REPUBLIC OF AZERBAIJAN

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ABSTRACT

of the dissertation for the degree of Doctor of Philosophy

ASSESSMENT OF THE ECONOMIC FEASIBILITY OF SUSTAINABLE UTILIZATION OF ENERGY RESOURCES IN AZERBAIJAN

Speciality: 5312.01 – "Field economy"

Field of science: Economic sciences

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GENERAL CHARACTERISTICS OF THE WORK

Relevance of the Topic and Degree of Its Elaboration

In the contemporary global economy, the utilization of energy resources is closely associated not only with production and export indicators but also with energy security, macroeconomic stability, competitiveness, technological modernization, and climate commitments. Within the framework of the United Nations Sustainable Development Goals (SDGs), Goal 7, "Affordable and Clean Energy," calls for the prioritization of efficiency, sustainability, and low-carbon transformation in energy policy [1]. At the same time, the European Union's Carbon Border Adjustment Mechanism (CBAM), which entered its definitive phase on 1 January 2026, imposes new compliance requirements on countries characterized by energy-intensive production and export structures. Consequently, the economic implications of energy resource utilization must now be assessed not only in terms of domestic markets and fiscal revenues but also with regard to access to foreign markets, the carbon footprint of exports, product competitiveness, and the technological modernization of production.

The Republic of Azerbaijan is one of the region's principal energy-producing countries, owing to its abundant oil and natural gas reserves, established energy infrastructure, favourable geostrategic position, and international export routes. Nevertheless, the substantial share of fossil fuels in the country's energy mix, global decarbonization trends, risks associated with the long-term sustainability of oil and gas revenues, and the need to improve energy efficiency make it essential to reassess energy policy within a new conceptual framework. The designation of "a clean environment and green growth" as a national priority in the document *Azerbaijan 2030: National Priorities for Socio-Economic Development* strengthens the institutional foundations for this transition. Accordingly, assessing the economic potential of energy resources is no longer merely a sector-specific issue; rather, it constitutes a strategic research area directly related to macroeconomic stability, economic diversification,

[1] *United Nations. Goal 7: Affordable and Clean Energy. https://sdgs.un.org/goals/goal7*

enhanced competitiveness of the non-oil sector, and the formation of a long-term development model[2]

ubject has primarily been investigated in relation to energy strategy, oil revenues, energy diplomacy, export routes, macroeconomic stability, and renewable energy potential. In this regard, the works of authors such as Sh. Babayev, Z. F. Mammadov, R. Ibrahimov, E. Hajizadeh, S. Gurbanov, N. Vidadili, E. Suleymanov, J. Mahmudlu, I. Shaban, and V. Bayramov contribute to the academic foundation of the research across several related areas. Their studies address issues such as the impact of oil revenues on economic growth and financial stability, the role of energy strategy in the national development model, the geoeconomic implications of energy diplomacy, the economic dimensions of renewable energy potential, and the assessment of international energy cooperation in terms of Azerbaijan's national interests. Nevertheless, a substantial proportion of these studies have examined the hydrocarbon sector, energy diplomacy, or renewable energy potential as separate areas of inquiry, without adequately integrating the economic, environmental, institutional, technological, and forecasting dimensions of the sustainable utilization of energy resources within a comprehensive analytical framework.

In particular, research gaps can be identified in the following areas: the integrated assessment of energy resource efficiency using macroeconomic and sector-specific indicators; the economic analysis of renewable energy projects in conjunction with natural gas savings, emissions reduction, and export opportunities; the examination of the emerging green energy model in Karabakh and East Zangezur in conjunction with transmission infrastructure, energy corridors, and market liberalization; the systematic analysis of the effects of new institutional mechanisms, including green finance, green bonds, power purchase agreements (PPAs), and market operators, on energy policy; and the application of modern modelling techniques, such as ARIMA, TAR, and STAR, to energy indicators using data from Azerbaijan.

[2] *Azərbaycan Respublikasının Prezidenti. "Azərbaycan 2030: sosial-iqtisadi inkişafa dair Milli Prioritetlər", 02.02.2021. https://president.az/az/articles/view/50474*

These research gaps further reinforce the theoretical and practical relevance of the selected topic.

Thus, a comprehensive assessment of Azerbaijan's existing energy resource potential, utilization efficiency, institutional environment, environmental outcomes, and future development trajectories is of strategic importance for strengthening the country's energy security, diversifying the economy, substantiating green transition policies, and establishing a sustainable development model.

Research conducted by Azerbaijani economists has also examined energy security, oil strategy, energy diplomacy, renewable energy potential, and the economic dimensions of energy policy from various perspectives. Nevertheless, the comprehensive assessment of the economic potential of the sustainable utilization of energy resources in terms of the energy transition, green finance, market liberalization, and econometric modelling necessitates further scientific investigation of the subject. [3, 4]

Research Object and Subject. The object of the research is the energy sector of the Republic of Azerbaijan and its principal areas of interaction with economic development, energy security, socio-economic welfare, and sustainable transformation. The subject of the research comprises the economic mechanisms for the efficient and sustainable utilization of Azerbaijan's oil, natural gas, and renewable energy resources; the outcomes of such utilization; its institutional prerequisites, environmental and social impacts; and the future development prospects of the country's energy policy.

Aim and Objectives of the Research. The aim of the research is to assess the economic potential of the sustainable utilization of energy resources in Azerbaijan, identify the strengths and weaknesses of the existing energy model, analyse key trends in terms of energy efficiency and energy security, and formulate scientifically

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[3] *Stern, D. I. The role of energy in economic growth // Annals of the New York Academy of Sciences. 2011, vol. 1219, pp. 26–51. DOI: 10.1111/j.1749-6632.2010.05921.x. International Energy Agency. Azerbaijan 2021: Energy Policy Review. Paris: IEA, 2021. https://www.iea.org/reports/azerbaijan-2021*

[4] *Karimli, A.; Aghayev, A. The economic opportunities of renewable energy resources in Azerbaijan: major challenges and scenarios // Business & IT. 2020, vol. X, no. 2, pp. 71–81. DOI: 10.14311/bit.2020.03.06.*

substantiated conclusions and recommendations for the balanced development of conventional and renewable energy sources.

