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Regulatory and Institutional Frameworks for Ensuring Financial Security in Ukraine's Energy Sector: Challenges and Future Outlook

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Abstract

The study aims to analyze the existing regulatory and institutional foundations for establishing financial security in Ukraine's energy sector in the context of prospects for improvement and addressing related challenges. The article examines the basic conceptual principles of achieving energy security, including integration into a unified European energy space, ensuring stable energy independence, enhancing energy efficiency, and maximizing the potential of renewable energy sources. The proposed model of forming financial security in the energy sector and strategies for diversification and collaboration between Ukraine and the developed international community are critically evaluated. The study identifies ways to optimize the institutional and regulatory framework for financial security in the energy sector, including modernizing energy infrastructure, harmonizing legislation with European standards, and diversifying supply. The findings conclude that Ukraine's integration into the European unified energy space and robust investment support from the international community are considered prerequisites for the intensive development of Ukraine's energy sector.

Keywords

Strategic approach; Institutional and regulatory framework; Energy efficiency; Management mechanisms; Energy security

Introduction

Global challenges concerning energy security underscore the need to optimize the institutional and regulatory framework to strengthen financial security in the energy sector. In this context, attention should be given to energy supply diversification, advancing energy independence, and intensifying renewable energy development (Thaler and Hofmann, 2022). It is essential to position energy security as a critically important area of managerial activity and to stimulate the formation of effective strategic decisions. Ukraine is actively developing digital technologies in the energy sector, which significantly increases financial security (Pecheniuk *et al.*, 2022). In particular, the national programme 'Digital Ukraine' is actively being implemented, which introduces modern monitoring systems and digital management of energy networks.

Ensuring the financial stability of the energy sector plays a vital role in maintaining stable socio-economic development and national security. The vulnerability of energy systems poses significant financial and economic consequences, which have been complicated and intensified during wartime in aspects such as price policy instability, adverse external market conditions against the backdrop of geopolitical risks, and the destructive impact of the industry on the environment and climate policy (Rogovyi *et al.*, 2021). These challenges necessitate transforming approaches to ensuring energy security in Ukraine, emphasizing integration into the international market environment (Stepanenko *et al.*, 2023). This concept will enable the identification of the most effective tools for the sustainable development of the energy sector and bring the institutional and regulatory framework for financial security in the energy sector into alignment with European legislative practices (Sutrisno *et al.*, 2022). Ukraine's path to diversifying its energy supply to guarantee energy security requires finding opportunities to minimise dependence on monopolistic suppliers. This strategy promotes the development of renewable energy while also advancing the country's oil and gas fields. However, several challenges exist in the European context and at the national level: geopolitical instability, infrastructural issues, a weak investment climate, and an imperfect regulatory framework (de Rosa *et al.*, 2022). Energy systems' vulnerability has serious consequences, including geopolitical risks and price instability in the energy sector. Understanding the specifics of strategies and approaches to implementing financial security in the energy sector will allow the identification of the most effective methods to ensure sustainable development.

The relevance of this study is driven by the need to develop financial and legal tools for the sustainable management of natural resources and reduce the economy's dependence on traditional energy sources (Taghizadeh-Hesary and Yoshino, 2020). Gaps in the regulatory and institutional frameworks for achieving financial security in Ukraine's energy sector must be identified. Financial and legal tools require particular attention. The research findings will have potential practical significance regarding integration into regional or national energy security and energy efficiency programmes.

Literature Review

The issue of ensuring financial security in the energy sector has been actively researched by scientists in recent years. Stepanenko, Ovsiuchenko and Tokhtamysh (2023) state that

energy security is a prerequisite for sustainable national development. In the works of Medvid (2009) and Vashchenko (2022), the security concept combines the energy sector diversification and the transition towards renewability. The publications of Tkachov (2023) and Furman (2024), Rogovyi *et al.* (2020), and Rogovyi *et al.* (2021) examine the functionality of financial security in guaranteeing resilience in the energy supply sector under conditions of instability and crisis phenomena.

Several studies, such as Galkin *et al.* (2019), Batygin, Golovashchenko, and Gnatov (2013), Shabala and Matiichuk (2023), and Khotian and Rozen (2022), explore the functionality of management bodies and international cooperation in ensuring energy security. Meanwhile, Iatsenko and Mohylna (2023) and de Rosa *et al.* (2022) analyze the interdependence between energy resource availability, financial and economic security, and the level of geopolitical conflict. The issue of assessing the level of financial security in the energy sector amid active European integration processes is studied in the works of Sutrisno, Nomaler and Alkemade (2022), Iakovenko (2023), and Thaler and Hofmann (2022).

Contemporary publications examine the role of alternative energy sources in the modern business environment (Kothari, Ranjan and Singal, 2021), highlighting aspects of sustainable development using innovative renewable energy technologies (Papadis and Tsatsaronis, 2020). They also explore sustainable solutions for green financing and investments in renewable energy projects (Ozili and Iorember, 2024). They also analyze the foundations for forming business models in the alternative electricity market (Lu *et al.*, 2020). Recent developments position the studied phenomenon as a priority for sustainable economic development, converging societal, managerial, and business efforts to achieve high decarburization goals soon (Qadir *et al.*, 2021). Individual researchers generalize the convergence issues between sustainable entrepreneurship, innovation, and business models during the global transformation of socio-economic processes toward minimizing environmental impacts and preventing climate change (Polzin and Sanders, 2020).

The conceptual horizons of the studied issues are further expanded in the work of Wang, Sun and Iqbal (2022), who propose a model for encouraging renewable energy use in businesses through managerial motivation and raising the level of environmental awareness. Most cited researchers interpret the transition to renewable energy sources as a foundation for reducing emissions, increasing resilience to climate change, ensuring sustainable development within circular economic processes, and prospective strategic greening of the energy sector.

