

Support Mechanisms of the Financial Sector in the Context of Energy Transformation

Malik Alilli

Nakhchivan State University, Azerbaijan

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ABSTRACT

The article comprehensively analyzes the role of the financial sector and the support mechanisms it provides against the backdrop of accelerating energy transformation. Global climate change, commitments to reduce carbon emissions, and sustainable development priorities have led to fundamental changes in the structure of energy systems, necessitating new approaches to the allocation of financial resources. The main objective of the study is to identify financing instruments for green energy projects, risk-sharing mechanisms, and the institutional role of financial institutions in this process. The findings reveal that strengthening financial cooperation between the public and private sectors, as well as the application of innovative financial instruments such as green bonds, sustainable loans, and investment funds, are of particular importance for the effective implementation of energy transformation. At the same time, increasing transparency in financial markets, improving methodologies for assessing environmental risks, and adopting incentive-based regulatory policies emerge as key factors enhancing the attractiveness of green investments. The article also examines existing challenges in financing the energy transition, including long-term capital shortages, technological uncertainties, and institutional constraints, and proposes conceptual approaches to address them. Ultimately, the strategic orientation of the financial sector is assessed as a decisive factor in accelerating energy transformation and is substantiated as playing a significant role in ensuring sustainable economic development.

Keywords: Energy transformation; green finance; renewable energy; financing mechanisms; sustainable development; financial sector; green bonds; public–private partnerships

1. INTRODUCTION

The transformation of energy systems has emerged as one of the principal directions of development in the contemporary global economy. The deepening impacts of climate change and the urgent necessity of reducing carbon emissions have accelerated structural changes in the energy sector. Within this context, increasing the share of renewable energy sources has become one of the priority directions of economic policy. The energy transition represents not merely a technological but also an institutional and financial process of complex character.

The role of the financial sector in this process is of particular significance from the perspective of shaping investment flows and distributing resources efficiently. The high initial capital requirements of green energy projects necessitate the improvement of financial instruments and mechanisms. For this reason, the activities of financial institutions in managing risks and expanding long-term financing opportunities come to the fore. The sustainability and flexibility of the financial system under conditions of energy transformation are directly linked to the continuity of economic development. In recent years, the concept of green finance has become widely disseminated as one of the principal directions of financial support for the energy transition. Financial instruments such as green bonds, sustainable loans, and climate funds have begun to occupy an important place in the structure of investment portfolios. At the same time, the coordination of international financial institutions and state policies broadens the possibilities for financing green projects.

The examination of the financial aspects of energy transformation is of current relevance from the perspective of economic security and competitiveness. Existing scientific approaches demonstrate that without the active participation of the financial sector, the acceleration of the energy transition is not possible. The improvement of the institutional environment and the optimization of regulatory mechanisms serve to reduce investment risks. At the same time, the application of innovative products in financial markets creates conditions for the more effective direction of capital. Energy transformation is evaluated as a multidimensional process closely connected with long-term economic strategies. The scientific-theoretical and practical significance of the topic is accordingly increasing. The relevance of the research is explained by the need for systematic analysis of the mechanisms of financing the energy transition. The article aims to scientifically investigate the support mechanisms of the financial sector under conditions of energy transformation, drawing on existing theoretical approaches and international experience to provide insights relevant to energy policy formation and the improvement of financial strategies.

2. FINANCIAL AND REGULATORY FOUNDATIONS OF GREEN ENERGY TRANSFORMATION

Energy demand is assessed as one of the important socio-economic challenges facing states, and they utilize various energy sources to meet this demand (Bulut Deniz et al., 2019). However, some of these sources cause environmental problems and exert negative impacts on the global ecosystem. Global climate change and the global warming that results from it constitute one of the important factors leading to the formation of new approaches regarding the use of traditional fuel types (Öztürk & Çelik, 2023). Within this framework, a number of international regulations aimed at expanding the use of renewable energy sources have begun to be implemented, led primarily by developed countries. The first important document adopted in this direction was the United Nations Framework Convention on Climate Change (UNFCCC), signed in Rio de Janeiro in 1992, which emphasized that countries should form their development strategies taking carbon emissions into account (Hickman et al., 2021). Another important regulation in this field was the Kyoto Protocol of 1997, in which measures that states could take to reduce carbon emissions and projects aimed at reducing greenhouse gases were defined (Böhringer, 2003). Subsequently, the Paris Climate Agreement adopted in 2015 established specific targets and commitments for both developed and developing countries and created a global regulatory mechanism ensuring broader participation (Clemençon, 2016).