To achieve this aim, the following research objectives have been defined:

- To analyse the structure, economic significance, and statistical trends of existing energy resources in Azerbaijan, including oil, natural gas, and renewable energy sources;
- To assess the efficiency indicators of energy resource utilization, including energy intensity, natural gas savings, and emissions reduction;
- To determine the role of the energy sector in the systems of domestic security, socio-economic welfare, and external economic relations;
- To examine Azerbaijan's energy diplomacy, export routes, role in European energy security, and emerging formats of energy cooperation;
- To conduct a comparative analysis of the economic, technological, and institutional outcomes of renewable energy projects, particularly those at Garadagh, Khizi–Absheron, Babek, and Julfa;
- To evaluate reform priorities in the energy market, including market liberalization, tariff policy, green finance, power purchase agreement (PPA) mechanisms, and the attraction of private investment;
- To analyse the economic potential of the green energy zones being developed in Karabakh and East Zangezur in conjunction with transmission infrastructure and the concept of energy corridors;
- To produce forecast estimates through time-series analysis and scenario modelling based on electricity generation indicators;
- To identify, through regional comparisons, institutional and strategic lessons that can be applied to Azerbaijan's energy transition policy;
- To develop practical recommendations concerning public policy, investment models, and human capital for the sustainable utilization of energy resources.

Research Methods. The study employs both theoretical and

empirical research methods. The theoretical analysis draws on general scientific methods, including the systems approach, comparative analysis, analysis and synthesis, induction and deduction, and causal analysis. The empirical component involves comparative and dynamic analyses of official statistical data, while changes in energy indicators over time are assessed using econometric tools. For this purpose, descriptive statistical analysis, stationarity tests, trend analysis, ARMA/ARIMA-type modelling, and TAR and STAR approaches for scenario modelling are employed. To complement the quantitative analysis with a qualitative component, semi-structured and structured expert interviews, an analysis of regulatory and legal documents, and a comparative case study approach applied to selected projects are also utilized. [5,6]

The information base of the research comprises statistical materials published by the State Statistical Committee of the Republic of Azerbaijan, official statements issued by the Ministry of Energy, reports prepared by SOCAR and other sectoral institutions, analytical materials produced by international energy organizations, academic literature, and expert data.

Key Propositions Submitted for Defence. Based on the findings of the research, the principal scientific propositions formulated in the dissertation are submitted for defence as follows:

1. Azerbaijan's long-term energy security cannot be ensured through a model based solely on hydrocarbon exports. Rather, such security is strengthened through the balanced development of conventional and renewable energy sources, improvements in energy efficiency, and the optimization of the balance between domestic consumption and exports.

2. Although oil and natural gas resources will remain the principal sources of revenue for the Azerbaijani economy in the short and medium term, global decarbonization trends, declining oil

[5] *Hamilton, J. D. Time Series Analysis. Princeton: Princeton University Press, 1994.*

[6] *Tong, H. Non-linear Time Series: A Dynamical System Approach. Oxford: Clarendon Press, 1990. Teräsvirta, T. Specification, Estimation, and Evaluation of Smooth Transition Autoregressive Models // Journal of the American Statistical Association. 1994, vol. 89, no. 425, pp. 208–218. DOI: 10.1080/01621459.1994.10476462.*

production, and structural changes in energy markets undermine the long-term sustainability of this model and necessitate the diversification of energy policy.

3. Renewable energy sources represent not merely an environmental alternative for Azerbaijan but also a strategic resource offering economic advantages in terms of natural gas savings, reduced carbon emissions, diversification of the energy mix, and expansion of export potential.

4. Projects such as the Garadagh Solar Power Plant, the Khizi–Absheron Wind Power Plant, the Babek Solar Power Plant, and the Julfa hybrid project constitute complementary practical models demonstrating that renewable energy projects can generate tangible economic and institutional outcomes at different scales.

5. The economic efficiency of the green energy zone approach being developed in Karabakh and East Zangezur depends not only on the establishment of new generation capacities but also on their integration into the national electricity system and their connection with the Nakhchivan interconnection and regional transmission routes.

6. Resource potential alone is insufficient to ensure the successful implementation of the energy transition. Market operators, balancing mechanisms, transparent grid access rules, contractual arrangements such as power purchase agreements (PPAs) and public-private partnerships (PPPs), as well as green finance instruments, constitute essential prerequisites for institutional resilience in the energy market.

7. The subsidized energy consumption model undermines efficiency in the energy sector, distorts investment signals, and creates barriers to market entry for new participants. Consequently, the implementation of gradual tariff reforms and the establishment of targeted protection mechanisms for socially vulnerable groups are necessary.

8. The energy transition is closely linked to technological infrastructure, innovation, and human capital. Shortages of qualified personnel, limited technology transfer, and underdeveloped local manufacturing capabilities are among the key factors impeding the expansion of renewable energy projects.

9. Time-series analysis and econometric modelling of electricity generation indicators provide significant analytical advantages for energy policy planning, the identification of structural changes, and the substantiation of short-term forecasting decisions.

10. Regional comparisons indicate that the green energy transition experiences of Türkiye, Kazakhstan, and Ukraine offer practical strategic lessons for Azerbaijan regarding legal and institutional stability, international financial cooperation, technology localization, and green recovery approaches in the post-conflict period.

The Scientific Novelty of the Research Is Reflected in the Following Key Areas:

1. The issue of the sustainable utilization of energy resources in Azerbaijan has been established as a unified subject of economic analysis, extending beyond the oil and gas sector to encompass renewable energy, energy efficiency, energy diplomacy, green finance, market liberalization, and regional energy integration.
2. A time-series approach has been applied to assess and forecast the dynamics of electricity generation, and the practical relevance of ARMA/ARIMA-based modelling for Azerbaijan has been substantiated, taking into account seasonality, trends, stationarity, and structural changes.
3. The methodological applicability of nonlinear scenario-modelling approaches, including TAR- and STAR-type models, has been substantiated for assessing the future trajectories of changes in energy indicators.
4. Based on a comparative assessment of the technical and economic indicators of the Garadagh Solar Power Plant, the Khizi–Absheron Wind Power Plant, the Babek Solar Power Plant, and the Julfa hybrid model, the principal mechanisms through which these projects can improve the domestic energy balance and reduce natural gas consumption and emissions have been identified.
5. The green energy zone model emerging in Karabakh and East Zangezur has been systematized on the basis of the interrelationships among energy generation, transmission infrastructure, energy corridors, regional interconnections, and

commercial viability. The economic and institutional dimensions of its development have also been substantiated.

