





Aligning economic feasibility, investor perceptions, and media narratives in renewable energy transitions: A socio-economic systems perspective ☆, ☆☆

Aleksandar Dedinec ^a  , Aleksandra Dedinec ^b, Jana Prodanova ^a, Stefani Kulebanova ^a, Darko Janevski ^c, Samir Latif ^c, Ljupco Kocarev ^a

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Highlights

- Proposes an integrated framework to assess renewable energy development as a dynamic socio-economic system.
- Combines economic feasibility analysis, investor perceptions, and media discourse using computational tools.
- Shows that while financing improved, non-financial challenges continue to affect renewable energy deployment.
- Applies NLP techniques (sentiment analysis and topic modeling) to over 9,500 media articles to evaluate public narratives.
- Provides a transferable method for transitional economies to align markets, institutions, and legitimacy in energy.

Abstract

This study explores the systemic nature of renewable energy sources (RES) development, treating it as a complex and evolving socio-economic process shaped by multiple interacting forces. This paper integrates three critical dimensions, economic modeling, investor perceptions, and media coverage, to assess the current state of photovoltaic and wind power development and identify pathways for improvement. An economic analysis demonstrates that, given current payback periods and the growing trend in RES installations, additional subsidies are unnecessary. However, insights from an investor survey reveal that the primary barriers lie in complex and delayed administrative procedures for permits and approvals. Complementing these findings, sentiment analysis and topic modeling of news articles highlight a predominantly neutral tone and an emphasis on success stories and strategic developments, yet with limited coverage of the procedural and infrastructural barriers most frequently cited by investors. The paper demonstrates how advanced computational tools can uncover hidden interdependencies within socio-economic energy systems and provides a transferable framework for other small-to-medium economies seeking to balance market logic, institutional performance, and public legitimacy in their renewable energy transitions.

Introduction

Socio-economic systems, especially in the domain of energy transitions, are characterized by a high degree of interdependence between markets, institutions, technologies, and public discourse. These systems are dynamic and complex, constantly evolving through feedback loops between policy decisions, investor behavior, infrastructure development, and societal response [1]. Analyzing such systems requires approaches that can capture multidirectional influences and non-obvious linkages that emerge over time [2]. To this end, a combination of methods, including machine learning,

statistical analysis, systems modeling, and discourse analysis can help uncover the underlying dynamics that shape real-world outcomes.

This paper explores one such socio-economic system: the intersection of renewable energy policy, investment behavior, and media discourse in the context of national energy transitions. It focuses particularly on how financial viability, administrative performance, and public narratives interact to influence renewable energy uptake. The dynamics examined include feedback loops between policy incentives and investor confidence; the complexity of navigating regulatory and institutional barriers; and the effects generated when narratives across media channels reinforce or weaken investor decisions. These interactions often result in system-level outcomes, such as delays, distortions, or accelerations in project deployment, that cannot be captured through isolated sectoral analysis.

To study these phenomena, the research combines three analytical components, each using specific computational tools. First, economic modeling based on net present value (NPV), modified Levelized Cost of Electricity (LCOE), payback periods, and risk-adjusted return scenarios assesses project-level feasibility under evolving market conditions. Second, a structured investor survey is used to capture institutional experience, risk perception, and behavioral response, analyzed through descriptive and inferential statistics. Third, advanced machine learning - natural language processing (NLP) techniques are applied to over 9500 media entries, allowing a fine-grained analysis of how energy transitions are framed in public discourse.

Recent literature underscores that the effective deployment of renewable energy technologies (RETs) hinges on three critical domains: sound economic and financial frameworks, transparent and supportive administrative environments, and the shaping power of public and media narratives. While significant progress has been made in modeling the techno-economic dimensions of renewable energy, much of the existing research overlooks the institutional inertia, regulatory friction, and narrative dissonance that often constrain real-world outcomes. In transitional economies, these factors are particularly pronounced, yet few studies offer an integrated perspective that captures how financial viability is mediated by bureaucratic hurdles and discursive dynamics. This fragmented understanding limits our ability to explain why viable projects stall despite favorable market signals.

Economic feasibility in renewable energy deployment is increasingly shaped by integrated investment planning, long-term socioeconomic goals, and risk-adjusted public finance mechanisms. Regional investment models demonstrate that locally optimized support, such as interest-free loans, enhance household-scale solar and wind uptake more efficiently than uniform national programs [3]. In Algeria, [4] based on net present value confirm that project success hinges not just on resource availability or LCOE but also on alignment with national objectives like socio-economic feasibility. Complementary findings from Iran (fossil fuel-rich country) illustrate how carbon pricing mechanisms can improve the cost-effectiveness of feed-in tariff (FiT) schemes by internalizing environmental externalities while enhancing investor confidence [5]. Environmental taxes have also

shown positive effects, as shown by a statistically significant correlation between carbon tax revenue and increases in green total factor productivity in emerging Asian economies like China [6]. At the same time empirical analysis for China demonstrates that green finance (financial depth, financial stability, and financial efficiency) contributes to reducing carbon emissions and accelerating the adoption of renewable energy technologies [7].