Despite these significant achievements, the financial security of the energy sector requires further exploration in the context of improving Ukraine’s regulatory and institutional foundations. The study's relevance is due to the need to develop financial and legal instruments for the sustainable management of natural resources and to reduce the economy's dependence on traditional energy sources. This underscores the need for extensive scientific research on this topic (Pecheniuk *et al.*, 2022).

Challenges and prospects for financial security in Ukraine's energy sector demand innovative institutional and regulatory support approaches. Several modern scholars

(Rusch *et al.*, 2023; Shen, Hu and Hueng, 2021) have studied the dynamics of communication business models against the backdrop of the economy's digital transformation. In the energy sector, positive development trends are expected in resource optimization processes, establishing effective internal communication, modernizing outdated systems, and adopting functional chatbots, mobile applications, and interactive media products.

Researchers such as Yue *et al.* (2022) advocate *optimizing* communication in the business environment through modern informational tools that ensure feedback based on accessibility and openness principles. Shaikh *et al.* (2023) and Mhlanga (2020) findings state that *digitalization* is identified as a fundamental element of market development. Scholars emphasize that information modelling within the management paradigm can be positioned as an effective tool for analyzing large volumes of data. However, the functional characteristics of transitioning from traditional to renewable energy sources, the analysis of the relevant tools, and the possibilities for improving the structural-functional model of the process using innovative motivational strategies remain underexplored, necessitating an expanded study of these topics.

This study aims to analyze the existing regulatory and institutional framework for forming financial security in the Ukrainian energy sector from the perspective of improving and mitigating related challenges.

Materials and Methods

During the study, a comparative analysis was used to assess the regulatory and institutional framework for ensuring financial security in Ukraine's energy sector, with an emphasis on environmental aspects. Based on an understanding of global trends and practices, the study compares the evolution of regulation in Ukraine with European standards, considering the contextual specifics of Ukraine's national regulatory framework.

Data collection. The primary data sources include legislation, political documents, and institutional reports from national and international bodies. Secondary data from the scientific literature on energy policy, investment law, and financial security systems supplement these. While the study focuses on Ukraine, relevant examples from the EU and other jurisdictions are included to contextualise Ukraine's regulatory approaches within broader global trends.

Sampling methodology. The research procedure included two main stages: data collection and analysis. In the first stage, secondary data sources were utilised. These were obtained by analysing industry statistical information, regulatory acts, and publications. This sample size was justified in light of practical realities that needed to be considered.

Research instruments. The unity of analysis and synthesis facilitated an objective and adequate investigation of financial and institutional practices, reflecting the unity of opposites about the interconnectedness of the particular and the general. The analytical dissection of the system within the global concept into separate components enabled the

identification of the structure of the studied object, its specificity, and the separation of the essential from the non-essential, thereby enabling the classification of priority technologies. In contrast to analysis, synthesis enabled the integration of individual components and properties identified through analysis into a unified whole. This process involved the meaningful combination of identical and essential elements towards differentiation and diversity, synergizing the general and the particular into a cohesive whole. The scientific abstraction method was used to form theoretical generalisations, highlight key concepts and categories, and formulate research conclusions. Here, the abstraction of potential feasibility was used as a mental distraction from the standard properties of management technologies, concepts, and tools while simultaneously highlighting the essential properties sought.

Data analysis. The data analysis was conducted using quantitative and qualitative statistical analysis methods. Key factors influencing the financial security of the energy sector were identified. Subsequently, an algorithm was developed to optimize institutional and regulatory support for financial security in Ukraine's energy sector. An analysis of capital investments in energy production, processing, and supply from 2010 to 2022 was conducted. Data on capital investments and renewable energy growth were obtained from official sources, including the National Commission for State Regulation of Energy and Public Utilities (NKREKP) and Energy Map (2023). This analysis synthesized annual growth data for renewable energy capacities in Ukraine. The findings were used to draw conclusions and propose recommendations aimed at enhancing institutional and regulatory support for financial security in Ukraine's energy sector. These recommendations are intended to optimize the industry's resilience and adaptability, particularly in light of environmental challenges and global energy trends.

Results

Financial security in the energy sector is positioned as a factor in ensuring a sustainable and affordable energy supply for national needs. Sustainable financial-economic security in energy focuses on modernising energy infrastructure, intensifying energy efficiency and environmental sustainability, geopolitical interaction, and stabilising pricing policies (Sutrisno, Nomaler and Alkemade, 2022; Thaler and Hofmann, 2022). Significant factors affecting financial security in the energy sector (see Figure 1) enable the development of effective strategies to protect its financial aspects of energy security.

Diversifying energy supply is a priority aspect of enhancing financial security in the energy sector today. The European community views diversification as a strategic priority, actively developing a network of alternative logistics and suppliers to minimise dependency on industry monopolists. Ukraine's progress towards diversifying energy supply and guaranteeing energy security requires promoting renewable energy development, exploring domestic resources, and attracting foreign investments, necessitating appropriate institutional and regulatory support.

The post-war recovery and sustainable development of the energy sector must emphasize green energy as a significant factor in creating a unified, sustainable ecological-economic space. Given the readiness of socio-political thought for change and the global community's openness to financially supporting environmentally-focused projects, there

is growing confidence in the practical accessibility and reality of changes towards developing a sustainable environment. In this context, the directions of strict control and the establishment of dynamic analytical monitoring systems in the energy sector gain particular importance.