6. The role of emerging institutional mechanisms in the energy market—including power purchase agreements (PPAs), public-private partnerships (PPPs), market operators, balancing markets, green bonds, green taxonomies, and private-sector participation—in Azerbaijan's sustainable energy transition has been systematically synthesized.
7. Institutional and strategic approaches adaptable to Azerbaijan have been identified through a comparative analysis of the green energy transition experiences of Türkiye, Kazakhstan, and Ukraine.
8. Based on the findings concerning the economic potential of the sustainable utilization of energy resources, a set of practically applicable recommendations has been developed in the areas of public policy, investment models, the institutional organization of the energy market, and human capital development.

Theoretical and Practical Significance of the Research. *The theoretical significance of the research* lies in examining the sustainable utilization of energy resources through the integrated consideration of economic, environmental, institutional, and technological dimensions. The interrelationships among energy security, energy efficiency, energy diplomacy, the green transition, market reforms, green finance, and regional energy integration are interpreted within a unified analytical framework. This approach contributes to adapting theoretical perspectives in energy economics to the realities of Azerbaijan, refining relevant concepts, and expanding the methodological foundation of the field.

The practical significance of the research lies in the potential application of its findings to improving energy policy, substantiating tariff and subsidy reforms, attracting private investment, implementing green finance instruments, developing mechanisms for energy market liberalization, assessing the economic viability of green energy zones in Karabakh and East Zangezur, developing Nakhchivan's renewable energy model, and designing energy efficiency programmes.

The research materials may also be used in teaching such subjects as *Energy Economics*, *Sustainable Development and*

Environmental Economics, *Economic Modelling*, *Macroeconomic Policy and Energy Security*, and *International Economic Relations* at higher education institutions.

Approbation and Implementation of the Research. The principal propositions and findings of the research have been discussed at academic meetings of the department where the research was conducted, as well as at various scientific gatherings and conferences. The findings obtained during the research process have been evaluated from theoretical and practical perspectives in academic discussions addressing energy security, renewable energy, the green transition, energy diplomacy, and economic efficiency.

The research findings have potential applications in improving energy policy, refining strategic approaches, providing an economic justification for renewable energy projects, and supporting the educational process.

Name of the Institution Where the Dissertation Was Conducted. The research was conducted at the Department of Economics of the Azerbaijan University of Architecture and Construction.

Total Length of the Dissertation in Characters, with the Length of Each Structural Section Specified Separately.

The dissertation comprises an introduction (17,548 characters), three chapters (Chapter I: 44,001 characters; Chapter II: 122,626 characters; Chapter III: 81,903 characters), a conclusion (23,268 characters), and a list of 189 bibliographic references. The dissertation contains 26 tables, 28 diagrams, 9 graphs, and 14 figures. Excluding tables, figures, graphs, and the list of references, the dissertation has a total length of 289,346 characters.

STRUCTURE OF THE DISSERTATION

Introduction

Chapter I. The Formation of the Energy Sector in Azerbaijan and the Theoretical and Methodological Foundations of Sustainable Energy Utilization

1.1. Energy Resources and the Economic Essence of the Energy Sector in Azerbaijan: The Concept of Sustainable Energy Utilization

1.2. Theoretical Approaches and Analytical Framework for the Energy–Economic Development–Sustainability Nexus

1.3. Assessment Methodology: Dynamic Indicators, Data Sources, and Modelling Approach

Chapter II. Azerbaijan's Energy Resource Base and Energy Market Dynamics: Statistical Analysis, Efficiency, and Policy Factors

2.1. Existing Energy Resources in Azerbaijan and the Structural Characteristics of the Resource Base, Including Renewable Energy Potential

2.2. Dynamic Trends in Azerbaijan's Energy Demand, Production, and Consumption and Analysis of Key Statistical Indicators

2.3. Energy Intensity and Efficiency, and the Role of the Energy Sector in the Context of Domestic Security and Socio-Economic Welfare: Domestic Policy and Energy Diplomacy Factors

Chapter III. Economic Aspects and Prospects of Energy Resource Utilization in Azerbaijan

3.1. Economic Assessment: Analysis Based on the Efficiency and Impact Indicators of Energy Resource Utilization

3.2. Forecasting and Scenario Modelling: ARIMA, TAR, and STAR Approaches

3.3. Formulation of a Sustainable Energy Strategy and Development Prospects

Conclusion

References

GENERAL CHARACTERISTICS OF THE WORK

Chapter I of the study examined the theoretical and methodological foundations of sustainable energy utilization. Within this framework, issues relating to the efficient and environmentally responsible management of energy resources over the long term were analysed.

According to forecasts by the International Energy Agency (IEA), global electricity demand is expected to increase in the coming years. This trend indicates a further deepening of the interrelationship between energy and economic development.[7]

The concept of the green economy entails the simultaneous achievement of economic growth, social welfare, and environmental balance.[8]

Comparative analysis across different periods, taking into account temporal consistency, comparability, and the scope for economic interpretation of the indicators. The research draws on statistical data from the Ministry of Energy, the State Statistical Committee of the Republic of Azerbaijan, the International Energy Agency (IEA), and other international organizations.

One of the principal quantitative tools employed in the study is time-series analysis. Time-series methods were applied to assess and forecast the dynamics of electricity generation indicators. The analysis accounted for trend, seasonality, and stationarity characteristics, and forecast estimates were produced using ARIMA-based modelling and scenario-based approaches.[9]

The preliminary examination and forecasting of time series generally begin with graphical analysis. At this stage, an initial understanding is developed of the overall trend of the indicator, potential breakpoints, the nature of fluctuations, and the functional form of the model to be selected. Hypothetical examples of stationary and non-

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[7] *International Energy Agency. Electricity 2024. Paris: IEA, 2024.* https://www.iea.org/reports/electricity-2024

[8] *United Nations Environment Programme. Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication. UNEP, 2011.* https://wedocs.unep.org/handle/20.500.11822/9158

[9] *Azərbaycan Respublikasının Dövlət Statistika Komitəsi. Energetika: statistik göstəricilər və enerji balansları.* https://stat.gov.az/source/balance_fuel/

stationary time series are presented below. In this study, modelling is regarded not merely as a technical tool for ensuring statistical fit, but as an analytical instrument for uncovering the economic rationale underlying structural changes in the energy sector.

