Financial Internet Quarterly 2024, vol. 20 / no. 4, p. 96-108
10.2478/fiqf-2024-0030

Financial Internet Quarterly

EFFECTIVE STRATEGY FOR IMPLEMENTING STATE FINANCIAL ASSISTANCE IN THE USE OF ALTERNATIVE ENERGY TECHNOLOGIES FOR CRITICAL INFRASTRUCTURE ENTERPRISES UNDER ELEVATED NATIONAL SECURITY THREATS

Marta Kopytko[1], Iryna Ruda[2], Mariana Yatsyk[3], Olha Viunyk[4]

Abstract

The purpose of this article is to present a contemporary methodological approach to developing an effective strategy for implementing state financial assistance in the use of alternative energy technologies for critical infrastructure enterprises. The object of the study is critical infrastructure enterprises. The scientific task involves modeling that would allow the formation of an effective strategy for implementing state financial assistance in the use of alternative energy technologies for critical infrastructure enterprises. The research methodology includes the application of the IDEF0 method to construct a model for implementing state financial assistance in the use of alternative energy technologies for critical infrastructure enterprises. As a result of the conducted research, a decomposition of the context diagram was proposed to improve the efficiency of implementing state financial assistance in the use of alternative energy technologies for critical infrastructure enterprises. The study is limited by considering only critical infrastructure enterprises in Ukraine. Prospects for further research will include considering enterprises from other countries, particularly Poland.

JEL classification: O13, C02, M21, O10

Keywords: Financial Security, Financial Assistance, Financial Aid, National Security, Threats, IDEF0 Modeling, Critical Infrastructure Enterprises, Alternative Energy

Received: 10.08.2024 Accepted: 04.11.2024

Cite this:

Kopytko, M., Ruda, I., Yatsyk, M. & Viunyk, O. (2024). Effective strategy for implementing state financial assistance in the use of alternative energy technologies for critical infrastructure enterprises under elevated national security threats. Financial Internet Quarterly 20(4), pp. 96-108.

[1] Lviv State University of Internal Affairs, Lviv, Ukraine, e-mail: kopytko@lvduvs.edu.ua, ORCID: https://orcid.org/0000-0001-6598-3798.
[2] Ivan Franko National University of Lviv, Lviv, Ukraine, e-mail: dr.irynaruda@gmail.com, ORCID: https:// orcid.org/0000-0002-7873-6742.
[3] Lviv State University of Internal Affairs, Lviv, Ukraine, marekjacyk@gmail.com, ORCID: https://orcid.org/0000-0002-7061-9066.
[4] Central Ukrainian National Technical University, Kropyvnytskyi, Ukraine, alionatkachuk2017@ukr.net, ORCID: https://orcid.org/0000-0001-5024-7325.

Introduction

It should be noted that energy is the most crucial area of life support, developing at an extraordinarily rapid pace. As the technological foundation of the national economy's functioning, energy largely determines its development prospects and Ukraine's national security. Market transformations in global energy have changed the geography of most critical infrastructure enterprises, their organizational structures, as well as the methods and mechanisms of managing their business activities. For all developed countries, the electricity sector is one of the most important branches of the national economy, which automatically places it among the basic, strategically important sectors necessary for the normal functioning of all industries and critical infrastructure enterprises.

Energy is a leading sector in Ukraine, and the choice of a long-term development strategy for this sector determines the level of national security. In the energy sector, there are growing multifactorial crisis phenomena of both global and intra-sectoral nature. Global-scale processes are caused, on one hand, by the depletion of geological reserves of major fuel resources such as coal, oil, and gas, and on the other hand, by increasing negative environmental factors caused by energy activities, which pose catastrophic threats. This is the main contradiction that may soon affect the sustainable development of both the sector and society as a whole. This contradiction can no longer be resolved by traditional methods and approaches in energy, as numerous intra-sectoral problems have accumulated, mainly due to the wear and tear of major assets. Solving these problems requires very large investments, which is associated with increased electricity tariffs and fuel prices, leading to many negative consequences. In turn, the potential of alternative energy in Ukraine exceeds fuel reserves manifold and can guarantee a long-term prospect for sustainable sector development. However, the existing methodology in alternative energy requires substantial adjustments using methods that allow for concrete steps to increase the efficiency of implementing state financial assistance in the use of alternative energy technologies for critical infrastructure enterprises under elevated national security threats.

Alternative energy is gradually developing and becoming one of the main sectors in the global economy. Renewable energy sources not only reduce dependence on traditional energy sources but also provide significant competitive advantages for countries that use them effectively. The development of modern technologies and their further implementation in production makes energy generated from "green" sources cheaper than that produced by thermal power plants. The need to supplement the existing list of developed theories with a new one is due to, firstly, the fact that in the latest theories, the main provisions are presented fragmentarily and sometimes even inconsistently with the principles of development for critical infrastructure enterprises. Secondly, several issues related to the implementation of state financial assistance in the use of alternative energy technologies remain at a low level. Given the latter, the basis of the proposed study is to present a new methodological approach to modeling the formation of an appropriate strategy under elevated national security threats.