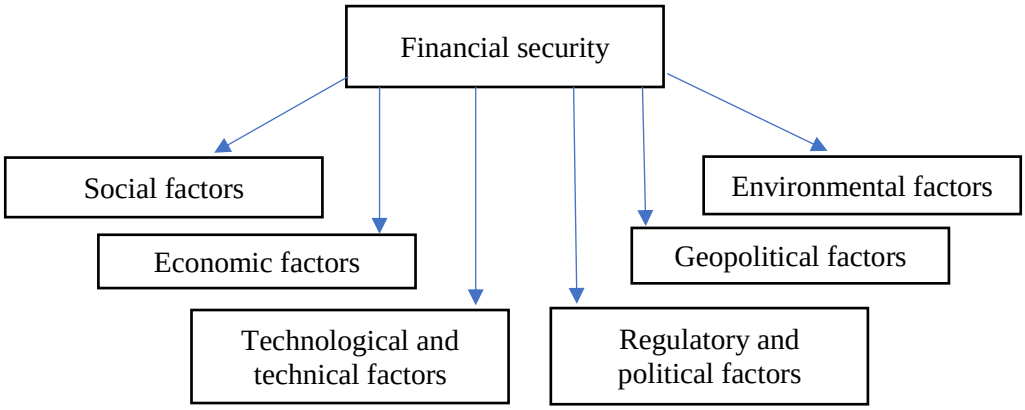

Figure 1: Factors influencing the financial security of the energy sector
Source: author's conception

Significant changes have occurred in Ukraine's energy legislation recently, including adopting European community practices and abandoning administrative-command market regulation mechanisms. Given the new threats associated with full-scale war, previously adopted mechanisms and instruments for institutional and regulatory support have proven ineffective. Implementing successful practices to optimise the institutional and regulatory foundations for financial security in the energy sector will establish a unified, coordinated approach, set priorities, and introduce specific mechanisms for their realisation (see Figure 2).

Priority legislative measures should establish the primary objectives for ensuring relevant financial security at a particular stage of socio-economic development. Identifying specific areas for improvement should be carried out at the level of strategic management activities, which determine the future directions of energy legislation development. The legislative and regulatory framework should enshrine management mechanisms to ensure financial security, including guaranteeing strategic energy reserves, specifying requirements for the protection of energy facilities and supply security, and improving mechanisms for regulating foreign investments (de Rosa *et al.*, 2022; Iatsenko and Mohylna, 2023).

The primary drawback of Ukraine's energy legislation is the lack of a systematic approach to ensuring financial security. Legislative frameworks are inconsistent across sectors. The departmental approach creates contradictions with the legislation of related industries, and the absence of a systematic vision leads to the misalignment of legislative norms with national interests. Currently, there is a deep differentiation between the strategic goals of state policy and their practical implementation in the direct activities of market entities, which inevitably affects the state of financial security in this sector.

