# Economic Barriers and Incentives in the Energy Transition: A Comparative Analysis of Policy Frameworks and Market Responses

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**Abstract**

The shift to green energy is not merely a technological challenge but a multifaceted economic upheaval. In numerous countries, the process remains precarious, influenced by regional constraints, shifting political climates, and the need to balance cost, long-term outcomes, and energy independence. This article examines how economic mechanisms—specifically carbon pricing, subsidies, and green finance—affect investment trends in renewable energy across various policy environments.

The research used a comparative methodology, examining the cases of the European Union, the United States, and South Korea. It integrates policy research with quantitative techniques, such as panel data regression and correlation analysis, to evaluate the effects of carbon pricing and government subsidies on private-sector investments in renewable energy. Findings indicate that effectively structured carbon pricing mechanisms and consistent regulatory frameworks are essential catalysts for investment in renewable technology. Capital expenditure-based subsidies are effective in initial market development, but operational expenditure-based incentives promote long-term efficiency. The data reveals a strong positive association between government subsidies and private-sector investment, especially in nations with open regulatory frameworks. Green finance instruments, including green bonds, are becoming vital facilitators but necessitate more alignment with public policy.

This research enhances the literature by providing a comprehensive economic analysis of energy transition programs, connecting public incentives with private sector responses. It offers a mostly overlooked viewpoint on nations such as South Korea, emphasising the impact of varied institutional environments on policy efficacy. The results provide evidence-based suggestions for policymakers: promote stable carbon prices, align subsidies with performance metrics, and enhance green finance markets. These insights facilitate the development of economically robust, investor-attractive energy markets that support an equitable and sustainable transition, particularly relevant to Romania and other OECD nations undergoing the shift to renewable energy.

**Keywords**

Energy transition, economic incentives, carbon pricing, green finance, renewable investment, policy design, energy markets

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## Introduction

Among today's challenges of the developed world, few rival the scale, urgency, and economic implications of the climate crisis—particularly as it reshapes the way societies produce and consume energy. With rising temperatures, intensifying weather extremes, and growing geopolitical tensions over resources, the urgency to decarbonise our economies is no longer a distant objective—it is a politically charged present necessity that must be placed at the forefront of economic and policy agendas.

Energy is the predominant contributor to global greenhouse gas emissions and concurrently the most powerful mechanism for systemic transformation. Transitioning from fossil fuels to renewable energy is not simply a matter of technology adoption—it is a deep economic restructuring that tests the resilience of markets, the foresight of policymakers, and the confidence of investors (Stiglitz et al., 2017; Carley and Konisky, 2020; Aklin and Urpelainen, 2013). While advancements in renewable technologies have made green energy increasingly cost-competitive, the pace and effectiveness of the transition depend heavily on the financial and regulatory environment.

Numerous studies have highlighted the importance of policy tools such as carbon pricing, feed-in tariffs, tax incentives, and green bonds in mobilising capital toward green investments (Zhao et al., 2022; Verdolini, Vona and Popp, 2018). However, the effectiveness of these instruments varies significantly across different national and institutional contexts. For instance, the European Union's Emissions Trading System (EU ETS) has provided a relatively successful framework for pricing carbon, creating long-term signals for investment in renewables. In contrast, Australia's carbon pricing initiative—introduced in 2012 and repealed just two years later—suffered from political instability and regulatory uncertainty, which undermined investor confidence and disrupted capital flows into green energy (Jotzo, 2012; Newell and Raimi, 2022).

This paper explores the economic levers that accelerate or impede renewable energy investment, focusing on three highly influencing OECD economies, but with diverse policy approaches and varying stages of energy transition: the European Union, the United States, and South Korea.

The European Union stand as an example of a highly institutionalised regional framework with a mature carbon market (EU ETS) and a tradition of renewable energy support schemes.

The United States on the other hand, while lacking a unified national carbon price, offers insight into market-driven transitions supported by tax incentives and decentralised state-level programs.

South Korea, in its turn, reflects a more controlled emerging model, where industrial policy and government-led investment shape the energy transition. Together, these cases provide a geographically and institutionally diverse perspective through which to examine how economic tools perform under different regulatory, political, and market conditions.

The research specifically examines how carbon pricing and government subsidies affect private-sector investment behaviour, using a comparative framework supported by econometric analysis and secondary data.