The purpose of this article is to present a contemporary methodological approach to developing an effective strategy for implementing state financial assistance in the use of alternative energy technologies for critical infrastructure enterprises. The object of the study is critical infrastructure enterprises. The specification of a critical infrastructure enterprise in our article refers to the detailed identification and categorization of organizations that are essential to national security, economic stability, public health, and safety. These enterprises operate within sectors that are crucial for the continuous functioning of society. In the article, we consider all types of critical infrastructure enterprises and provide a comprehensive list, which includes sectors such as energy production and distribution, water supply and sanitation, transportation networks, communication systems, healthcare services, financial institutions, and emergency services. By encompassing all these sectors, we aim to ensure that our proposed strategy for implementing state financial assistance in the use of alternative energy technologies is applicable and beneficial across all critical areas.

The structure of the article involves a review of the literature, presentation of key research methods, main results and their discussion, and coverage of the conclusions from the research results.

Literature review

The implementation of state financial assistance programs for alternative energy technologies in critical infrastructure, especially under conditions of heightened national security threats, necessitates an understanding of both the financial and environmental dynamics involved. This literature review draws on several studies that highlight the interplay between financial development, energy consumption, and sustainable business practices, providing a foundational backdrop for evaluating the current research landscape.

Shi and Deng (2020) investigate the relationship between financial development and energy consumption structures through a panel threshold regression model. Their findings suggest that improvements in financial systems significantly influence the energy consumption mix, shifting it towards more sustainable forms as financial markets mature. This relationship underscores the importance of robust financial systems in facilitating the transition to alternative energy technologies. As noted by Blikhar et al. (2022) the use of renewable energy resources has many advantages, among which practical inexhaustibility and environmental cleanliness are considered the main ones, which positively affects the ecological state of the planet and does not cause a change in the energy balance in the biosphere. According to Bazilyuk (2020) and Lezgovko (2007), the growth of the role of alternative and renewable energy in the world, and the focus on promoting and supporting its development in the world community is most visible when there is real financial support.

In a study by Sylkin et al. (2018) analyzes the issue of ensuring the financial security of machine-building enterprises. At the same time, the authors argue that ensuring financial well-being is a key condition for the effective implementation of crisis management strategies, which also include aspects of the introduction of alternative energy sources. The research of these authors demonstrates that enterprises with sufficient financial protection have more opportunities to implement alternative energy technologies even in the face of threats and challenges to national security.

State financial assistance encompasses a range of instruments, including grants, subsidies, tax incentives, and low-interest loans, designed to lower the financial barriers for enterprises adopting alternative energy technologies. According to Borysiak and Brych (2021), a methodological approach to assessing management models is essential for promoting green energy services, particularly within the framework of developing smart energy grids. Their study highlights the importance of strategic financial planning and management models that align with the broader goals of sustainability and energy efficiency. This approach is crucial for critical infrastructure enterprises that require reliable and resilient energy sources to maintain operational integrity under national security threats.

At the same time, a study by Brunnschweiler (2010) explores the financing of renewable energy projects in more detail through an empirical analysis of developing and transition countries. Thus, this study focuses on the critical role of adaptation of financial products and services in the issue of leveling or minimizing economic barriers in the context of the introduction of environmentally-friendly energy sources. This study is especially relevant in the context of forming a theoretical basis for the formation of practical measures to optimize financial support in this area.

Bojnec and Papler (2011) examine the linkage between economic efficiency, energy consumption, and sustainable development. They argue that energy efficiency and sustainable practices are crucial for achieving long-term economic stability and environmental sustainability. This perspective is vital when considering financial assistance for energy technologies, as it connects economic incentives with sustainability outcomes. Lapinskaitė and Skvarciany (2023) provide a contemporary view on how sustainability transformations within financial institutions can create value. Their analysis emphasizes that financial strategies oriented towards sustainability can not only enhance the financial viability of institutions but also drive broader societal benefits, including in the realm of alternative energy (Figure 1 on the next page).