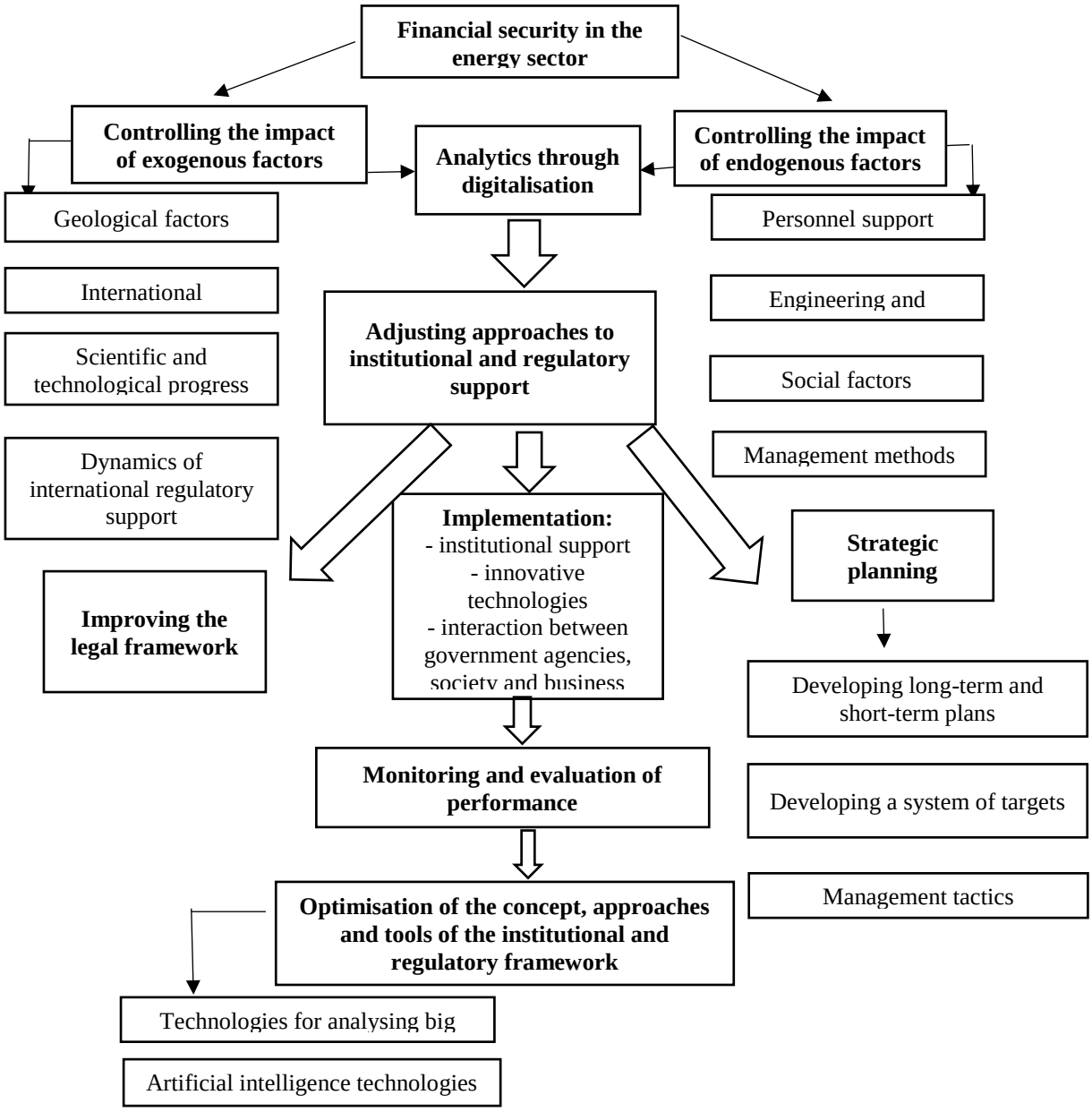

Figure 2: Algorithm for *Optimizing* the Institutional and Regulatory Support of Financial Security in the Energy Sector of Ukraine

An additional catalyst for qualitative changes is the redistribution of the energy market and the implementation of energy-efficient and resource-saving measures, which, in the context of wartime realities in Ukraine, have become necessary. These measures have gained widespread acceptance in socio-economic processes and become a commonplace phenomenon. The country's current approach underscores the prioritisation of sustainable development directions, readiness for fundamental changes, and participation in global socio-economic reorientation to reduce anthropogenic pressure on the environment and prevent a large-scale ecological catastrophe.

The financial security of the energy sector is determined primarily by the volume of capital investments in the industry. According to official data (Energy Map, 2023), capital investments in the extraction, processing, and supply of energy resources in 2022 amounted to 49.7 billion UAH, 49% lower than the 2021 figure of 97.04 billion UAH, indicating the destructive impact of the ongoing war. According to analysts' calculations, the dollar equivalent of investments in energy resource extraction and the production of coke and petroleum products in 2022 was the lowest since 2010, at 798 million USD. Investments in the supply of energy resources were the lowest in the last seven years, at 1.1 billion USD (see Figure 3).

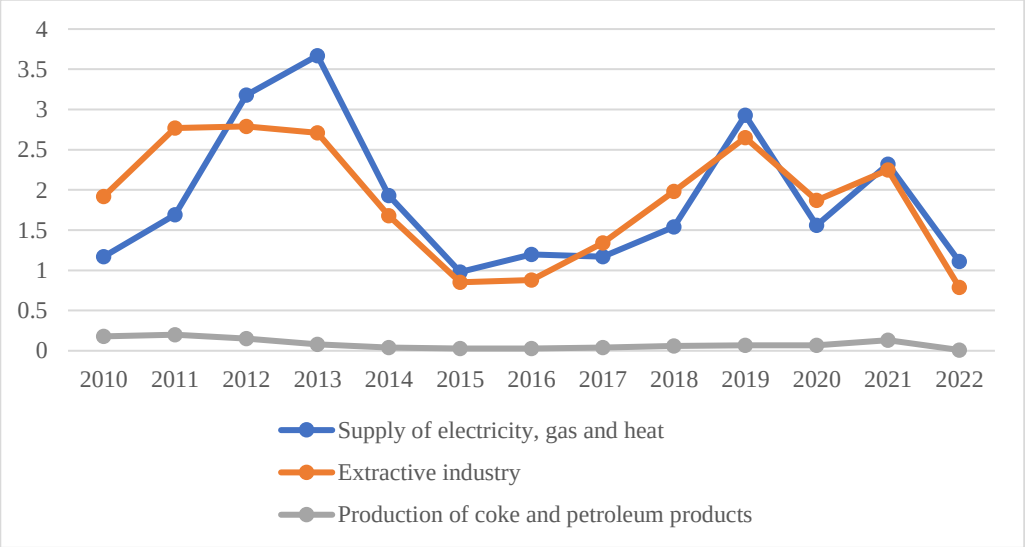

Figure 3: Capital Investment in Energy Production, Processing and Supply in 2010–2022, USD bn (Energy Map, 2023)

Before the full-scale war, the installed renewable energy capacity was about 10 GW. Most of its facilities were built before 2020 when the high "green" tariff was in effect. By 2022, investments in the industry had exceeded $12 billion. After the start of the war, many renewable energy facilities were located in occupied territories, regions with active combat, and front-line areas. Overall, the large-scale war caused significant losses to the industry, as evidenced by the more than twofold decrease in the share of renewable energy in total electricity production (see Figure 4). Before 2022, this indicator was 13.4%, and now it is 5-6% (NKREKP, 2024).

The tools for ensuring the protection of national entities in the domestic energy market, against the backdrop of Ukraine's implemented international commitments regarding the liberalisation of internal energy markets, are currently fragmented (National Commission for State Regulation of Energy and Public Utilities, 2023). It is also worth highlighting the current legislation's inability to effectively counter threats to the financial stability of the energy sector in the context of wartime threats — sabotage, terrorism, and cyberattacks.