The structure of the paper is as follows: Section 2 reviews the scientific literature on the economic mechanisms of the energy transition. Section 3 outlines the research methodology and data sources. Section 4 presents and discusses the results. Section 5 concludes with policy recommendations for facilitating a just and effective green energy transition.

## 1. Review of the Scientific Literature

### 1.1 Carbon Pricing and Market-Based Mechanisms

A large body of literature supports the role of carbon pricing as a cornerstone in the economic transition to low-carbon energy systems. Stiglitz et al. (2017) argue that carbon pricing is essential for correcting market failures associated with negative environmental externalities, and they emphasise that a predictable and sufficiently high carbon price can act as a long-term signal for investors. Their report recommends a global carbon price of USD 40–80 per ton of $CO_2$ by 2020, rising thereafter, to align with the Paris Agreement targets. However, as of March 2025, actual carbon prices remain below these levels in many regions.

The global average direct carbon price in 2023 was only $23.20 per metric ton of $CO_2$ equivalent (Statista, 2024). In contrast, the California carbon market is projected to average $46 per ton in 2025, up from $42 in 2024 (BloombergNEF, 2025), while prices under the European Union Emissions Trading System

(EU ETS) have experienced a recent decline of €4.20, or approximately 5.75%, since the beginning of 2025 (Trading Economics, 2025). These variations underscore the disparity between policy ambition and market reality, and highlight the need for stronger, more consistent price signals to guide investment decisions.

Empirical studies further demonstrate the effectiveness of carbon pricing mechanisms—particularly cap-and-trade systems and carbon taxes—in reducing emissions and shifting investment toward renewables.

For example, Fell and Kaffine (2018) use econometric modeling to assess the impact of both fuel prices and renewable policies on the U.S. power sector. Their results show that carbon pricing, when applied through cap-and-trade systems, can significantly reduce emissions and influence capital flows toward clean energy—especially when fossil fuel prices are low.

The European Union's Emissions Trading System (EU ETS) is often cited as a successful model. Zhao et al. (2022) highlight that the EU ETS has contributed to increasing investment in renewables by making emissions-intensive alternatives less attractive economically. Nonetheless, the system has not been without flaws. In its early phases, overallocation of permits led to a surplus of allowances, which caused prices to collapse—falling below €1 per ton in 2007—and introduced significant volatility (Newell, Raimi and Aldana, 2021). The absence of a price floor and delayed policy adjustments created a climate of regulatory uncertainty. These factors made it difficult for investors to forecast long-term carbon costs, ultimately weakening the incentive to shift capital from fossil fuels to renewables. As Wüstenhagen and Menichetti (2012) note, such uncertainty plays a key role in shaping risk perceptions in renewable energy markets, particularly for projects requiring high upfront capital.

Australia's short-lived carbon pricing initiative further illustrates the consequences of policy instability. Introduced in 2012 and repealed in 2014, the policy's reversal created a period of heightened uncertainty. As Jotzo (2012) and BloombergNEF (2015) show, this led to a sharp decline in clean energy investment, delays or cancellations of several wind and solar projects, and a rise in perceived regulatory risk. Industry surveys conducted at the time reported a significant erosion of investor confidence, with Australia increasingly viewed as a high-risk environment for low-carbon investment. These reactions underscore that while carbon pricing mechanisms can be powerful tools, their success is heavily dependent on political stability and regulatory credibility.

### 1.2 The Role of Subsidies: Capex and Opex

While carbon pricing seeks to internalise environmental costs, subsidies—both capital expenditure (capex)-based and operational expenditure (opex)-based—are often used to directly stimulate investment in renewable energy by reducing financial barriers, particularly in the early stages of market development.

Capex-based subsidies, such as investment grants, rebates, and upfront tax credits, aim to reduce the high upfront cost of renewable energy technologies, making them more accessible to both individuals and developers. While each instrument operates differently, they have proven effective in emerging markets and early-stage technologies, where capital scarcity often prevents project initiation. For instance, in the United States, many states offer solar rebates to incentivise small-scale solar deployment. California's Self-Generation Incentive Program (SGIP) provides rebates for battery storage installations, while other utilities offer fixed payments per kilowatt of installed solar capacity—effectively lowering the initial investment barrier for households and small businesses. Moreover, Verdolini, Vona and Popp (2018) argue that such capex-based support mechanisms are especially useful for lowering the perceived risk of entry, encouraging developers to invest in solar and wind projects even in uncertain markets, such as India and South Africa, where regulatory frameworks have historically been inconsistent and grid access limited.