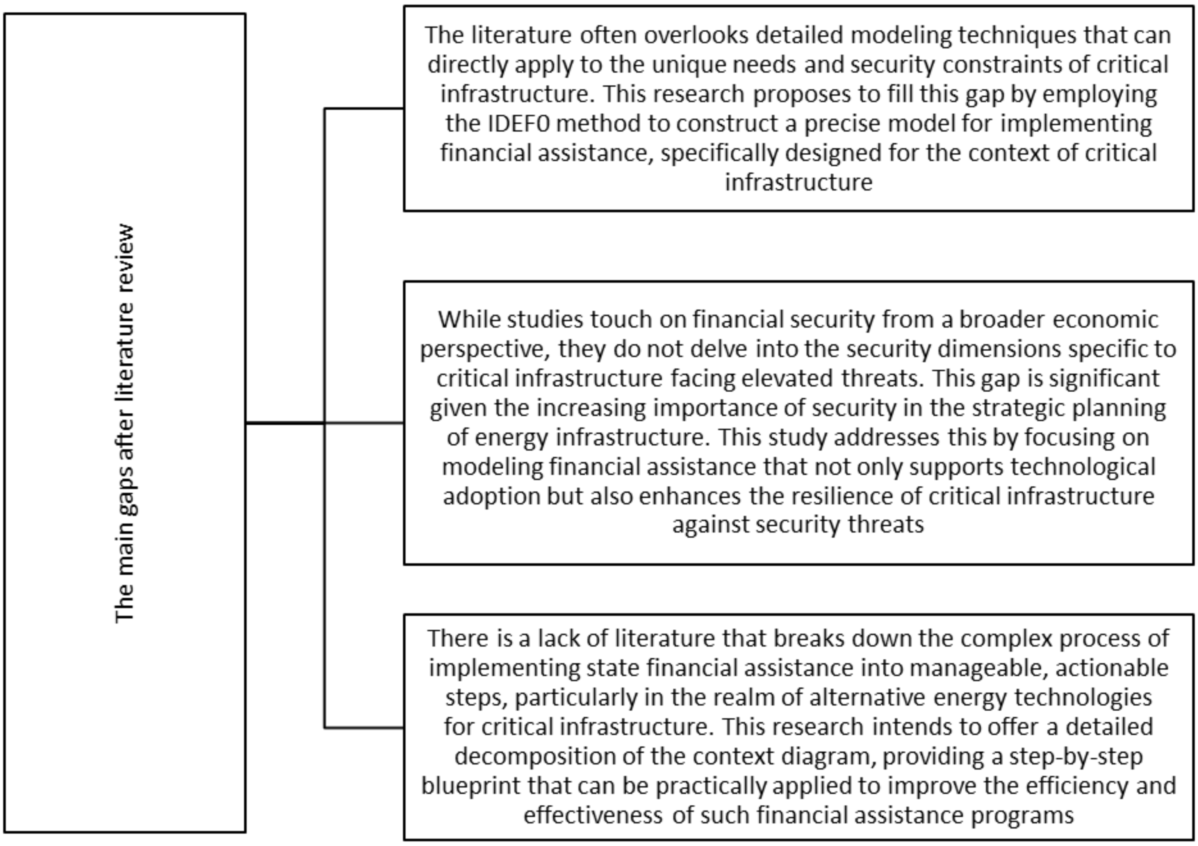
The scientific task involves modeling that would allow the formation of an effective strategy for implementing state financial assistance in the use of alternative energy technologies for critical infrastructure enterprises.

Methodology

The need to supplement the existing list of developed theories with a new theory is driven by the fact that, firstly, the core principles in the latest theories are presented fragmentarily, and sometimes even inconsistently, with the principles of security development in the energy sector in connection with critical infrastructure enterprises. A separate issue is the improvement of the efficiency of implementing state financial assistance in the use of alternative energy technologies for critical infrastructure enterprises under elevated national security threats. To address this, we apply the IDEF0 methodology.

The IDEF0 methodology (Integration Definition for Function Modeling) was created in the 1970s at the US Air Force Laboratory as part of the IDEF standards family. This methodology succeeded the outdated SADT (Structured Analysis and Design Technique) graphical language for describing functional systems. The search for new graphical language standards was driven by SADT's inability to meet all the needs and aspects of industrial processes and to adequately analyze the interaction processes within industrial chains. Another significant difference of the IDEF standard from the SADT graphical language was the formation of new methods of interaction within the "analyst-specialist" system. This method enabled group participation in forming the most effective model through optimal involvement of both analysts and practicing specialists.

Figure 1: The main gaps in literature accoring our topic of reaserch



Source: Author's own work.

Thus, the first application of the IDEF0 methodology occurred precisely for critical infrastructure enterprises as a method of better standardizing and optimizing production and management processes within the US military-industrial complex in the context of organizing and managing strategic weapons and control systems projects. As a result, over the years of its functioning, the IDEF0 standard has improved coordination between departments, enhanced management efficiency, and reduced costs. This modeling system became a key element in the modernization of the US military-defense complex.

Following the confirmation of the IDEF0 effectiveness, in 1983, the US Air Force expanded the IDEF functional modeling system and created subsequent standards: IDEF1 (for creating information models), IDEF2 (for creating dynamic models), and IDEF1X (for creating semantic data models). The significant success of the IDEF modeling standard, particularly the IDEF0 family, led to its rapid dissemination in the civilian sector after its final approval in 1993 by the National Institute of Standards and Technology (NIST). Boeing and General Motors were among the first to integrate it into their management and functional activities. The use of this standard became the foundation for improving strategies, especially in the context of critical infrastructure enterprises. In the following years, private and state enterprises from various sectors and industries integrated the IDEF family into their activities.

Today, the IDEF family includes a large number of standards, each with its specific goals and areas of application. The key standards among them are (Spanidis et al., 2021):

IDEF0: The primary standard, on which subsequent standards were based. Modeling with this standard allows for demonstrating the functional aspects of a system and is used for systematizing and designing various processes.