Recent developments in auction design and power purchase agreements (PPAs) illustrate the evolving financial landscape for renewable energy investment in Europe and the Energy Community. Competitive auctions have become a dominant policy instrument, helping to allocate resources efficiently and reduce technology costs, particularly for solar and wind energy [8]. Many EU member states now incorporate multi-criteria evaluation, financial guarantees, and integration of storage solutions to enhance project viability and system resilience [9]. Examples like Portugal's floating solar plans and Luxembourg's agrivoltaic tenders reflect this innovation. Auctions in transitional economies, such as those in Macedonia, Albania, and Georgia, are inspired by EU models but adapted to local contexts, with variable results in participation and price outcomes [10]. Macedonia's auction rounds since 2019 have led to measurable capacity expansion and revenue generation, though market liquidity and competition remain uneven across the region.

In parallel, PPAs are reshaping long-term investment security by enabling direct contracts between energy producers and corporate consumers. The European PPA market experienced record growth in 2023, with a 40% year-on-year capacity increase and expanded use of hybrid and multi-buyer contracts [11]. These instruments are particularly attractive to companies seeking price stability and sustainability targets, while also offering renewable developers predictable income streams.

Investor confidence in renewable energy (RE) depends heavily on stable policies, regulatory clarity, and supportive economic conditions. Evidence from OECD and BRICS countries shows that RE investments rise with economic growth and R&D support but decline with high energy consumption and CO₂ emissions, highlighting the need for policy alignment [12]. At the entrepreneurial level, legal predictability and access to reliable information significantly influence willingness to invest, while sudden regulatory shifts undermine [13]. In politically unstable environments, such uncertainty deters long-term investment, making transparent governance and consistent incentives essential for attracting capital.

The social acceptance of renewable energy technologies is influenced not only by their technical design and cost-efficiency but also by how they are communicated through media. Research on public attitudes toward solar and wind energy highlights that emotional responses, especially toward large-scale installations, significantly impact acceptance. A study conducted in Switzerland demonstrated that while solar power is generally viewed more favorably than wind, this preference fades when comparing similarly sized installations. Emotional reactions, particularly the negative affect triggered by visual and spatial intrusion, were shown to diminish support for large-scale solar projects, indicating that acceptance is less about the energy source itself and more about how the infrastructure is perceived and experienced [14].

Longitudinal media analysis in Sweden showed how narratives about wind power have evolved over time, reflecting shifts in public debate and political framing. Wind energy was increasingly portrayed as a solution to climate change in national discourse, whereas local and regional newspapers often emphasized conflicts over land use, democratic processes, and community disruption. This contrast illustrates the divergence between national energy ambitions and local acceptance, with individuals more likely to frame wind power as a problem, while politicians present it as a benefit to society [15]. Similarly, in Portugal [16] and the Czech Republic [17], studies show that public perceptions of renewable energy sources (RES) are shaped by both personal and regional location-related factors, while media channels, especially social and online platforms, play a growing role in influencing attitudes. In the Czech context, traditional media had little influence, while internet and social media engagement were significantly correlated with support or opposition to renewables, suggesting a media bubble effect and the vulnerability of public opinion to misinformation.

Additionally, recent research underscores how media framing influences not only public attitudes but also investor behavior and policy environments. Studies of Australian media coverage of just transitions reveal that the selection and framing of topics directly shape political and public priorities, steering debates toward specific narratives while sidelining others [18]. Complementary work in futures studies shows that idealized policy narratives, particularly in energy transitions, can both enable action and obscure systemic challenges by creating unrealistic expectations [19]. Moreover, findings from behavioral science indicate that media-driven frames can influence financial decision-making by altering perceptions of systematic risk in clean energy investments, thus impacting investor confidence and capital flows [20,21]. These insights highlight the need for strategically framed, emotionally intelligent, and transparent communication not only to engage the public but also to ensure coherent and stable investment and policy frameworks.

Social media platforms further amplify the emotional dimensions of renewable energy discourse. A large-scale sentiment analysis of Reddit content revealed that renewable and nuclear energy were viewed as complementary in positive discussions but substituted each other in contexts of negative sentiment, suggesting that public opinion is highly responsive to perceived safety and environmental risk [22]. Another analysis of social media word networks found that keywords such as “panel,” “battery,” and “generator” emerged as central to public conversation, even when not prominent in frequency-based analysis, revealing latent concerns and interests within the digital public sphere [23]. Topic modeling is also a very important tool, as it can improve the usefulness of the results by uncovering hidden themes in large text datasets [24]. In Indonesia, topic modeling of both traditional and social media indicated widespread support for solar PV, particularly in terms of safety and practicality, but also highlighted persistent skepticism due to cost, unclear government policies, and limited information access [25].