In contrast, opex-based subsidies—such as feed-in tariffs (FiTs), production tax credits, and contracts-for-difference—provide ongoing payments tied to electricity generation. These mechanisms incentivize not only deployment but also long-term performance and operational efficiency. Wüstenhagen and Menichetti (2012) emphasise that opex-based subsidies align more closely with market outcomes, encouraging cost-effective technologies while ensuring returns over time.

Empirical studies show that the design of subsidy schemes greatly influences investor behaviour. Zhao et al. (2020) found that in China, a combination of capex-based grants and performance-linked FiTs generated a strong multiplier effect, particularly in the wind energy sector. However, the effectiveness of subsidies can vary depending on the broader regulatory context. In the United States, Popp, Vona and Marin (2020) found that subsidy effectiveness was significantly enhanced when paired with transparent policy frameworks and stable permitting environments.

Even though these financial mechanisms stimulate investment and trust in renewable energy, subsidy dependency also presents potential downsides. Sudden reductions or retroactive changes can trigger market slowdowns, as seen in Spain's solar sector after the government slashed FiTs in 2013. This case underscores the importance of clear phase-out plans and transition mechanisms when reforming support policies (Carley and Konisky, 2020).

Overall, both capex and opex-based subsidies play critical roles in accelerating the energy transition, but their impact depends on careful policy design, predictability, and alignment with broader market reforms.

### 1.3 Green Finance and Investor Behaviour

According to Wüstenhagen and Menichetti (2012), perceived regulatory and market risks, as well as expected rewards, shape investment decisions in renewable energy. Besides direct government subsidies and carbon pricing, the growth of green finance has become an essential booster of the energy change. Green bonds, sustainability-linked loans, climate-aligned funds, and other vehicles envisioned of by financial institutions are meant to lower financing costs, lower risk perceptions and generally direct private capital into low-carbon technology and infrastructure.

In order to influence investor behaviour into aligning portfolios with climate objectives, the standardised green finance products help address concerns of transparency, reduced volatility, and alignment with ESG (Environmental, Social, and Governance) frameworks. Moreover, green bonds often attract lower interest rates— a concept known as "greenium", referring to the yield differential between green and conventional bonds. Bachelet, Becchetti and Manfredonia (2019), indicated that investors are ready to accept lower returns, especially among certified bonds, in exchange for environmental effect and alignment with ESG values, therefore reflecting this phenomena in the European markets.

Recent patterns, however, point to unpredictability in the greenium. For example in 2024, it diminished significantly, averaging around 1 basis point in the Euro green bond market by year's end (AXA Investment Managers, 2025). Given that interest rates are expected to decline in 2025, the greenium might move toward longer-dated bonds, as investors seek for sustainable assets at reasonable rates.

The market for green bonds continues to expand somewhat steadily. The volume of green, social, sustainability, and sustainability-linked (GSS+) debt matched Climate Bonds Methodologies in 2024 came to USD 1.1 trillion, therefore bringing the overall total to USD 5.7 trillion (Climate Bonds Initiative, 2025). This increase emphasises how capable the market is to direct large financial resources toward solutions for climate change. Looking ahead, forecasts suggest that sustainable bond issuance will remain steady at around USD 1 trillion in 2025, maintaining its share in the overall bond market (S&P Global Ratings, 2025).

Despite their expansion, green financial markets remain inconsistently developed. In emerging economies, limited access to international capital markets, underdeveloped regulatory frameworks, and lower investor confidence restrict the ability to scale the green finance solutions. Popp, Vona and Marin (2020), for instance, underline how institutional investors are reluctant to participate in long-term renewable energy projects in less developed markets, in the absence of complimentary state guarantees or risk-sharing mechanisms.

Empirical studies also show that market confidence is strongly shaped by the credibility of national climate policy frameworks. Countries with unified long-term renewable energy programs are more likely to draw continuous private investment, according to Aklin and Urpelainen (2013). In contrast, fragmented or frequently changing policies—even in high-income countries—can deter investors regardless of financial incentives.

Unlocking private finance at scale will need a mix of policy stability, innovative financial mechanisms, and more robust public-private partnerships as the worldwide financial industry starts to line up with climate objectives. Green financing is becoming increasingly significant in determining investor behaviour and accelerating the deployment of renewable energy infrastructure even if it cannot replace structural changes or direct subsidies.