The concept of renewable energy also occupies a special place in the 2030 Sustainable Development Goals published by the United Nations in 2016. The seventh of these goals directly envisages ensuring access to clean energy. Clean energy is also closely related to the reduction of carbon emissions, and the steps taken in this direction are accepted as contributing to preventing global warming. In the context

of global climate change, a serious reduction in carbon emissions is considered necessary to limit global warming to approximately 2°C (IPCC, 2015). The widespread application of renewable energy sources exerts a significant influence both on the reduction of greenhouse gas emissions (Amponsah et al., 2014) and on the weakening of countries' energy dependence (OECD/IEA, 2017). Nevertheless, although investments in the renewable energy sector have increased, countries continue to invest simultaneously in traditional energy projects to fully meet their energy demand. According to data from the end of 2021, in G-20 countries approximately 471 billion USD was directed to fossil fuels, while approximately 425 billion USD was directed to renewable energy projects (Energy Policy Tracker, 2023).

Despite the normative documents and incentive policies prepared by global organizations and states, the transition to renewable energy is not proceeding as rapidly as expected. One of the main reasons for this is the high infrastructure costs required for renewable energy projects (Purkayastha, 2019). The initial financial difficulty arising in this field is, above all, related to high initial investment costs (Akdağ & Gözen, 2020). Investors continue to prefer fossil fuel projects over renewable energy projects due to the relatively low level of profitability in the latter and the existing risks (Sachs et al., 2019). Especially during financial crisis periods, the reduction of state incentives directed to the renewable energy sector leads to the limitation of investment flows (Engelken et al., 2016). The partnership mechanisms formed between the state initiative and the private sector play an important role in the process of transition to renewable energy (Dinica, 2008). From this perspective, when financial support provided by the state is combined with the management capabilities of the private sector, it is expected that the financial burden of green energy projects will decrease and infrastructure costs will be optimized (Martins et al., 2011). Fluctuations in fossil fuel prices also constitute one of the important factors increasing the necessity of transition to renewable energy (Halldorsson & Svanberg, 2013).

The financing of renewable energy projects is of great significance both for eliminating energy shortages and for reducing the impacts of climate change through the expansion of low-carbon energy production (Sachs et al., 2019; Semieniuk & Mazzucato, 2019). Available assessments indicate that in the financing structure of renewable energy projects, approximately 30 percent of funds are formed from equity, while the remaining 70 percent of financial needs are met primarily through borrowing mechanisms (Mendoça et al., 2010). To eliminate this financing gap and stimulate investment flows, green financial products and instruments have begun to be formed (Elie et al., 2020). Renewable energy projects, especially in developing countries, also face various legal, political, and financial barriers (Painuly, 2001). The high infrastructure costs and the long payback period of investments are considered one of the main factors making the financial implementation of green energy projects difficult (Wüstenhagen & Menichetti, 2012).

3. ECONOMIC PERSPECTIVES ON FINANCING GREEN ENERGY

When the financial system perspective is applied to renewable energy, two main directions are observed to come to the fore. The first of these is the issue of financing renewable energy (Arslan, 2023), and the second is the reduction of carbon emissions in the economic system (Avcı, 2022). Various alternative mechanisms exist for financing renewable energy projects. These mechanisms include fixed tariff and premium guarantees provided to renewable energy producers, green certificates that create additional income opportunities for investors, competitive renewable energy auctions, and net metering-based regulatory models that provide for the efficient use of surplus energy production (Akdağ & Gözen, 2020). One of the methods for financing renewable energy is also the financial leasing mechanism. In addition, the direct financing opportunities provided by international financial institutions such as the

World Bank and the European Bank for Reconstruction and Development play an important role in this area (Günüşen Varlık & Yılmaz, 2017).

Analysis of the literature on the subject reveals that research investigating the legal and political variables affecting renewable energy investments are among the earliest scientific works in this field. In research conducted by Kahn and Goldman (1987), it was determined that tax regulations in the United States had a negative impact on renewable energy investments and the necessity of reducing investment costs was emphasized. In another study conducted by Rickerson and co-authors (2007), the potential of renewable energy applications in the USA and the tariff guarantee mechanisms applied in Europe were analyzed, and it was noted that state incentives played an important role in the expansion of renewable energy policies. Another study devoted to tariff guarantees was conducted by Proença and Aubyn (2013), who demonstrated that tariff guarantees were one of the main policy instruments for renewable energy production in Portugal. In that study, an empirical assessment was conducted on the basis of macroeconomic indicators, and it was concluded that tax policies aimed at reducing costs could contribute both to increasing renewable energy investments and to reducing carbon emissions.