Table 1. Indicators of Prospective Natural Gas Fields in Azerbaijan

Field name	Estimated Reserves	Estimated Investment	Estimate start of production
Absheron	350 bcm	$6.3 billion	2023
Araz, Alov, Sharg	700 bcm	$4 billion	–
ACG	280 bcm	–	2026
Umid	200 bcm	$5 billion	2012
Babek	400 bcm	–	2026–2027
Shafag-Asiman	500 bcm	–	–

Source: Compiled by the author based on official data from the Ministry of Energy of the Republic of Azerbaijan and BP.

As shown in the table, Azerbaijan has substantial prospective natural gas reserves.

In recent years, state policy has increasingly emphasized the diversification of the energy sector and sustainable energy use, while initiatives aimed at increasing the share of renewable energy and establishing "green energy zones" have been incorporated into institutional objectives.[10]

The growth in Azerbaijan's energy consumption is primarily driven by rising demand in the industrial, transport, residential, and service sectors. Although the country's abundant hydrocarbon resources enable the reliable satisfaction of domestic demand, the need to establish a more sustainable and diversified energy balance is becoming increasingly pronounced in the long term. In terms of energy intensity, Azerbaijan exceeds Türkiye but remains below Kazakhstan and Russia. This

[10] *Azərbaycan Respublikasının Prezidenti. "Azərbaycan 2030: sosial-iqtisadi inkişafa dair Milli Prioritetlər", 02.02.2021.* https://president.az/az/articles/view/50474

indicates that energy-intensive industries continue to account for a substantial share of the country's economic structure.

Chapter II of the dissertation examines the pivotal role of Azerbaijan's energy sector in the national economy, the risks facing the sector, and its strategic significance.

The Russia–Ukraine war has reshaped the European energy market and intensified interest in alternative energy supply routes. These developments have increased demand for Azerbaijan's energy exports and enhanced the country's importance as an energy supplier to Europe.

Chapter III of the dissertation analyses the assessment of energy resource utilisation based on economic models, Azerbaijan's energy diplomacy and regional cooperation, as well as the formation of a sustainable energy strategy and its development prospects.

New or renewed production-sharing agreements for the exploration and commercial development of hydrocarbon fields constitute one of the key mechanisms for ensuring the continuity of investment flows into the energy sector. Cooperation arrangements concerning fields such as Absheron, Muradkhanli–Jafarli–Zardab, Hovsan–Zigh, D230/North Absheron, Ashrafi–Dan Ulduzu–Aypara, and Karabakh are of particular importance in this regard.

The research findings indicate that the priorities of energy policy centre on the diversification of energy resources, the expansion of renewable energy potential, the economic and geopolitical dimensions of energy security, and the strengthening of environmental sustainability. The main findings of the survey have been grouped into the following areas:

Diversification of Energy Resources: Expert assessments indicate that expanding renewable energy sources, strengthening energy security, and ensuring economic diversification are considered priority areas of energy policy. Experts emphasised the importance of alternative energy projects for achieving long-term economic sustainability and promoting the development of the non-oil sector.

Renewable Energy Potential: The majority of experts noted that Azerbaijan possesses considerable potential in wind and solar energy. Nevertheless, they identified existing infrastructure deficiencies and gaps

in modern technologies as major obstacles to the development of this potential.

Energy Security and State Policy: According to the interview findings, representatives of government institutions assessed energy security not only from an economic perspective but also in geopolitical terms. One of the experts noted: "Energy exports are one of the key instruments for enhancing Azerbaijan's international standing, while ensuring a sustainable domestic energy supply is equally important from a strategic perspective."

Environmental Sustainability: One of the academic experts stated: "Hosting a global event such as COP29 has brought Azerbaijan's green energy agenda to the forefront and necessitates the acceleration of concrete and practical measures in this area."

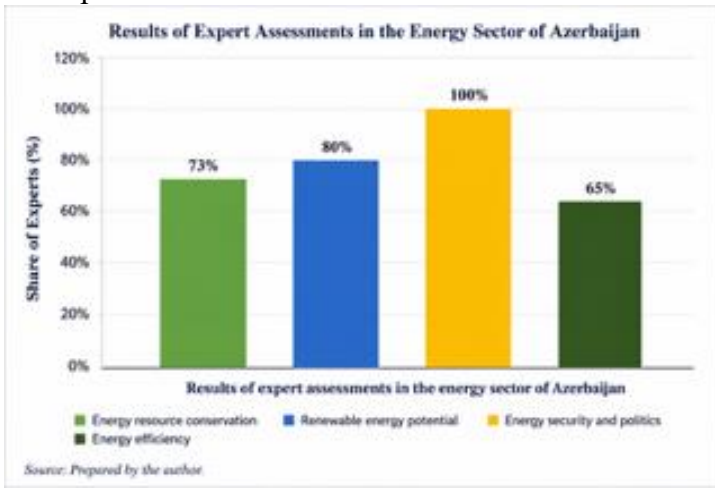


Figure 1. Results of Expert Interviews on Azerbaijan's Energy Sector

Source: Compiled by the author based on the results of expert interviews.

The diagram results indicate that energy security, diversification, and the green transition have emerged as parallel priorities in energy policy.

Table 2. Summary of Findings

Direction	Main Expert Opinions	Identified Advantages	Identified Limitations
Energy Diversification	Reducing dependence	Sustainable economic development	Lack of investment and technology
Renewable Energy	Wind and solar energy are the most promising sector	Export potential, environmental sustainability	Infrastructure and legislative gaps
Energy Security	Economic and geopolitical factor	Regional cooperation opportunities	Risks related to domestic energy supply
environmental sustainability	Climate goals should be a priority	COP29 and international support	Weak implementation of environmental standards

Source: Compiled by the author based on the results of expert interviews.

The overall findings of the expert assessments indicate that the key priorities of Azerbaijan's energy policy include the efficient utilisation of natural gas resources, alongside the expansion of renewable energy sources, the adoption of technological innovations, and the strengthening of environmental standards. The main barriers to the development of renewable energy projects are high initial investment costs, technological dependence, a shortage of qualified personnel, grid integration challenges, and infrastructure constraints.

