costs and capitalize on emerging opportunities. In contrast, economies that are highly dependent on fossil fuels may face significant adjustment challenges, including weak system interconnections, lower energy security, and labour market disruptions (Yang, 2025). These dynamics indicate that the economic benefits of the green transition are not automatic but depend on supportive economic and institutional conditions.

The energy transition is reshaping the balance of economic and political power within the European Union. Comparative studies highlight significant differences in both the pace and efficiency of the transition across member states, differences that have been further intensified by recent geopolitical developments, particularly the Russian–Ukrainian war. This context has exposed the EU’s dependence on external energy sources and has shifted policy priorities toward strengthening energy security (Rochet & Hanoteaux, 2023). Differences in achieving net-zero targets are often explained by variations in economic development, institutional quality, and energy dependency. Research on Central and Eastern European countries shows that, although progress has been made in increasing the share of renewable energy, these countries generally lag behind Western European economies in terms of transition efficiency (Rokicki et al., 2022).

Germany and Spain are frequently cited as successful transition models, characterized by strong policy frameworks, significant investment in renewable technologies, and consistent long-term strategies (Gao, 2022). By contrast, countries such as Romania and Poland face persistent structural challenges, including dependence on coal and other fossil fuels, as well as regulatory instability. These constraints hinder progress and reduce efficiency in meeting transition objectives, despite Romania’s relatively ambitious targets regarding the closure of coal-based energy production (Ciot, 2021).

The literature further emphasizes that the diversity of economic systems within the EU leads to different responses to common policy objectives. According to the “varieties of capitalism” perspective, national institutional configurations influence how countries adopt and implement renewable energy policies (Četković & Buzogány, 2016). As a result, similar policy instruments may generate different economic outcomes depending on the national context.

Despite these findings, the literature lacks an integrated analysis that combines policy frameworks with economic performance indicators in a comparative setting, explaining how specific national political-economic conditions facilitate or constrain sustainable renewable energy development. To address this gap, this study investigates how EU energy policies impact economic outcomes in countries with different development models, comparing long-established capitalist economies with the emerging capitalist systems of Eastern Europe.

In terms of theoretical contribution, this article enhances the understanding of the green energy transition within the European Union, while from a practical perspective, it aims to provide policy-relevant insights for designing more effective and context-specific energy transition strategies across EU member states.

3. Research Methodology

To assess the impact of the EU energy policy tools across nations with different development models, this study uses a comparative research design between four EU members, namely Romania, Poland, Germany, and Spain. These specific countries were chosen to represent distinct economic structures, institutional capacities, and energy transition approaches, as their dependence on fossil fuels also varies greatly. On one hand, Romania and Poland are countries of Central and Eastern Europe, characterized by structural limitations and vulnerable economies, whereas Germany and Spain are considered advanced transition models with more mature renewable energy sectors.

The analysis covers the period from 2018 to 2023, justifiably selected to capture the major phases of the European Union’s energy transition. The starting point reflects the post-financial crisis context, which

marked a shift in EU economic and energy policies toward sustainability and structural reform. This period also includes the progressive expansion of renewable energy targets under the EU climate framework, the introduction of the European Green Deal in 2019, and the implementation of the REPowerEU strategy in response to the 2022 energy crisis. It also allows for the analysis of both pre- and post-policy intensification dynamics, all the while capturing the impact of recent geopolitical developments, particularly the Russian-Ukrainian war.

To assess the relationship between policy frameworks and economic outcomes, the study uses a set of quantitative indicators reflecting both energy transition progress and economic performance. The main energy-related indicators include the share of renewable energy in total energy consumption and energy prices, while economic performance is evaluated using gross domestic product (GDP) growth. These indicators are selected based on their relevance in capturing both the direct and indirect effects of the transition process to green energy.

The methodological approach combines both descriptive and comparative analysis. To find variations in the rate and composition of the energy transition among the four nations, the study first analyses trends in the selected indicators. Then it continues to run a cross-national comparison to determine the differences in the economies and policy implementation and how they affect the observed results. This method enables the identification of patterns and divergences in the effectiveness of EU energy policies.

Although the analysis primarily relies on a descriptive comparative model, it focuses on the relationship between EU policy instruments, such as subsidies, regulatory measures, and financing mechanisms. It also compares key economic indicators, such as energy prices and GDP growth. The data from the study is based on expert analyses, governmental documents, and reports from the European Commission, the World Bank, and Eurostat. These selected resources provide consistent, reliable data and ensure comparability over time.

Finally, the study provides a foundation for further empirical investigation using econometric techniques, such as panel data analysis, which could extend the current findings by quantifying the strength and direction of these relationships.

4. Results and Discussion

The comparative analysis reveals significant differences in the structure and outcomes of the energy transition across the four selected countries. Based on the latest available data (2023), with trends over the 2018–2023 period indicating broadly consistent patterns, the results highlight important differences between countries, in terms of pace of the energy transition. At first glance, the data suggest that Romania and Spain outperform Germany in terms of renewable energy share, with Romania recording the highest value, followed by Spain while Germany lags behind. Out of the four countries, Poland remains the lowest performer. However, these results challenge conventional assumptions regarding energy transition leadership within the European Union.