IDEF1: The information modeling standard, used for structuring and analyzing information flows.

IDEF1X: An extension of the IDEF1 standard, which additionally allows for the modeling of relational data.

IDEF2: The system dynamics modeling standard, used today for modeling and predicting behavioral patterns over time.

IDEF3: Business process dynamics modeling, used for analyzing the sequence of events in studied processes.

IDEF4: The software modeling standard, used for modeling the complex architecture of software systems.

To understand the essence of constructing and using the IDEF0 methodology, it is important to explore its key structural elements.

Activity Boxes: These blocks represent the key functions or processes implemented in the studied system. They are graphically depicted as rectangles with special alphanumeric designations (Function Identification Numbers) indicating the diagram level and belonging to a specific process or function. The essence of the function or process is briefly described inside the rectangles.

Arrows: Within IDEF0 modeling, the following types of arrows are used: Inputs, Outputs, Controls, and Mechanisms. These arrows indicate the vectors and characteristics of information flows or denote control between functions.

Context Diagrams: Represent the highest level of the IDEF0 model, showing the basic relationships between functional blocks. All arrows indicating the vectors and characteristics of information flows can be included in the basic context diagram or depicted in a separate diagram.

Decomposition Diagrams: Represent the final stage of IDEF0 modeling, depicting the entire process to achieve the final goal. These diagrams include all structural elements, demonstrating the vectors and features of information flows and control mechanisms.

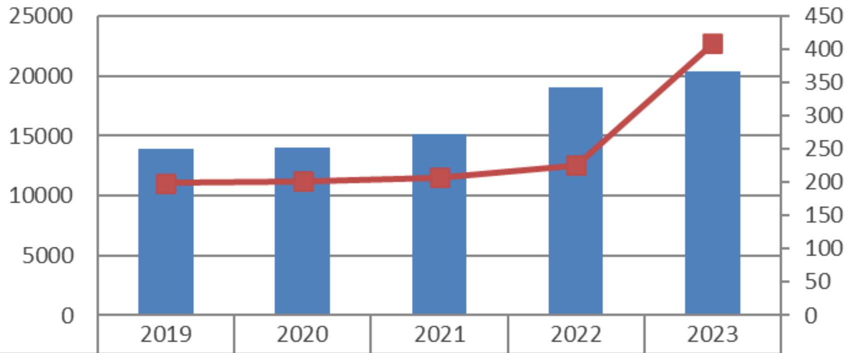
Thus, today, the IDEF0 functional modeling standard is a powerful tool for optimizing and enhancing the efficiency of processes in various sectors of public life. Due to its flexibility and simplicity of construction, this methodology is a relevant tool both in theoretical research and in practical implementation.

We chose the IDEF0 functional modeling standard for our study because it offers a robust and structured approach to representing complex processes, which is essential for our objective of optimizing state financial assistance implementation. IDEF0 allows for a detailed visualization of functions, data flows, and their interrelationships within the system. While other tools like business process benchmarking are valuable for performance comparison and improvement, IDEF0 is particularly suited for modeling and analyzing the functional aspects of processes in depth, making it the most appropriate choice for our research focus.

Results

Overall, in Ukraine, a significant number of critical infrastructure enterprises do not actively use alternative energy. One of the reasons is certainly the capacity of such energy sources. However, since the onset of full-scale war in 2022, the number of critical infrastructure enterprises using alternative energy has been increasing. Thus, due to national security threats, there is an intensified focus on the use of alternative energy sources, as constant missile strikes today reduce the country's traditional energy capacity. This support comes in various forms, including capital subsidies, grants, and preferential loans extended by foreign governments and international organizations. These financial instruments are designed to bolster Ukraine's energy independence and enhance the resilience of its critical infrastructure enterprises by facilitating the adoption of alternative energy technologies. By leveraging this international support, Ukraine aims to mitigate the impact of security threats on its energy sector and ensure the continuous functioning of essential services. Along with this, it is evident that state financial support for alternative energy in Ukraine has increased since 2022 (Figure 2).

Figure 2: Dynamics of changes in the financing of alternative energy in Ukraine for 2019-2023



	2019	2020	2021	2022	2023
The number of critical infrastructure enterprises using alternative energy, numbers	13921	14023	15109	19043	20429
Volumes of state funding for alternative energy, mln. USA	199.3	201.5	207.6	225.5	409.5