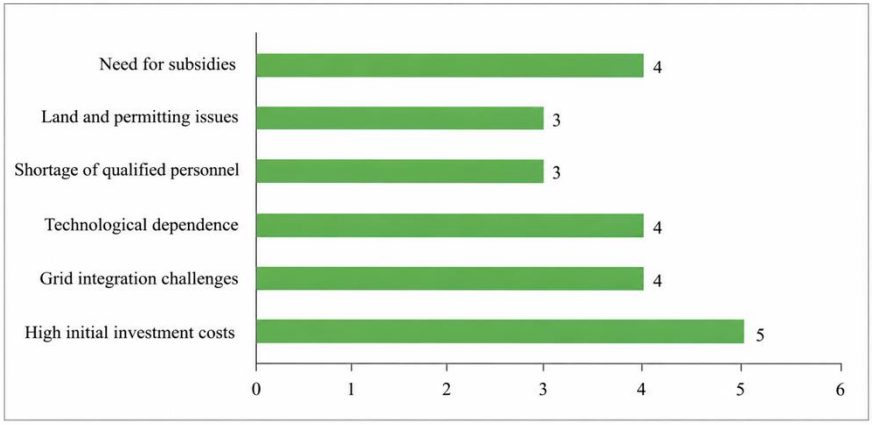


Figure 2. Barriers to the Realisation of Azerbaijan's Renewable Energy Potential

Source: Compiled by the author.

One of the principal challenges to ensuring the economic efficiency of renewable energy projects is the high level of initial capital investment. Grid integration and technological dependence also constitute major constraints. As Azerbaijan's electricity transmission and distribution networks have not yet been fully adapted to the characteristics of variable generation, issues related to energy losses and system stability may arise. Limited domestic production of solar panels, wind turbines, and energy storage systems increases dependence on imports, foreign currency expenditure, and technical maintenance risks. A shortage of qualified personnel, land allocation issues, complex permitting procedures, and the complexity of environmental assessment processes are also among the factors hindering the timely implementation of projects.

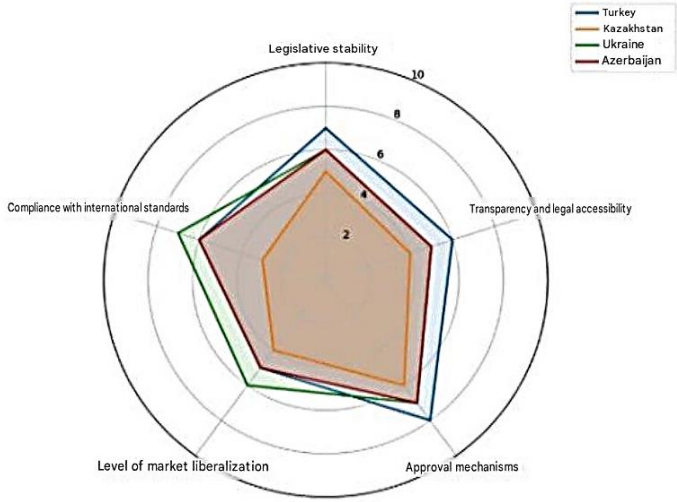


Figure 3. Comparative Analysis of Green Energy Policies in Türkiye, Kazakhstan, Azerbaijan, and Ukraine Using a Radar Chart

Source: Developed by the author using the Python programming environment (2025). The data were compiled using information from the International Energy Agency (IEA), the World Bank's "Renewable Energy Indicators" (2024), and IRENA's Renewable Capacity Statistics (2024).

Forecasting and Scenario Modelling: ARIMA, TAR, and STAR Approaches: The analysis draws on monthly electricity generation data

for Azerbaijan covering the period from January 2014 to July 2023 (2014M01–2023M07). The statistical series comprises total electricity generation from thermal, hydropower, wind, and solar energy sources. The selection of monthly data is not arbitrary: although annual indicators make it possible to identify the overall trend, they do not adequately capture seasonal fluctuations, short-term spikes, and potential regime shifts. Accordingly, a monthly time series was selected for the analysis, with seasonality explicitly accounted for in subsequent stages. [11]

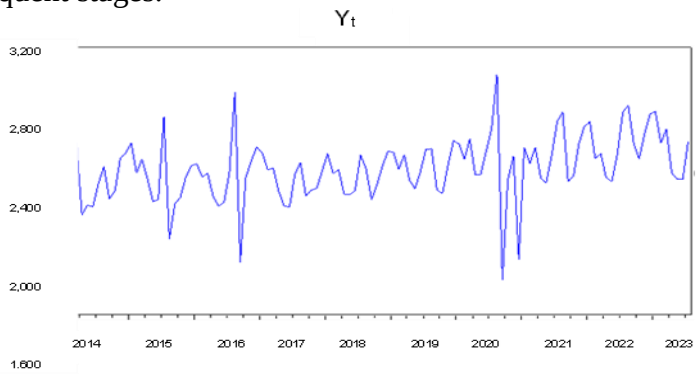


Figure 4. Time Series Plot of Electricity Generation (\(Y_t\))
Source: Calculated by the author.

The technical potential of Azerbaijan's renewable energy sources is estimated at 135 GW onshore and 157 GW offshore, while the economic potential is assessed at 27 GW. Of this economic potential, 3,000 MW is attributable to wind energy, 23,000 MW to solar energy, 380 MW to bioenergy, and 520 MW to the energy potential of mountain rivers.

Power plants utilising renewable energy sources with a total installed capacity of 2,170 MW are currently operational in Azerbaijan. These include 65 hydropower plants with a capacity of 1,443.5 MW, six wind power plants with a capacity of 306.5 MW, ten solar power plants with a capacity of 378.2 MW, one bioenergy power plant with a capacity of 37 MW, and three hybrid power plants with a

[11] *Azərbaycan Respublikasının Dövlət Statistika Komitəsi. Energetika: statistik göstəricilər və enerji balansları.* https://stat.gov.az/source/balance_fuel/

capacity of 7.3 MW. Renewable energy sources account for approximately 21.5% of the country's total installed power generation capacity. These figures indicate that the role of green energy sources in the energy system is expanding, although their potential has yet to be fully realised.

To determine whether such fluctuations in monthly data are associated with seasonal factors, changes in the generation mix, or short-term variations in production regimes, the seasonal component was first examined separately. For this purpose, the following regression model was applied using 12 monthly seasonal indicators:[12]

$$Y = a_1 \cdot January + a_2 \cdot February + \ldots + a_{12} \cdot December + \varepsilon$$

A comparison of the seasonally adjusted time series (YSA) with the original series indicates that YSA exhibits a smoother pattern. This facilitates a clearer observation of the underlying dynamics of the series and enables more reliable trend analysis and stationarity testing in subsequent stages. The reduction in seasonal amplitude diminishes the influence of short-term deviations within the series, thereby establishing a more suitable analytical basis for economic interpretation.