In Romania's case, the high share is largely explained by pre-existing hydropower capacity rather than policy-driven expansion, while in Poland, recent increases do not offset the continued structural dependence on fossil fuels. Similarly, Spain's strong performance reflects a combination of favourable natural conditions and sustained policy support.

In contrast, Germany's lower renewable energy share, combined with high electricity prices and negative GDP growth, suggests a more complex and cost-intensive transition process. This reflects the challenges of transforming a large, industrialized economy with high energy demand and advanced infrastructure requirements.

Poland presents a distinct case, characterized by low renewable energy share and relatively low electricity prices, which reflect continued dependence on fossil fuels. While this structure may reduce short-term economic pressure, it delays the transition process and limits long-term alignment with EU decarbonisation goals.

Romania and Poland, on the other hand, show more uneven transition patterns. While Romania has made noteworthy progress in increasing its share of renewable energy (approximately 23 - 25%), especially wind and hydropower (Bucur et al., 2021), its growth is still limited by outdated infrastructure and policy inconsistency. Surprisingly, Poland reports a significantly lower share of renewable energy (approximately 11-15 %) (Mrozowska et al., 2021), a heavy dependence on coal and a slow transition progress overall.

These differences highlight the importance of initial energy structures and institutional capacity of each country striving to align with EU's decarbonisation targets. As the deadline for most measures is 2030, consistent progress is key and it is demonstrated by countries with diversified energy portfolios and stable

regulatory frameworks. The countries still relying on fossil fuels experience slower and more uneven transitions.

The impact of the green energy transition varies between countries, especially considering the correlation between renewable energy adoption, energy prices and economic growth. Germany and Spain show relatively stable GDP growth rates and a steady increase of share of renewables, but their energy prices remain above the European average. However, they have been stable over long periods of time indicating a managed transition process and it shows that green investment can be part of a broader economic plan.

In contrast, Romania and Poland have more unstable relationships between the selected parameters. Romania records GDP growth rates above the European average, but this growth is not consistently aligned with higher investments in renewable energy infrastructure, indicating a less direct relationship between transition progress and economic performance. Poland, on the other hand, experiences both lower green energy adoption and unstable energy costs during the transition to renewables, reflecting the structural challenges associated with transitioning from coal-based energy systems.

These findings demonstrate that there are two sides to the energy transition process. In the initial phases of the infrastructure development, the economies are burdened with higher costs. However, in the long term, countries with diversified energy systems, in which renewables get a higher share, are less likely to be affected by energy price variations and have improved energy security.

The comparative results obtained in the study show that the effectiveness of the EU policies is directly correlated to national policy consistency and robust institutional capacity. Germany and Spain demonstrate a more robust alignment between policy objectives and economic outcomes, evidenced by their steady investment levels, stable energy price trends and elevated shares of renewable energy. This suggests that EU policy instruments, such as subsidies and funding mechanisms, are more effectively absorbed and implemented in these countries.

Romania and Poland on the other hand, show a weaker link between policy frameworks and actual results. In Romania, the transitions process is less stable and economically unpredictable, as policy implementation is inconsistent. In Poland, EU-level policies have more limited effects as the country is still dependent on fossil fuels and has a slow adaptation of regulatory frameworks. These patterns show that the same policy tools can have different effects depending on national institutional conditions.

To support the comparative analysis discussed above, Table no. 1 presents the selected indicators which highlight the significant differences in energy transition performance across the four countries. Based on renewable energy share, GDP growth, and energy prices, a clustering approach was applied to identify distinct transition models within the European Union.

Table no. 1. Comparative Indicators of Energy Transition Performance (2023, latest available data)

Country	Renewable Energy Share (%)	Avg. GDP Growth (%)	Energy Price (€/kWh)
Germany	21	-0.9	0.29
Spain	24	2.5	0.21
Romania	25	2.3	0.14
Poland	16	0.2	0.09

Notes: Values refer to the latest available year (2023). Differences across the 2018–2023 period remain broadly consistent.

Source: Eurostat (2026); World Bank (2026)

The results indicate four distinct country profiles rather than a simple hierarchical ranking. The analysis identifies distinct transition models that reflect different combinations of structural conditions and economic outcomes.

Spain emerges as an efficient transition model, combining a high renewable energy share (24%) with strong economic growth (2.5%) and moderate electricity prices (0.21 €/kWh). This suggests a balanced integration of renewable energy policies with economic performance.

Germany represents a cost-intensive transition model, characterized by relatively high electricity prices (0.29 €/kWh) and negative economic growth (-0.9%), despite a moderate renewable energy share (21%). This indicates that the transition process may impose significant short-term economic pressures, particularly in complex industrial economies.

Romania can be classified as a structural advantage model, exhibiting the highest renewable energy share (25%), strong economic growth (2.3%), and relatively low electricity prices (0.14 €/kWh). However, this performance is partly explained by pre-existing energy structures, particularly hydropower, rather than recent policy-driven transition dynamics.