## 2. Research Methodology

This study uses a comparative, mixed-methods research approach to assess the effects of carbon pricing and subsidies on renewable energy investment in various policy contexts. The methodology integrates quantitative research, including trend comparison and correlation analysis, with qualitative policy review, based on three relevant case studies: the European Union, the United States, and South Korea.

### 2.1 Research Objectives and Approach

The objective of this section is to examine how carbon pricing and government subsidies affect private-sector investment in renewable energy. The research is structured around three guiding questions to determine how context influences the use and performance of economic instruments in practice:

- How does carbon pricing influence investment behaviour?
- What is the impact of capital expenditure and operational expenditure subsidies on the deployment of renewable energy?
- What political or institutional factors influence the effectiveness of these tools?

### 2.2 Data Collection and Sources

Data were collected for selected OECD and G20 countries over the period 2010–2023, focusing on the following indicators:
- Carbon pricing levels (USD/ton $CO_2$)
- Renewable energy investment volumes (USD billion)
- Public subsidy flows (national budgets and incentives)

The main data sources include:
- World Bank Carbon Pricing Dashboard
- IRENA (International Renewable Energy Agency)
- OECD Green Growth Indicators
- BloombergNEF
- IMF Energy Subsidies Database
- Qualitative insights on national frameworks, policy stability, and investor behaviour were drawn from:
- National energy strategy documents
- Reports by the IEA, Climate Bonds Initiative, and Climate Policy Initiative

### 2.3 Comparative and Correlation Analysis

The study applies descriptive and comparative analysis across the selected countries to identify key trends and differences in policy performance. In addition to the qualitative review, a Pearson correlation analysis was used to assess the relationship between government subsidies and private investment levels.

This statistical method measures the strength and direction of a relationship between two variables—generating a coefficient between –1 and +1. A positive value indicates that higher subsidies are generally associated with higher levels of private investment, while a negative value suggests the opposite. Although correlation does not imply causation, the analysis helps identify whether public support mechanisms tend to motivate or displace private capital in the renewable energy sector.

These methods aim to provide a balanced understanding of how different policy mixes and market structures influence renewable energy investment, with a focus on developed economies.

## 3. Results

This section presents the main findings from the comparison and correlation analyses carried out across the European Union, the United States, and South Korea. It examines the effects of carbon pricing and subsidy programs on renewable energy investment, emphasising both facilitating elements and structural constraints. The discussion is organised into two main areas: carbon pricing and subsidy effectiveness, followed by cross-country insights into policy design and institutional frameworks.

### 3.1 Carbon Pricing and Investment Signals

Among the three countries analysed, the European Union is set apart by its comparatively advanced Emissions Trading System (EU ETS). Following a phase of diminished and inconsistent prices, recent changes have strengthened market confidence, resulting in elevated carbon prices and more reliable long-term signals for investors. This stabilisation has corresponded with a substantial rise in renewable energy investment throughout EU member states.

This relationship is illustrated in Figure no. 1, which shows the parallel upward trends in EU carbon prices and renewable energy investment from 2010 to 2023. Although causation cannot be directly inferred, the data suggest that price stability and regulatory maturity have contributed to increased investor engagement in renewables.