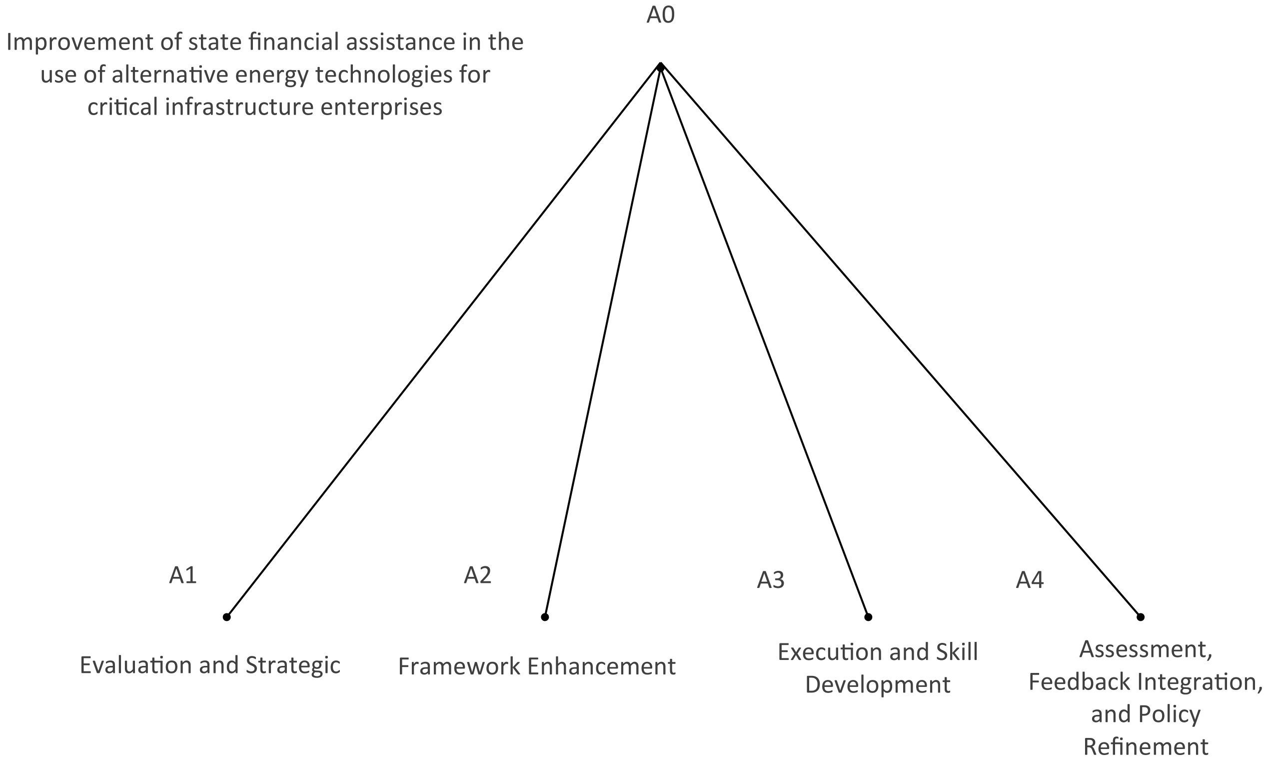
Source: State Statistics Service of Ukraine (2023).

Thus, it is important to identify the most optimal processes for improving the strategy of implementing state financial assistance in the use of alternative energy technologies for critical infrastructure enterprises under conditions of elevated national security threats. For this purpose, we will formulate the key goal of modeling: A0. Improvement of state financial assistance in the use of alternative energy technologies for critical infrastructure enterprises. This goal is designated with the mathematical notation A0, which in turn is achieved through a series of subsets (in our case, processes) according to the substitute model (1):

$$A0 = \left\langle A1 \middle| A2 \middle| An \right\rangle \quad (1)$$

Thus, thanks to IDEF0, we can present all this hierarchically. In our case, there will be four functional blocks An to achieve A0; therefore, within the modeling process, we will present the hierarchical structure of the IDEF0 functional model (Figure 3).

Figure 3: The hierarchical structure of the IDEF0 functional model



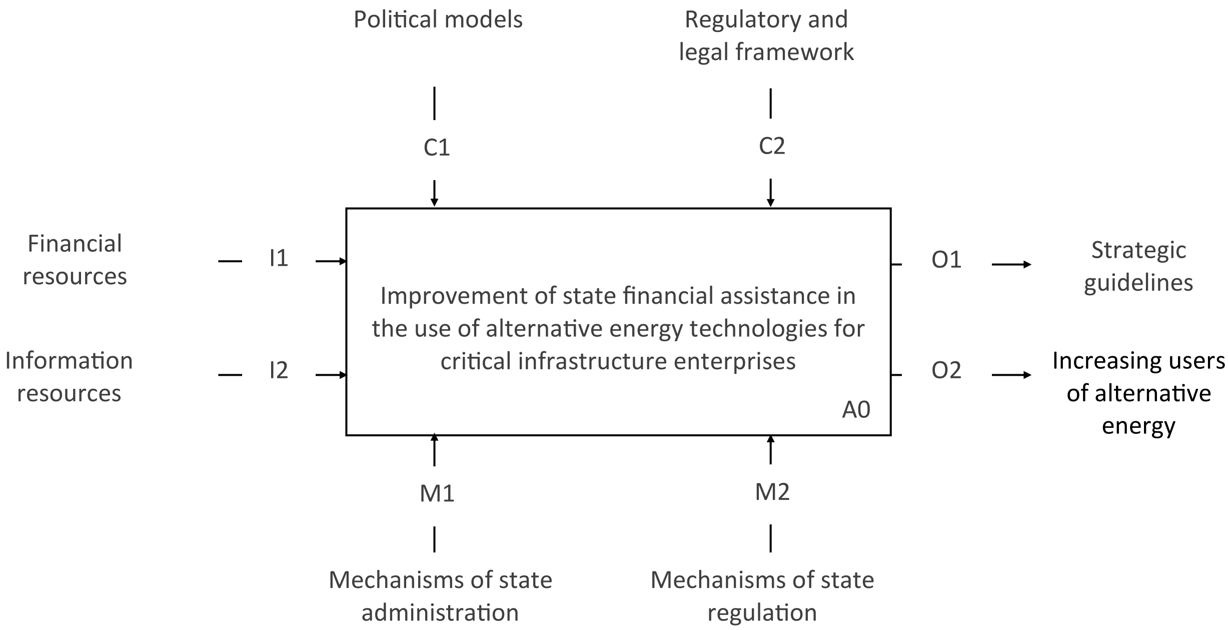
Source: Author's own work.