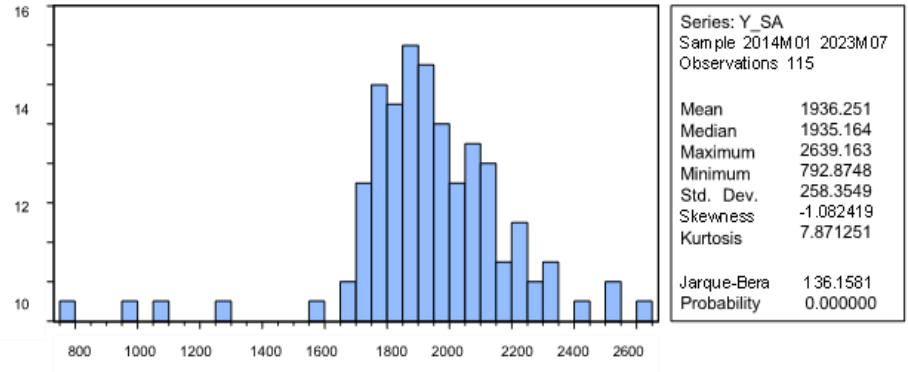


Figure 5. Descriptive Statistics of Electricity Generation

Source: Calculated by the author.

According to the descriptive statistics, the average volume of electricity generation during the study period was 1,936.251 million

[12] *Azərbaycan Respublikasının Energetika Nazirliyi. Azərbaycanda bərpa olunan enerji mənbələrindən istifadə. 22.09.2026. https://minenergy.gov.az/az/alternativ-ve-berpa-olunan-enerji/azerbaycand a-berpa-olunan-enerji-menbelerinden-istifade*

kWh, while the maximum and minimum values were 2,639.163 million kWh and 792.8748 million kWh, respectively. The Jarque–Bera statistic and its associated probability value indicate that the series does not follow a normal distribution.

A linear trend model was estimated to test for the presence of a trend in the seasonally adjusted series (YSA).

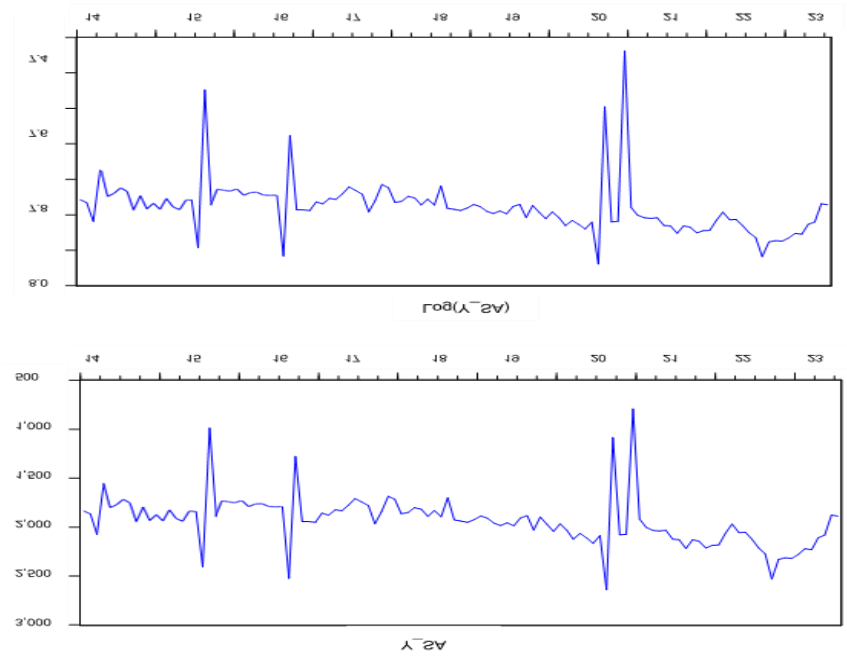


Figure 6. Comparative Analysis of the Seasonally Adjusted Series (YSA) and Its Logarithmic Transformation (log(YSA))

Source: Calculated by the author

The statistical significance of the trend coefficient in the trend model estimated for the logarithmically transformed series further confirms the presence of a deterministic trend in the dynamics of the series. The resulting model is expressed as follows: log(YSA) = 7.451150 + 0.001772TREND. Furthermore, a comparison of the YSA and log(YSA) plots indicates that logarithmic transformation does not substantially alter the overall pattern of the series but facilitates the analysis of its variability.

The ADF test enables the presence of a unit root in the series to be examined. The DF and ADF specifications employed are summarised in the table below. The results obtained indicate that the ADF test statistic is lower than the critical values and that the associated p-value is below the 5% significance level. This indicates that the log(YSA) series is stationary in levels. In other words, the series does not require differencing, and the order of integration can be specified as $d=0$ within the ARIMA framework. Accordingly, the practical specification was formulated in the form of an ARMA model. Taking the stationarity test results into account, an ARMA(1,2) model was estimated for the log(YSA) series.

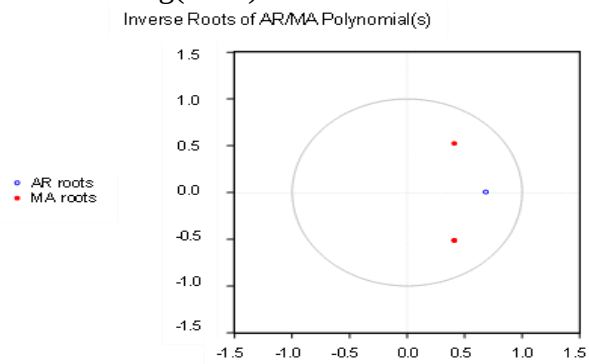


Figure 7. Characteristic Roots of the ARMA(1,2) Model

Source: Author's calculations using the ARMA Structure function in EViews.