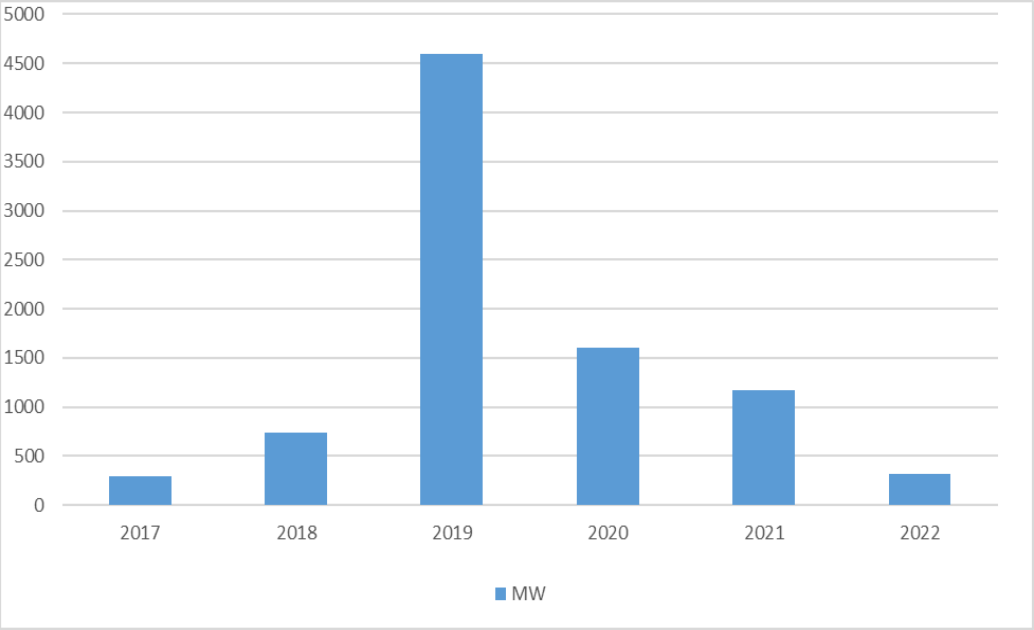

Figure 4: Annual Growth of Renewable Energy Capacities in Ukraine, MW (NKREKP, 2023)

Ensuring energy security is regulated at the departmental level without proper coordination and alignment with other national priorities. Furthermore, no legislative requirements exist for implementing an effective strategic planning system, critical energy infrastructure cyber protection, or international collaboration for market stability and transparency (Pecheniuk *et al.*, 2022).

Reducing greenhouse gas emissions and mitigating the effects of climate change begins with minimizing fossil fuel usage. This can be achieved by adopting alternative transport and renewable energy sources, an efficient waste management system, and using environmentally friendly building materials with low energy consumption. To optimise financial security in Ukraine's energy sector, the following concepts should be highlighted and supported by appropriate institutional and regulatory foundations:

- Development of renewable energy sources to minimise dependence on imports and monopolists and to ensure sustainable energy supply;
- Interaction in terms of sharing experience, practices, and technologies in the field of energy efficiency, stimulating the development of alternative energy sources, and modernising infrastructure;
- Investment activities in the format of financing projects to improve energy efficiency, innovation progress, and modernisation;
- Intensification of integration into the single energy market and the development of practical international cooperation;
- Implementing integrated international institutional and regulatory provisions to ensure stability and transparency of the energy market, attracting the attention of foreign investors.

With the increasing dependence on digital technologies and the intensification of data storage on digital platforms, cybersecurity is positioned as a top-priority issue. Digital technologies now offer reliable solutions in this field, including encryption, artificial intelligence-based intrusion, and threat identification systems. They securely protect confidential information, strengthen protection against cyber threats, and prevent data leaks, which is especially relevant in the energy sector. Accordingly, these innovations must be embedded in the legislative framework.

The use of targeted digital technologies in the security field makes it possible to minimize financial losses from cyberattacks and ensure the integrity of financial systems. By allowing the automation of traditional risk management processes, they reduce human error risks, and by operating in real-time, they ensure the effectiveness and promptness of risk management actions. Blockchain technology guarantees unprecedented openness, accessibility, and transparent accountability in financial operations. With blockchain, it becomes possible to strengthen trust among stakeholders and minimize financial fraud.

Diversifying energy supply sources is a priority aspect of intensifying energy security today. Given Ukraine's European integration course, particular attention should be paid to analyzing the European Union's successful practical experience in energy security. The European community views diversification as a strategic priority, actively developing alternative routes and supplier networks. This approach allows for minimizing dependence on monopolists in the energy sector. The European Community promotes diversification through intensive renewable energy development, reducing the share of coal and nuclear energy, and implementing technologies for decommissioned energy sources.

For successful integration into the single European energy space, it is advisable to adopt standards, norms, and regulations that align with European norms, particularly in energy efficiency, market competitiveness, and transparency. It is necessary to intensify activities to diversify the energy supply through expanding cooperation and developing new transport routes. An essential prerequisite for sustainable energy security in the national space is the increase in energy awareness among society and the business sector, stimulation of the implementation of energy-efficient technologies and reduction of consumption, and enhancing the motivation for innovative activities in the energy sector.

Discussion

The analysis of the existing regulatory and institutional framework for ensuring financial security in Ukraine's energy sector highlights the need to optimise the system for forming financial security within the concept of flexible solutions to achieve the priority security objectives of the energy sector. The limitations in this area include the complexity of practically implementing European energy solutions within Ukraine's national socio-economic context and the constraints on diversification processes. One of the leading modern approaches to ensuring the financial stability of the energy sector is the concept of identifying it as a systemic phenomenon, advocating for the expansion of energy storage technology integration and its application in convergence with renewable energy sources (Babuta, Oswald and Janjeva, 2020; Klijn and Koppenjan, 2020; Lin and Raza,

2020). Some scholars consider *optimizing* the financial situation in the energy sector through large-scale integration into the global market environment with its network of renewable energy sources (Anwary, 2022; Bonavolontà and D'Angelo, 2021; Mandel and Irwin, 2021). At the same time, representatives of another scientific school (Østergaard *et al.*, 2020; Taghizadeh-Hesary and Yoshino, 2020) emphasize renewable energy in terms of energy democracy and sustainable development to accelerate the energy transition in developing countries.