At the same time, it is important to remember that according to the methodology, each An depends on the results and data of the previous one, thus, there is a certain sequence (2):

$$A1 \Rightarrow A2 \Rightarrow An \quad (2)$$

The developed hierarchical structure became the basis for constructing a context diagram (Figure 4), which corresponds to the strategic approach of implementing state financial assistance in the use of alternative energy technologies for critical infrastructure enterprises under conditions of elevated national security threats.

Figure 4: Context diagram of the IDEF0 model for implementing state financial assistance in the use of alternative energy technologies for critical infrastructure enterprises



Source: Author's own work.

In Figure 5, by using a program for creating vector diagrams, we constructed a first-order decomposition.

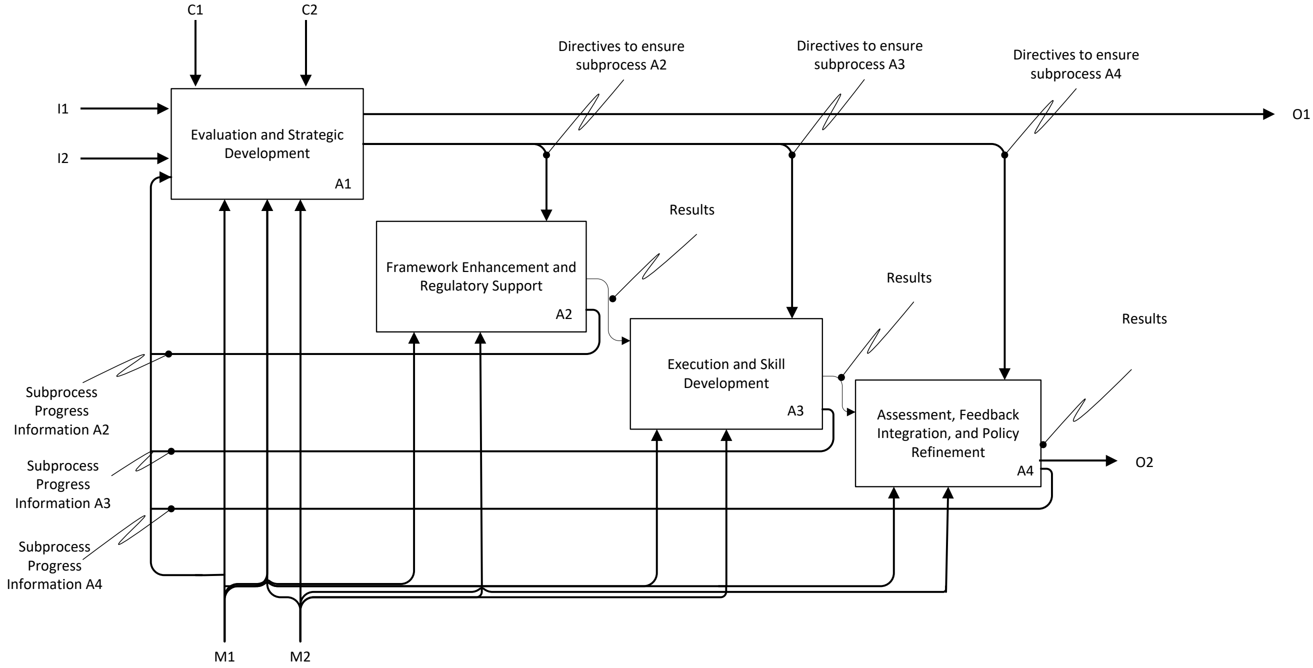
A1. Evaluation and Strategic Development. At this stage, a detailed analysis of the most vulnerable elements of critical infrastructure is carried out, which can be eliminated after the integration and use of alternative energy sources. This stage also includes conducting a comprehensive assessment of identified energy security risks and further identifying the most effective technologies for leveling or minimizing them. At the same time, a detailed financial analysis is carried out to understand the possible economic consequences (positive and negative) from the use of these technologies. Together, this will create a strategic plan that will identify the necessary financial investments and subsequent expected results.