The fundamental assumptions of the model include a zero expected value of the error terms, constant variance, the absence of systematic correlation among the residuals, the independence of the error terms from the explanatory variables, and linearity of the model with respect to its parameters. These assumptions are expressed as follows:

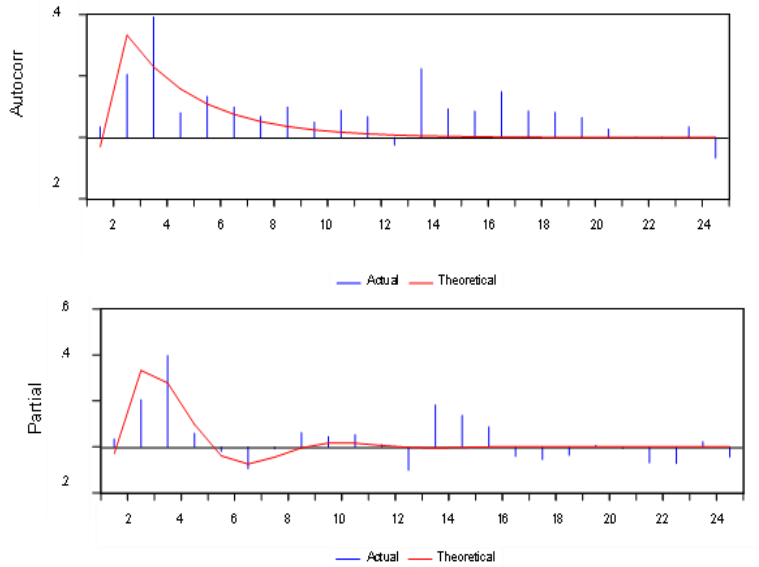


Figure 8. Goodness of Fit of the ARMA(1,2) Model: Actual versus Fitted Values

Source: Author's calculations.

The linear ARMA model was employed as a baseline approach for short-term forecasting of total monthly electricity generation.

To assess nonlinear changes, a scenario-based approach was adopted using the TAR model.

Energy security should be assessed not only in terms of resource abundance but also in terms of the quality of governance, infrastructure planning, and technical reliability.

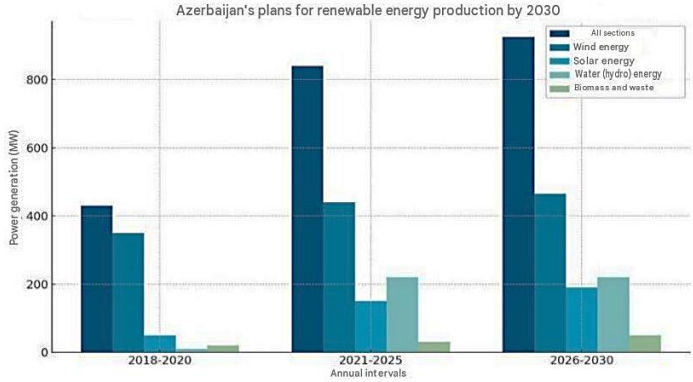


Figure 9. Phased Expansion of Installed Renewable Energy Capacity in Azerbaijan through 2030

Source: Compiled by the author based on data from the Azerbaijan Renewable Energy Agency (AREA) and the Ministry of Energy.

Azerbaijan's strategic objectives for renewable energy development through 2030 are not limited to an overall share target but are also accompanied by a phased expansion plan for individual energy sources.

The establishment of the legal framework for Azerbaijan's green energy transition constitutes a gradual and complementary institutional process. The model presented below systematically illustrates the main stages of this process.

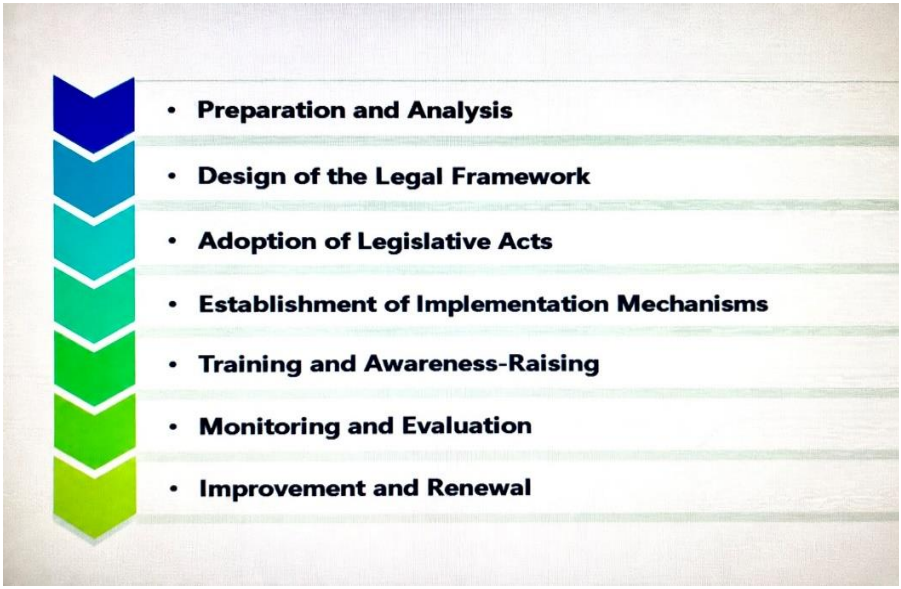


Figure 10. Stages in the Development and Implementation of Green Energy Legal Reforms in Azerbaijan (the "Energy Law Tower" Model)

Source: Compiled by the author.

The "tower model" presented in the figure illustrates that legal reforms in the field of green energy should be implemented sequentially, beginning with the preparatory and analytical stage, followed by the design of the legal framework, the adoption of legislative acts, the establishment of implementation mechanisms, training and awareness-raising, monitoring and evaluation, and, ultimately, improvement and renewal. This approach indicates that legal reforms are not limited to the adoption of normative legal acts but must be complemented by mechanisms for implementation, oversight, and continuous updating.

CONCLUSION

The dissertation provides a comprehensive examination of the economic challenges facing Azerbaijan's energy sector and the issues associated with improving the efficiency of domestic energy production. In this context, the involvement of the private sector in the energy market and the alignment of energy prices more closely with production costs have been identified as key priorities. The gradual optimisation of subsidies should be accompanied by targeted support measures for socially vulnerable groups. This approach could facilitate the development of solar and wind energy potential, enhance energy efficiency, and reduce greenhouse gas emissions.[13]

To ensure the long-term and sustainable use of existing energy resources, Azerbaijan must maintain consistency in strategic decision-making and strengthen unified, coordinated governance mechanisms. In the post-COP29 period, global climate change and the transition to clean energy have gained even greater prominence. In this context, the long-term risks associated with dependence on oil and gas reserves must be taken into account, strategic measures in the renewable energy sector must be expanded, and investment mobilisation and international cooperation must be strengthened.