Some contemporary scientists (Anton and Nucu, 2020; Khan *et al.*, 2020; Lüdeke-Freund, 2020) identify the main prerequisites for the formation and effective financial development of the energy sector as those that create the basis for an effective management paradigm of its functioning. Researchers (Kebede *et al.*, 2022; Sabbagh, 2023; Tan *et al.*, 2021) argue that the integration of European norms and requirements into the energy system of countries actively developing towards European integration is a farsighted strategy on the path to a sustainable development process.

Liu *et al.* (2022), while examining the recommendations of the UN General Assembly's SDG-7 on enhancing energy efficiency, propose exploring various innovative financing methods, including green financing, financial inclusion, and financial technologies. The authors verified the empirical role of these financial instruments in the energy efficiency of the E7 economies. The research results demonstrated a significant role for these financing methods in energy efficiency, with green financing showing the highest efficiency. The authors suggest reviewing the potential of financial technology (FinTech) and financial accessibility parameters, mainly green bonds, to achieve energy efficiency in the shortest possible time. The researchers also justify the need to develop favourable energy policies for providing green financing to energy systems.

At the same time, Shahbaz *et al.* (2021) present in their research the existence of a long-term relationship between renewable energy consumption and financial development. The empirical data convincingly show that financial development drives the growth in demand for environmentally clean energy sources. To achieve sustainable development goals, the researchers argue that governments should implement incentives and tax policies that increase enterprise demand for renewable energy sources and expand investment opportunities through public-private partnerships.

Ahmad *et al.* (2021) emphasize that the development of digital technologies and artificial intelligence has the potential to change energy supply radically. Intelligent software should autonomously control integrating energy supply, demand, and renewable energy sources into the energy network, *optimizing* decision-making and operations. The researchers explore the aspects of using artificial intelligence in producing solar and hydrogen energy, as well as managing demand and supply. Ahmad *et al.* (2021) argue that machine learning and artificial intelligence will play a crucial role in the future energy market, allowing for the maximum greening of energy production and consumption processes.

Overall, among the prospects for *optimizing* financial security in the energy sector, the following should be highlighted: the development of national potential in the context of renewable energy sources with active support from the global community, which

minimises dependence on imports and monopolists while ensuring sustainable energy supply; integration into the unified energy market; active investment activity; collaboration in exchanging experiences, practices, and technologies; and the implementation of international developments in energy standardisation, regulatory, and legislative policies.

Our study convincingly demonstrates that *optimizing* the institutional and regulatory framework for financial security in Ukraine's energy sector is a priority for socio-economic development and implementing energy and economic stability strategies.

Conclusion

The study aimed to analyse the existing regulatory and institutional framework for ensuring financial security in Ukraine's energy sector in the context of prospects for its improvement and addressing related challenges. This article explores the dynamics of external and internal conditions that currently define the specifics of energy security and necessitate a corresponding shift in the priorities of the paradigm of international economic relations. It has been established that the instability of the socio-economic and geopolitical situation, as well as the potential threat of risks and crises, requires the optimisation of the regulatory and institutional framework for forming financial security within the concept of flexible solutions to achieve the priority security objectives of the energy sector.

Ensuring the financial security of the energy sector involves integrating into the European energy space, achieving sustainable energy independence, enhancing energy efficiency, and utilising renewable energy sources, as well as strategies for diversification and cooperation between Ukraine and the developed international community, require the optimization of the institutional and regulatory framework for financial security in the energy sector. Financial security in the energy sector is complex and requires activating the unified energy market, fostering international cooperation, and harmonizing national legislation with European standards. Ukraine's integration into the single energy space of the EU and investment support from the international community are considered prerequisites for Ukraine's intensive progress during the post-war recovery period. Prospects for further development of the research topic include extended analytics of digital potential for modelling financial and economic security strategies in the energy sector.

References

Ahmad, T., Zhang, D., Huang, C., Zhang, H., Dai, N., Song, Y. and Chen, H. (2021). Artificial intelligence in sustainable energy industry: Status Quo, challenges and opportunities. *Journal of Cleaner Production*, 289: 125834. DOI: https://doi.org/10.1016/j.jclepro.2021.125834

Anton, S.G. and Nucu, A.E.A. (2020). The effect of financial development on renewable energy consumption. A panel data approach. *Renewable Energy*, (147): 330–338. DOI: https://doi.org/10.1016/j.renene.2019.09.005

Anwary, I. (2022). The Role of Public Administration in Combating Cybercrime: An Analysis of the Legal Framework in Indonesia. *International Journal of Cyber*

Criminology, 16(2): 216–227. Available online at: http://surl.li/aqvkbt [Accessed on 17 August 2024]

Babuta, A., Oswald, M. and Janjeva, A. (2020). Artificial intelligence and UK national security: policy considerations. Technical Report. RUSI, London. Available online at: https://nrl.northumbria.ac.uk/id/eprint/42963/ [Accessed on 17 August 2024]

Batygin, Y.V., Golovashchenko, S.F. and Gnatov, A.V. (2013). Pulsed electromagnetic attraction of sheet metals – Fundamentals and perspective applications. *Journal of Materials Processing Technology*, 213(3): 444–452. DOI: https://doi.org/10.1016/j.jmatprotec.2012.10.003

Bonavolontà, V. and D'Angelo, M. (2021). Digital transition and public administration in Italy: the experience of the Italian National Social Security Institution − INPS. *Ubezpieczenia Społeczne. Teoria i praktyka,* 4: 87–101. DOI: https://doi.org/10.5604/01.3001.0015.5236

de Rosa, M., Gainsford, K., Pallonetto, F. and Finn, D.P. (2022). Diversification, concentration and renewability of the energy supply in the European Union. *Energy*, 253: 124097. DOI: https://doi.org/10.1016/j.energy.2022.124097