The previous literature explains how large-scale changes in infrastructure and energy systems are clearly shaped by technological innovation but also by entrenched institutional routines, regulatory

landscapes and actor networks [26,27]. Moreover, it is of crucial importance to understand the distributional justice, in terms of fair access to resources, the procedural justice enabling transparency and participation in decision-making, and the recognition justice represented by marginalized stakeholders. In our study, this translates into interpreting investor dissatisfaction with opaque approval processes and unequal access to support mechanisms, issues that are rarely captured in economic models but deeply affect deployment outcomes [28].

Policymakers and investors increasingly require integrated analyses that capture not only the technical or financial dimensions of energy projects, but also the institutional and social contexts that enable or hinder implementation. Despite growing interest in the socio-economic dimensions of renewable energy transitions, much of the literature remains fragmented, focusing either on techno-economic assessments, regulatory frameworks, or public acceptance studies in isolation. This compartmentalized perspective overlooks the interdependencies between financial viability, institutional performance, and media-driven narratives that often shape real-world project outcomes. There is a particular lack of studies that integrate these dimensions to explore how cross-domain interactions produce delays, distortions, or accelerations in renewable energy deployment.

This study addresses that gap by combining three analytical perspectives rarely brought together: economic modeling, investor experience captured through structured surveys, and large-scale analysis of media discourse using natural language processing. The analysis is empirically grounded in the case of the Republic of Macedonia, chosen for its clear policy targets, data availability, and evolving energy market, however, the proposed framework is applicable to a wider range of small and medium-sized economies undergoing energy transitions.

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Section snippets

Conceptual framing and analytical dimensions

To assess the current state of RES (PV and wind), development and to identify pathways for improvement, it is necessary to move beyond purely technical or economic assessments. This study adopts a systemic, multi-dimensional perspective that integrates analytical, institutional, and discursive dimensions of energy transition. On a theoretical level, the approach recognizes that energy systems are embedded within broader socio-economic environments and that successful RES deployment requires ...

Methodology

The proposed conceptual framework provides the rationale for an integrated methodological design that incorporates economic modeling, investor surveys, and media discourse analysis. This section outlines the specific tools and procedures employed to operationalize this approach. ...

The case of Republic of Macedonia

The Republic of Macedonia presents a compelling case study of a transitional energy system grappling with both opportunities and constraints. As a member of the Energy Community, yet not of the European Union, Macedonia is influenced by EU energy directives while retaining domestic flexibility in policy implementation. As a contracting party to the Energy Community, Macedonia is heavily influenced by EU policy frameworks such as the “Fit for 55” package and the Renewable Energy Directive (RED) [...

Data collection

This study employs a mixed data collection approach, combining economic indicators, investor survey responses, and longitudinal media discourse analysis, which are explained in this section. ...

Economic feasibility assessment

Analysis of photovoltaic and wind power plants reveals a difference in market pricing. In 2023, electricity from photovoltaic plants was sold at an average of 96 EUR/MWh, approximately 30% below the HUPX average price, while wind power plants achieved parity with the market average of 105 EUR/MWh (Fig. 3). By 2024, average photovoltaic prices fell further to 62.6 EUR/MWh, while wind power averaged 90.4 EUR/MWh.

The analysis indicates that for PV power plants to achieve profitability, enabling ...

Discussion

This study presents an integrated perspective on the development of RES in Macedonia, combining economic modeling, stakeholder feedback, and public discourse analysis through NLP methods. The alignment across these dimensions offers a robust foundation for evaluating the current policy landscape and identifying practical interventions to accelerate RES deployment.

To further interpret the findings, this discussion draws on social science frameworks explaining sociotechnical transitions and the ...

Conclusion

This study offers an integrated assessment of Macedonia's renewable energy transition by combining economic viability modeling, investor perspectives, and media discourse analysis. The results indicate that while PV and wind investments are financially sustainable under current market conditions, administrative and infrastructural obstacles—particularly related to permitting and grid connection—remain key bottlenecks. Moreover, although media coverage has matured in tone and expanded in volume, ...

CRedit authorship contribution statement

Aleksandar Dedinec: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Supervision, Validation, Visualization, Writing – original draft. **Aleksandra Dedinec:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Supervision, Validation, Visualization, Writing – original draft. **Jana Prodanova:** Conceptualization, Investigation, Methodology, Validation, Writing – review & editing. **Stefani Kulebanova:** Data curation, ...

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. ...

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