Energy Diversification and Investment. To ensure efficient and sustainable development of Azerbaijan's energy sector, energy diversification must be strengthened, and the share of renewable energy sources should reach approximately 30% by 2030. To this end, substantial investment in solar and wind energy projects is essential. To promote solar energy development, subsidies and long-term lending mechanisms should be introduced for the installation of rooftop and commercial solar panels, while the share of domestic production should be increased gradually by 2030.

Human Capital Development. Strengthening human capital is of strategic importance. The number of specialised professionals in the energy sector should be increased, professional training programmes should be organised for approximately 500 specialists annually, and

[13] *International Energy Agency. Azerbaijan 2021: Energy Policy Review. Paris: IEA, 2021.* https://www.iea.org/reports/azerbaijan-2021

higher education institutions should expand specialist training in energy management and renewable energy. This approach will improve the quality of human resources involved in project planning and management and facilitate the adoption of technological innovations.

Technological Infrastructure and Energy Efficiency. The development of technological infrastructure should be a priority, and the share of domestically manufactured solar panels and wind turbines should be increased. The pilot implementation of technologies that ensure high energy efficiency is expected to generate annual energy savings. To improve energy efficiency and reduce carbon emissions in the transport sector, the use of electric and hybrid vehicles should be encouraged. The deployment of electric buses and other environmentally friendly vehicles in urban transport should be expanded through the introduction of investment incentives, tax concessions, and subsidy mechanisms.

Governance and Investment Models. Public–Private Partnership (PPP) mechanisms should be applied to major energy projects, accompanied by the establishment of risk-sharing arrangements and transparent accountability mechanisms. The share of private-sector participation should be increased by 2030. Renewable energy producers should be provided with access to long-term financing, tax concessions, and subsidy mechanisms to create a more favourable investment environment. Energy market data should be open and accessible, government support should be provided for research into and monitoring of renewable energy potential, and international best practices should be adapted to Azerbaijan's specific circumstances.[14]

Legal and Economic Framework. In the area of the legal and economic framework, uncertainties associated with energy contracts and the issuance of permits and licences should be eliminated, tariff policy reforms should be implemented, and gas and electricity subsidies should be provided through targeted social support

[14] *International Energy Agency. Implementing a Long-Term Energy Policy Planning Process for Azerbaijan: A Roadmap. Paris: IEA, 2022.* *https://www.iea.org/reports/implementing-a-long-term-energy-policy-planning-process-for-azerbaijan-a-roadmap*

mechanisms. The research findings concerning the country's energy diplomacy, international cooperation projects, and regional energy policy may also serve as a practical foundation aligned with the content of the International Economic Relations course.

Furthermore, the application of time-series models such as ARIMA, TAR, and STAR to Azerbaijan's energy sector may serve as an important tool for imparting both theoretical and practical knowledge to students within the Economic Modelling course.

The findings of the dissertation are of practical significance and can contribute to the improvement of energy policies and strategies, as well as to the organisation of the educational process in a manner that ensures higher quality and compliance with contemporary requirements. The proposed approaches may be utilised in the strategic plans of government institutions, long-term energy policy development concepts, and the preparation of decisions concerning international energy cooperation.

The following articles and conference abstracts by the author have been published on the topic of the dissertation:

1. **A.M.Ağayev, Ə.Kərimli.** "Azərbaycanda Enerji Sektorunun İqtisadi Aspektləri və Əhəmiyyəti". / UNEC Elmi Xəbərləri, Azərbaycan Dövlət İqtisad Universiteti, Bakı: 2020, №8, s.30-40.
2. **A.M.Aghayev, A.Karimli.** "Economic Perspectives of Sustainable Use of Energy Resources in Azerbaijan" Test Engineering and Management Journal, The Mattingley Publishing Co., Inc, 2020, s.24354–24358.
3. **A.M.Ağayev, Ə.Kərimli.** "Azərbaycanda Enerji Sektorunun İnkişafı Üçün Əsas Strateji Addımlar və Daxili Siyasət" Azərbaycan Vergi Jurnalı, Bakı: 2020, №1, s.121-128.
4. **A.M.Aghayev, A.Karimli.** The Economic Opportunities of Renewable Energy Resources in Azerbaijan: Major Challenges and Scenarios // Business & IT Journal, Czech Technical University, Prague, 2020, №2, s.71-81.
5. **K.A.Aghayeva, A.Karimli.** Sustainable Development and Effective Use of Renewable Energy Resources in Azerbaijan // Building Innovations – 2021, Azərbaycan Memarlıq və İnşaat Universiteti və Poltava Milli Texniki Universiteti. 2021, s.351–354.
6. **K.A.Ağayeva, Ə.Kərimli.** "Azərbaycanda Sosial-İqtisadi Rifahın Yüksəldilməsində Dağlıq Qarabağ Regionunun Mövcud Enerji Potensialı" Qarabağ regionunun iqtisadi və sosial inkişaf problemləri, Respublika elmi-praktik konfransı, Bakı: 2021, s.139–142.
7. **K.A.Aghayeva, A.Karimli.** Economic Potential of Traditional and Alternative Energy Resources of Azerbaijan // Qarabağ regionunun iqtisadi və sosial inkişaf problemləri, Respublika elmi-praktik konfransı, Bakı: 2021, s.149-155
8. **A.M.Aghayev, A.Karimli.** The Energy Factor as the Main Mechanism of Azerbaijan's Domestic and Foreign Policy // İqtisadiyyat və idarəetmə sahəsində magistr və doktorantların beynəlxalq elmi konfransı, Gəncə: 2021, s.147-152.
9. **A.M.Aghayev, A.Karimli.** Economic Potential of Traditional and Alternative Energy Resources of Azerbaijan // 37th IBIMA Conference, Kordoba, İspaniya: 2021, s.4-6.

10. **K.A.Aghayeva, A.Karimli.** “Energy Efficiency and Sustainable Energy Development in Azerbaijan”. E-Mobility and Smart City Series, Dunaujvaros Universiteti, Macarıstan: 2022, №8, s.145-152.
11. **A.Karimli.** “Renewable Energy Development in Azerbaijan: Economic Rationale and Export Potential”. “Конку-ренто-способность в глобальном мире: экономика, наука, технологии” elmi jurnal, RF - Moskva: 2026, №2, s.289–292.



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