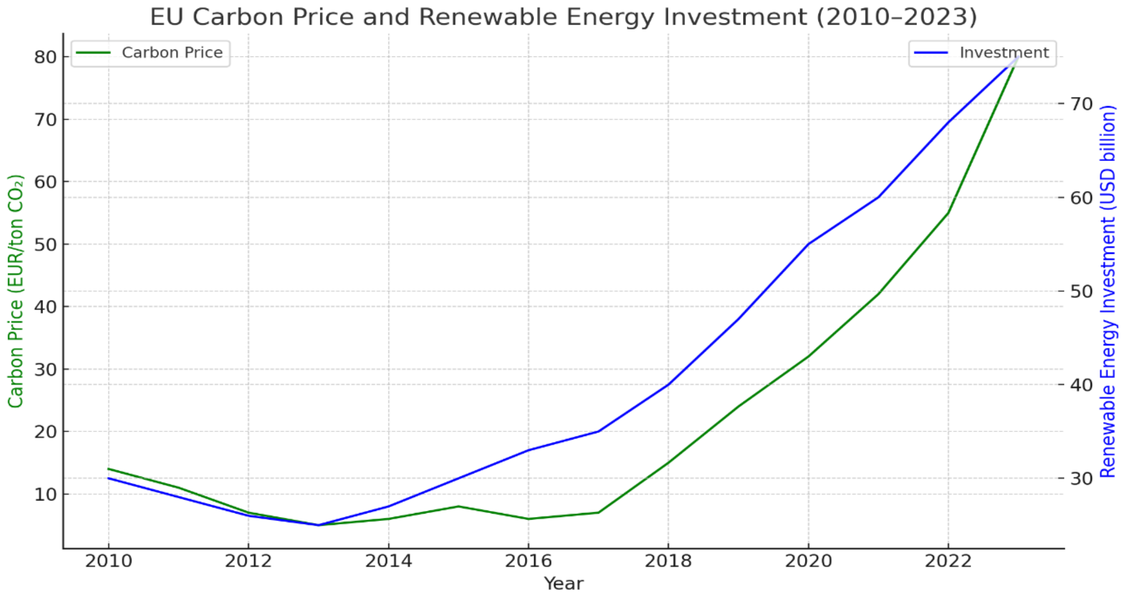


**Figure no. 1. EU Carbon Price and Renewable Energy Investment (2010–2023)**

*Source: Simulated data based on trend analysis and public databases from the World Bank (2023), BloombergNEF(2023), and IRENA (2023).*

Conversely, the United States does not have a unified national carbon pricing framework. Instead, it depends on regional programs like the Regional Greenhouse Gas Initiative (RGGI) in the Northeast and California's cap-and-trade program. Although these initiatives have shown beneficial local effects, their restricted geographic scope and policy fragmentation diminish their overall influence on national investment flows.

In its turn, South Korea, which instituted a cap-and-trade system in 2015, has encountered difficulties over the overallocation of permits and relatively low carbon pricing. While the system has enhanced institutional capacity, its impact on renewable investment is limited, indicative of a conservative regulatory approach and a comparatively brief implementation period relative to the EU.

These findings highlight that while carbon pricing has significant potential, its effectiveness depends heavily on price level, stability, geographic scope, and the political credibility of the system in the eyes of investors.

### 3.2 Subsidy Performance and Private Investment

The second essential aspect examined is the significance of government subsidies—both capital expenditure (capex) and operational expenditure (opex)—in stimulating private-sector investment in renewable energy. In all three case studies, governmental financial support was fundamental in reducing entry barriers and enhancing investor confidence, while the design and execution of these subsidies differed significantly in breadth and efficacy.

In the European Union, a combination of capital expenditure-based investment subsidies and operational expenditure-based feed-in tariffs (FiTs) has historically supported the rise of renewable energy, especially in nations like Germany and Denmark. The EU has progressively transitioned to market-oriented mechanisms such as auctions and contracts-for-difference (CfDs), which ensure renewable energy producers receive a fixed price by compensating them when market prices dip below a predetermined threshold. The enduring legacy of stable and predictable support frameworks fostered investor confidence and stimulated private capital inflows during the 2010s. Nonetheless, retroactive alterations in certain member states—exemplified by Spain's sudden decrease of FiTs in 2013—temporarily eroded market confidence and underscore the significance of policy stability.

In the United States, the mix of federal Investment Tax Credits (ITC) and Production Tax Credits (PTC)—both capital expenditure and operational expenditure instruments—has continually empowered the solar and wind sectors. These schemes have fostered significant investment momentum, especially when combined with state-level incentives and renewable portfolio mandates. Nonetheless, ambiguity over the renewal and termination of these subsidies has occasionally resulted in investment delay, emphasising the necessity for enduring policy transparency.

By contrast, South Korea has predominantly utilised capital expenditure-based grants and low-interest loans to facilitate its energy transformation. Although these instruments have prompted the initiation of many large-scale renewable projects, the country's constrained use of performance-based incentives has hindered the evolution of a competitive and varied investment environment. Furthermore, comparatively low power prices and restricted grid access have further limited the viability of renewable energy sources, diminishing the crowding-in effect of state subsidies.

**Table no. 1. Comparison of Subsidy Mechanisms by Country**

| Country | Capex-Based Subsidies | Opex-Based Subsidies | Main Challenges |
|---|---|---|---|
| **EU** | Investment grants, upfront tax credit | Feed-in tariffs, CfDs | Retroactive changes (e.g., Spain) |
| **USA** | ITC, state-level rebates | Production Tax Credit (PTC) | Uncertainty over extensions |
| **S Korea** | Grants, low-interest loans | Limited use, feed-in tariffs | Low grid access, electricity prices |

*Source: Compiled by the author based on public policy reports and academic literature*

These findings align with the conclusions of Wüstenhagen and Menichetti (2012), who emphasised that policy predictability significantly shapes investor risk perception—particularly in capital-intensive sectors like renewable energy. In their comparative study of European markets, they showed that stable, long-term support frameworks such as Germany's Feed-in Tariffs (FiTs) were instrumental in attracting private capital, whereas abrupt policy changes, as seen in Spain, eroded investor confidence. Similarly, in the United States, the continuation of federal tax credits has been a key determinant of investment momentum.