A2. Framework Enhancement and Regulatory Support. Here, the emphasis is on adapting the legislative and regulatory environment to support the transition to alternative energy technologies. This means advocating for and drafting new legislation that provides incentives for adopting these technologies, while also adjusting existing regulations that might impede quick deployment, especially in emergency scenarios. Additionally, the stage involves fostering partnerships between government bodies and private companies to encourage investment and collaboration in the development and implementation of these technologies.

A3. Execution and Skill Development. This stage includes the practical implementation of financial support programs aimed at introducing alternative energy technologies in the areas of critical infrastructure. Such financial support can come in various forms. For example, this could be in the form of subsidies, grants and preferential lending terms. At the same time, special attention should be paid to technical support and support. This is important to ensure that businesses can effectively integrate and maintain new systems. An important direction at this stage is also investment and motivation to form and actively participate in training programs aimed at improving the skills of personnel to work with new technological equipment.

A4. Assessment, Feedback Integration, and Policy Refinement. The final stage is centered around monitoring and evaluating the implemented projects to assess their impact on improving energy security through alternative technologies. It involves setting up systems to continuously monitor the projects and collect feedback from the enterprises involved. This feedback is crucial for identifying both the successes and the challenges faced, which in turn informs the necessary adjustments to policies and programs. The aim is to create a dynamic policy environment that can adapt to new developments and ensure the sustainable integration of alternative energy technologies in critical infrastructure.

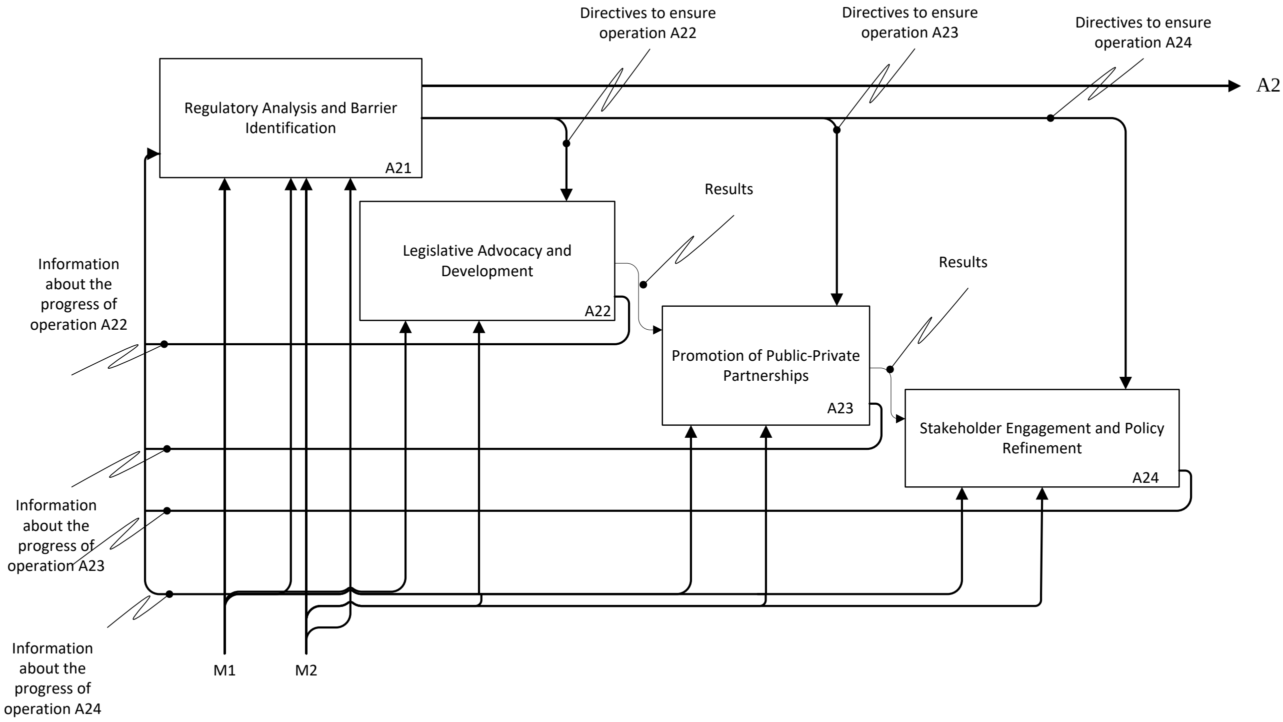
Figure 5: Decomposition of the first level of the context diagram of the IDEF0 model for implementing state financial assistance in the use of alternative energy technologies for critical infrastructure enterprises



Source: Author's own work.

One of the key features of the IDEF0 method is that each subprocess can be further detailed by developing a decomposition of the second and subsequent levels. We used this opportunity to take a more thorough look at subprocesses A2 (Figure 6).