Energy Map (2023). Capital investments in the extraction, processing and supply of energy resources. Available online at: http://surl.li/ifqied [Accessed on 17 August 2024]

Furman, I. (2024). Development of bioenergy in the context of ensuring Ukraine's energy security. *Economy and society*, 61. DOI: https://doi.org/10.32782/2524-0072/2024-61-41

Galkin, A., Obolentseva, L., Balandina, I., Kush, E., Karpenko, V. and Bajdor, P. (2019). Last-mile delivery for consumer-driven logistics. In *3rd International Conference on Green Cities – Green Logistics for Greener Cities. Transportation Research Procedia*, 39: 74–83. DOI: https://doi.org/10.1016/j.trpro.2019.06.009

Iakovenko, V.S. (2023). The latest opportunities and forms of business organisation in the circular economy. In *Entrepreneurship: Modern challenges, trends and transformations: a monograph*, pp. 88–120. Bila Tserkva. Available online at: http://surl.li/wupjdk [Accessed on 17 August 2024]

Iatsenko, V.V. and Mohylna, K.O. (2023). Economic and social aspects of creating autonomous energy regions in Ukraine. *Energy: Economy, technology, ecology*, 4(74): 150–157. DOI: https://doi.org/10.20535/1813-5420.4.2023.290946

Kebede, A.A., Kalogiannis, T., van Mierlo, J. and Berecibar, M. (2022). A comprehensive review of stationary energy storage devices for large-scale renewable energy sources grid integration. *Renewable and Sustainable Energy Reviews*, 159: 112213. DOI: https://doi.org/10.1016/j.rser.2022.112213

Khan, S.A.R., Zhang, Y., Kumar, A., Zavadskas, E. and Streimikiene, D. (2020). Measuring the impact of renewable energy, public health expenditure, logistics, and environmental performance on sustainable economic growth. *Sustainable Development*, 28(4): 833–843. DOI: https://doi.org/10.1002/sd.2034

Khotian, A.A. and Rozen, V.P. (2022). State and prospects of developing local energy objects within microgrids. *Energy: economy, technology, ecology*, 2: 75–81. DOI: https://doi.org/10.20535/1813-5420.2.2022.261373

Klijn, E.H. and Koppenjan, J.F. (2020). Public management and policy networks: foundations of a network approach to governance. In: *Making Policy Happen*, pp. 28–40. Routledge. DOI: https://doi.org/10.4324/9781003060697-5

Kothari, D.P., Ranjan, R. and Singal, K.C. (2021). *Renewable energy sources and emerging technologies.* Eastern Economy Edition

Lin, B. and Raza, M.Y. (2020). Analysis of energy security indicators and CO2 emissions. A case from a developing economy. *Energy*, 200: 117575. DOI: https://doi.org/10.1016/j.energy.2020.117575

Liu, H., Yao, P., Latif, S., Aslam, S. and Iqbal, N. (2022). Impact of Green financing, FinTech, and financial inclusion on energy efficiency. *Environmental Science and Pollution Research*, 1-12. DOI: https://doi.org/10.1007/s11356-021-16949-x

Lu, X., Li, K., Xu, H., Wang, F., Zhou, Z. and Zhang, Y. (2020). Fundamentals and business model for resource aggregator of demand response in electricity markets. *Energy*, 204. DOI: https://doi.org/10.1016/j.energy.2020.117885

Lüdeke-Freund, F. (2020). Sustainable entrepreneurship, innovation, and business models: Integrative framework and propositions for future research. *Business Strategy and the Environment*, 29(2): 665–681. DOI: https://doi.org/10.1002/bse.2396

Mandel, D. and Irwin, D. (2021). Uncertainty, Intelligence, and National Security Decisionmaking. *International Journal of Intelligence and Counterintelligence*, 34(3): 558–582. DOI: https://doi.org/10.1080/08850607.2020.1809056

Medvid, F.M. (2009). Energy security of the state in the context of the development of the national security strategy of Ukraine. *Bulletin of the Scientific Information and Analytical Centre of NATO of the Carpathian National University named after V. Stefanyk*, 23: 99–104. Available online at: https://nato.pu.if.ua/old/journal/2009/2009-23.pdf [Accessed on 17 August 2024]

Mhlanga, D. (2020). Industry 4.0 in finance: the impact of artificial intelligence (AI) on digital financial inclusion. *International Journal of Financial Studies*, 8(3): 45. DOI: https://doi.org/10.3390/ijfs8030045

National Commission for State Regulation of Energy and Public Utilities (2023).Monitoring of the electricity market. Available online at: https://www.nerc.gov.ua/ [Accessed on 17 August 2024]

Østergaard, P.A., Duic, N., Noorollahi, Y., Mikulcic, H. and Kalogirou, S. (2020). Sustainable development using renewable energy technology. *Renewable Energy*, 146: 2430–2437. DOI: https://doi.org/10.1016/j.renene.2019.08.094

Ozili, P.K. and Iorember, P.T. (2024). Financial stability and sustainable development. *International Journal of Finance and Economics*, 29(3): 2620-2646. DOI: https://doi.org/10.1002/ijfe.2803

Papadis, E. and Tsatsaronis, G. (2020). Challenges in the decarbonisation of the energy sector. *Energy*, 205:118025. DOI: https://doi.org/10.1016/j.energy.2020.118025

Pecheniuk, A., Garasymchuk, I., Potapskyi, P., Vusatyi, M., Dubik, V. and Pukas, V. (2022). Renewable Energy of Ukraine in Global Energy Transformations. *Grassroots Journal of Natural Resources*, 5(4), 19-33. DOI: https://doi.org/10.33002/nr2581.6853.050402