By situating the comparative analysis of this study within this conceptual framework, the correlation results presented here further reinforce the argument that subsidy volume alone is insufficient. The structure, credibility, and consistency of support mechanisms play a decisive role in mobilising private investment across diverse institutional environments.

The correlation analysis across all three scenarios indicates a positive relationship between state subsidies and private-sector investment levels. This indicates that effectively structured support mechanisms— especially when they are predictable, transparent, and aligned with long-term policy frameworks—can efficiently utilise government funds to attract private capital. The efficacy of these systems is evidently influenced by institutional variables, including regulation uniformity, administrative efficiency, and general investor attitude.

## Conclusions

As the world moves toward decarbonisation, this study highlights that policy design matters just as much as policy ambition. In their effort to align with centralised regulations and accelerate the green transition for environmental reasons, governments must carefully consider not only what instruments to deploy, but also how and where to implement them.

Using a comparative, mixed-method approach, this paper explored the role of economic tools—specifically carbon pricing and subsidies—in three distinct policy environments: the European Union, the United States, and South Korea. The analysis revealed that while financial incentives are crucial for boosting private-sector investment in renewable energy, their impact depends heavily on the predictability, design, and institutional context in which they are applied. The European Union's Emissions Trading System (EU ETS) stands as a benchmark for reforms that reduced volatility and strengthened investor confidence. Conversely, weaker or fragmented systems—such as those seen in South Korea and parts of the U.S.—struggle to deliver comparable impact.

Carbon pricing can serve as a powerful investment signal when prices are stable, sufficiently high, and embedded in credible policy frameworks. Subsidy schemes, both capex- and opex-based, have proven effective in lowering upfront costs and managing investment risk—but their success depends on transparency, consistency, and alignment with broader energy strategies. Correlation analysis confirms a positive relationship between public support and private investment, while also showing that subsidies alone are not enough: they must be integrated into mature and policy-aligned ecosystems.

The three case studies show that hybrid approaches—combining market-based mechanisms with targeted subsidies—tend to outperform standalone policies. The most important interventions combined long-term carbon pricing signals with predictable, well-structured subsidies. Also, from a policy design perspective, long-term credibility and institutional capacity are often the determining factors in whether economic tools lead to real-world infrastructure development.

This cross-country analysis holds particular relevance for Romania, a member of the EU with strong renewable energy potential, but still challenged by an aging energy infrastructure and regulatory uncertainty. While Romania is under pressure to align with European climate regulations, it continues to rely on fossil fuels such as gas and coal, which remain important natural resources and could, in theory, support energy independence. Currently, Romania lacks a comprehensive national carbon pricing mechanism beyond its participation in the EU ETS, and while it benefits from EU structural funds, the use of support instruments such as green auctions or contracts-for-difference remains limited.

In light of the findings in this paper, Romania could improve investment outcomes by enhancing policy predictability, streamlining licensing procedures, and aligning subsidies with long-term grid modernisation goals. In particular, aligning green bond programs with long-term decarbonisation targets can offer new path ways to sustainability. Both institutional capacity and improving transparency in energy governance will be essential for attracting both public and private investment—positioning Romania as a key player in the green development strategies.

As countries accelerate toward global decarbonisation goals, the alignment of economic tools with political and institutional realities will be the defining factor in the success of the energy transition.

**Abbreviations and Acronyms**

$CO_2$ – Carbon Dioxide
CfD – Contract-for-Difference
ETS – Emissions Trading System
EU – European Union
FiT – Feed-in Tariff
GSS+ – Green, Social, Sustainability, and Sustainability-linked
IEA – International Energy Agency
IMF – International Monetary Fund
IRENA – International Renewable Energy Agency
ITC – Investment Tax Credit
OECD – Organisation for Economic Co-operation and Development
PTC – Production Tax Credit
RGGI – Regional Greenhouse Gas Initiative
USD – United States Dollar

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