Poland forms a fossil-dependent model, with the lowest renewable energy share (16%) and limited economic alignment with transition goals. Its relatively low electricity prices (0.09 €/kWh) reflect continued reliance on fossil fuels, which delays the transition but reduces short-term economic costs.

These findings demonstrate that energy transition outcomes are not uniform and cannot be evaluated using a single indicator. Instead, they reflect the interaction between energy structure, economic performance, and policy implementation. The clustering highlights the need for differentiated policy approaches that consider national structural conditions rather than applying a uniform transition framework across the European Union and accepting a certain flexibility in reaching the carbon zero objectives.

The results of this study challenge conventional assumptions regarding the effectiveness and distribution of energy transition performance across the European Union. While EU-level policies strive to establish a common pathway toward decarbonisation for all its members, the findings demonstrate that the economic outcomes are highly different and cannot be adequately assessed using single indicators such as renewable energy share.

In particular, the analysis reveals that systems with high renewable energy shares do not necessarily exhibit the most efficient or advanced transition processes. Romania, on one hand, shows the highest renewable energy share among the selected countries, combined with strong economic growth and relatively low electricity prices. However, this performance is largely influenced by structural factors, including pre-existing hydropower capacity, rather than consistent policy-driven transformation. This shows the importance of distinguishing between structural advantages and policy effectiveness when evaluating transition outcomes.

Poland's analysis, in contrast, illustrates the challenges associated with long-term fossil fuel dependency. Its relatively low renewable energy share and continued reliance on coal contribute to slower transition progress, even though lower energy prices mean less public pressure to adopt renewables. This highlights a key policy trade-off between short-term affordability and long-term sustainability.

Germany—often considered a benchmark for energy transition—demonstrates a more complex and cost-intensive trajectory. Despite sustained policy efforts, its relatively moderate renewable energy share, high electricity prices, and negative economic growth suggest that the transition process may impose significant short-term economic pressures, particularly in large industrial economies. This finding stresses the need to account for economic structure and system complexity when assessing policy performance.

Out of the four analyzed countries, Spain emerges as the most balanced case, combining relatively high renewable energy adoption with strong economic growth and moderate energy prices. This suggests that effective policy design, combined with favorable structural and environmental conditions, can support a more efficient integration of renewable energy into the economy.

Overall, the findings suggest that a uniform approach to EU energy policy may not be sufficient to achieve balanced economic and environmental results across member states. Instead, policy design should account for differences in national energy structures, institutional capacity, and economic development. For countries with structural advantages, policy efforts should focus on improving efficiency and integration, while for fossil-dependent economies, greater emphasis should be placed on supporting structural transformation and balancing transition costs.

Furthermore, the results highlight the importance of adopting a multi-indicator framework when evaluating energy transition performance. Relying on a single metric, such as renewable energy share, may lead to misleading conclusions and inappropriate policy recommendations. A more comprehensive approach that integrates economic and energy indicators is necessary to accurately assess the effectiveness of EU policies.

These insights reinforce the need for more flexible and differentiated policy strategies within the European Union, ensuring that transition pathways are aligned with national conditions while maintaining overall coherence with EU sustainability objectives.

Conclusions

This study set out to analyse the impact of European Union energy policy instruments on the economic outcomes of the green energy transition in four countries with different economic models. Using a comparative approach on Romania, Poland, Germany, and Spain, the analysis used three critical indicators—renewable energy share, GDP growth, and electricity prices—to evaluate both the progress of the transition and its economic outcomes.

The results show that the energy shift performance in the European Union is very different from one country to the next, and one indicator is not enough to measure it. The results challenge a common assumption in literature, that higher shares of renewable energy always mean that the transition process is more advanced or efficient. Romania, for instance, has the highest percentage of renewable energy among the countries chosen. It also has strong economic growth and relatively low electricity prices. However, structural factors, like the fact that there was already a lot of hydropower capacity, rather than changes in policy, most likely explain this result.

The analysis also shows that Germany's transition is characterized by higher costs and more complicated economic adjustments. In contrast, Spain's integration of renewable energy into its economy is more balanced. Poland, on the other hand, shows slower adaptation to renewables because it still depends largely on fossil fuels, even though energy costs are lower. These findings highlight the necessity of examining various dimensions to evaluate correctly the true efficiency of the energy transition policies.

From a theoretical perspective, this study enhances the literature by illustrating the limitations of single-indicator methodologies and by introducing a multi-indicator comparative structure that shows the connection between the energy structure, economic performance, and policy implementation. From a practical standpoint, the results indicate that a standardized approach to EU energy policy may be inadequate for attaining uniform results among member states. Policy design should be tailored to national circumstances, considering structural disparities, institutional capabilities, and economic limitations.

Ultimately, the study is subject to certain limitations. The analysis focuses on a limited number of countries and a small number of indicators, which may not show the full complexity of the energy transition process. Subsequent research may enhance this framework by integrating additional variables, expanding the country sample, and employing econometric methodologies to quantify the relationships identified in this study.

Overall, the results emphasize that a successful decarbonisation in the European Union relies not only on strong, uniform policy frameworks but also on their interaction with the national economic structures. To ensure that energy remains affordable, safe and green across member states, the Union needs a more flexible and context-sensitive policy approach.

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