Another important issue attracting attention during the literature review is the carbon tax applied to promote the spread of renewable energy. Abolhosseini and Heshmati (2014) noted that renewable energy investments could be expanded through tariff guarantees, tax exemptions, and green certificate mechanisms to reduce carbon emissions. In research conducted by Brännlund and Nordström (2004) on Sweden, the impact of carbon tax on consumer behavior was investigated and the conclusion was reached that the application of this instrument would lead to a reduction in carbon emissions. Literature analyses that evaluate renewable energy financing from the perspective of cost and efficiency are also encountered. In research conducted by Fagiani and co-authors (2013), electricity energy production was assessed on the basis of efficiency and cost indicators, and it was determined that the decisions of regulatory bodies could affect the reduction of the cost price of renewable energy investments. In another study, Yakıcı and Ayan (2013) assessed the importance of renewable energy in Turkey through the analytical hierarchy process method, and as a result of the research, hydropower investments emerged as a priority direction when institutional and ecological factors were taken into account.

In research conducted in Africa on the financing of renewable energy, country policies, tax instruments, and incentive mechanisms emerge as the main factors. In research conducted by Baker (2015), the process of transition to renewable energy in South Africa, where coal-based energy production predominates, and the role of banks and the financial system within the framework of the country's renewable energy procurement program were assessed through graphical analyses. In research conducted by Carafa (2015), it was determined that government policies in Middle Eastern and North African countries play a decisive role in the financing of renewable energy projects. Chirambo (2016) reached the conclusion that, in Malawi where the level of access to electricity is low, the necessary financial resources for renewable energy could be provided through price guarantees, state incentives, and environmental taxes.

Yang and Park (2020) conducted an analysis of panel data based on macroeconomic indicators of 98 developing countries for the period 2000–2014 and determined that state institutions' incentive and support policies play an important role in the development of renewable energy. In another study conducted by Brunnschweiler (2009) based on panel data covering 119 countries, it was found that the banking sector exerts a positive impact on the development of renewable energy. In another study based on the panel data analysis method, Anton and Nucu (2020) assessed the indicators of European Union countries for the period 1990–2015 and determined that the banking sector was in a positive relationship with renewable energy. On the other hand, in research conducted by Elie and co-authors (2020), existing

scientific works in the field of renewable energy were systematized and evaluated using the bibliometric analysis method.

4. CONCLUSION

The conducted research demonstrates that under conditions of energy transformation, the development of renewable energy sources is closely connected not only with technological innovations but also with the institutional capabilities of the financial system and the effectiveness of regulatory policies. The analysis of the literature and theoretical approaches prove that the accessibility of financial resources, risk-sharing mechanisms, and incentive policies implemented by the state play a decisive role in the expansion of green energy projects.

The research findings indicate that instruments such as green bonds, state guarantees, tariff guarantees, and the support of international financial institutions make important contributions to increasing investment flows in the financing structure of renewable energy projects. At the same time, the stability of the legal and institutional environment, transparent regulatory mechanisms, and fiscal stimuli constitute the main factors increasing the attractiveness of green energy investments.

The research also shows that the level of development of the banking sector and financial markets is directly related to the volume of renewable energy investments. The strengthening of cooperation mechanisms between the state and private sector, the expansion of long-term financial instruments, and the integration of environmental risks into financial decisions are of particular significance for accelerating the energy transition. Thus, the strategic approach of the financial sector and the application of complex support mechanisms can be assessed as one of the main conditions ensuring the expansion of renewable energy. The improvement of the policies and instruments formed in this direction will make an important contribution to strengthening energy security, reducing carbon emissions, and ensuring sustainable economic development. For future research, comparative analysis of renewable energy financing by countries and empirical assessment of the impact of financial innovations on investment effectiveness represent promising directions.

DECLARATIONS

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ABOUT THE AUTHOR

Malik Alilli is a second-year master’s student at Nakhchivan State University, Azerbaijan. His research interests include green finance, energy transformation, renewable energy financing mechanisms, and sustainable economic development policy.

<https://orcid.org/0009-0000-2220-1012>

Email: malik.aliyev.95@bk.ru

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