Polzin, F. and Sanders, M. (2020). How to finance the transition to low-carbon energy in Europe? *Energy Policy*, 147: 111863. DOI: https://doi.org/10.1016/j.enpol.2020.111863

Qadir, S.A., Al-Motairi, H., Tahir, F. and Al-Fagih, L. (2021). Incentives and strategies for financing the renewable energy transition: A review. *Energy Reports*, 7: 3590-3606. DOI: https://doi.org/10.1016/j.egyr.2021.06.041

Rogovyi, A., Khovanskyy, S., Grechka, I. and Pitel, J. (2020). The wall erosion in a vortex chamber supercharger due to pumping abrasive mediums. In Ivanov, V., *et al. Advances in Design, Simulation and Manufacturing II. DSMIE 2019.*

Lecture Notes in Mechanical Engineering, pp. 682–691. Springer, Cham. DOI: https://doi.org/10.1007/978-3-030-22365-6_68

Rogovyi, A., Korohodskyi, V., Khovanskyi, S., Hrechka, I. and Medvediev, Y. (2021). Optimal design of vortex chamber pump. *Journal of Physics: Conference Series*, 1741(1): 012018. DOI: https://doi.org/10.1088/1742-6596/1741/1/012018

Rusch, M. (2023). Application of digital technologies for sustainable product management in a circular economy: A review. *Business strategy and the environment*, 32(3): 1159–1174. DOI: https://doi.org/10.1002/bse.3099

Sabbagh, F. (2023). The impact of renewable energies on sustainable development. *Journal of Engineering, Management and Information Technology*, 1, 3(04): 137–140. DOI: https://doi.org/10.61552/JEMIT.2023.03.004

Shabala, O.P. and Matiichuk L.P. (2023). Bioenergy potential of Ukraine: development trends under martial law. *Economic Space*, 183: 31–36. DOI: https://doi.org/10.32782/2224-6282/183-5

Shahbaz, M., Topcu, B.A., Sarıgül, S.S. and Vo, X.V. (2021). The effect of financial development on renewable energy demand: The case of developing countries. *Renewable Energy*, 178: 1370-1380. DOI: https://doi.org/10.1016/j.renene.2021.06.121

Shaikh, A.A., Glavee-Geo, R., Karjaluoto, H., and Hinson, R.E. (2023). Mobile money as a driver of digital financial inclusion. *Technological Forecasting and Social Change*, 186: 122-158. DOI: https://doi.org/10.1016/j.techfore.2022.122158

Shen, Y., Hu, W., and Hueng, C.J. (2021). Digital financial inclusion and economic growth: a cross-country study. *Procedia Computer Science*, 187: 218-223. DOI: https://doi.org/10.1016/j.procs.2021.04.054

Stepanenko, S., Ovsiuchenko, Y. and Tokhtamysh, N. (2023). Prospects for developing the Ukrainian electricity market in the context of European integration. *The national scientific, production and information magazine "Energy Saving. Energy. Energy Audit",* 12(190): 98–110.

Sutrisno, A., Nomaler, O. and Alkemade, F. (2021). Has the global expansion of energy markets truly improved energy security? *Energy Policy*, 148: 111931. DOI: https://doi.org/10.1016/j.enpol.2020.111931

Taghizadeh-Hesary, F. and Yoshino, N. (2020). Sustainable solutions for green financing and investment in renewable energy projects. *Energies*, 13(4): 788. DOI: https://doi.org/10.3390/en13040788

Tan, K.M., Babu, T.S., Ramachandaramurthy, V.K., Kasinathan, P., Solanki, S.G. and Raveendran, S.K. (2021). Empowering smart grid: A comprehensive review of energy storage technology and application with renewable energy integration. *Journal of Energy Storage*, 39: 102591. DOI: https://doi.org/10.1016/j.est.2021.102591

Thaler, P. and Hofmann, B. (2022). The impossible energy trinity: Energy security, sustainability, and sovereignty in cross-border electricity systems. *Political Geography*, 94: 102579. DOI: https://doi.org/10.1016/j.polgeo.2021.102579

Tkachov, Z.V. (2023). International economic relations of Ukraine: identification of strengths and challenges. In *The 12th International scientific and practical conference "Scientific progress: innovations, achievements and prospects"* (August 21–23, 2023). MDPC Publishing, Munich, Germany

Vashchenko, A.V. (2022). Problems of transition to renewable energy sources in overcoming the EU energy crisis. *Doctoral dissertation, National Aviation*

University. Available online at: https://er.nau.edu.ua/handle/NAU/57039 [Accessed on 17 August 2024]

Wang, S., Sun, L. and Iqbal, S. (2022). Green financing role on renewable energy dependence and energy transition in E7 economies. *Renewable Energy*, 200: 1561-1572. DOI: https://doi.org/10.1016/j.renene.2022.10.067

Yue, P., Korkmaz, A.G., Yin, Z., and Zhou, H. (2022). The rise of digital finance: Financial inclusion or debt trap? *Finance Research Letters*, 47. DOI: https://doi.org/10.1016/j.frl.2021.102604.

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Authors' Declarations and Essential Ethical Compliances

Authors' Contributions (in accordance with ICMJE criteria for authorship)

Contribution	Author 1	Author 2	Author 3	Author 4	Author 5
Conceived and designed the research or analysis	Yes	No	Yes	Yes	No
Collected the data	Yes	No	Yes	No	No
Contributed to data analysis & interpretation	Yes	Yes	No	Yes	No
Wrote the article/paper	Yes	Yes	Yes	Yes	Yes
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