Figure 6: Decomposition of the second level of the context diagram of the IDEF0 model for implementing state financial assistance in the use of alternative energy technologies for critical infrastructure enterprises



Source: Author's own work.

A21. Regulatory Analysis and Barrier Identification. At this initial stage, a detailed analysis of the existing regulatory framework is carried out to identify any obstacles and problem areas that may negatively affect the success of the implementation and use of alternative energy technologies. The range of actions at this stage includes the identification of restrictive laws, excessive bureaucratization and outdated standards that no longer meet international requirements or within the framework of the introduction of modern technologies. The goal of this stage is to thoroughly understand the current regulatory framework and develop a comprehensive list of obstacles and problems that are critical to eliminate.

A22. Legislative Advocacy and Development. With a clear understanding of the regulatory barriers, this phase focuses on the advocacy and development of new laws or amendments to existing laws. The objective is to create a supportive legislative environment that offers incentives for adopting alternative energy solutions. These could include tax rebates, subsidies, expedited permitting processes, or other financial incentives designed to reduce the cost and complexity of deploying new energy technologies. This phase involves close collaboration with lawmakers, industry experts, and stakeholders to ensure that proposed legislative changes are feasible and effective.

A23. Promotion of Public-Private Partnerships. At this stage, there is a need to determine the importance of using the opportunities and resource provision of the private sector. At the same time, special attention is paid to the development and maintenance of partnerships between government bodies and private enterprises. Such communications play a key role in the process of combining government monitoring mechanisms and the introduction of private innovations and investments, which will ultimately make the implementation of alternative energy technology projects more successful and viable. At the same time, it is important for the government to facilitate this type of partnership and communication through efforts to find partners and investment funds that are aimed at supporting critical infrastructure facilities.

A24. Stakeholder Engagement and Policy Refinement. The final phase involves continuous engagement with all relevant stakeholders, including energy companies, critical infrastructure operators, environmental groups, and local communities. This engagement ensures that the regulatory changes are well-received and effectively implemented. Feedback from these groups is invaluable for refining policies, making necessary adjustments, and ensuring that the regulatory framework remains responsive to technological advancements and industry needs. This phase ensures that the legislative and regulatory adjustments achieve their intended goals and can be adapted over time as circumstances change.

Our "Decomposition of the first level of the context diagram of the IDEF0 model for implementing state financial assistance in the use of alternative energy technologies for critical infrastructure enterprises" is indeed the model that has been created to address this concern. This model not only supports the adoption of alternative energy technologies but also enhances the resilience of critical infrastructure to security threats. By detailing the processes and interactions involved in implementing state financial assistance, the model provides a comprehensive framework that ensures both technological advancement and increased security resilience are achieved.

Our research aims to build upon previous studies by developing a more structured strategy for implementing government aid through a detailed process decomposition model. Our adaptation is specifically tailored to address the complexities of providing state financial assistance to critical infrastructure enterprises adopting alternative energy technologies. We propose the following practical solutions:

1. Special tariffs: Implementing feed-in tariffs or other pricing mechanisms that incentivize investment in alternative energy.
2. Financial incentives: Providing capital subsidies, grants, or tax credits to reduce the financial burden on enterprises.
3. Preferential loans: Offering low-interest or long-term loans with grace periods to improve access to capital.
4. Market mechanisms: Establishing policies that encourage private investment and participation in the energy sector.

While we did not delve into the specifics of each regulatory measure within the article, our intention was to highlight the critical role that supportive regulations play in the successful implementation of state financial assistance programs. We recognize that detailing specific proposals, such as special tariffs for Transmission System Operators (TSO) or Distribution System Operators (DSO) to generate additional investment funds, would make our strategy more actionable.

Discussion

In this article, we have formed an innovative methodological approach that allows us to formulate an effective strategy for the implementation of state financial assistance in the use of alternative energy technologies for critical infrastructure enterprises. To achieve our goals, we used the IDEF0 method, through which a context diagram was generated for the process of increasing the efficiency of the implementation of financial assistance and support. To confirm the scientific novelty and relevance of our research, an important step will be to compare the results of the study with the results of existing research in this area.

Thus, in a study by Oke and Oyedokun (2007), a mathematical model was formed to estimate additional energy costs in the context of disproportionate energy consumption. The approach developed by these authors highlights the importance of an effective theoretical modeling approach to managing energy costs. Similarly, our study also focuses on the correct selection and use of the modeling method, which in our case is the IDEF0 method. In the context of our study, this method was used to model government financial assistance strategies. At the same time, our study includes a broader scope since the study by Oke and Oyedokun (2007) only includes cost estimation in the modeling.

The work of Blikhar et al. (2021) assessed the economic security of innovative enterprises, focusing on economic and regulatory aspects. The conclusions drawn by the authors are relevant and consistent with our results. Thus, the authors determined that today it is important to introduce modern innovative methodological approaches to ensuring the financial stability of enterprises. Our research complements these results by forming a more structured strategy for implementing government assistance, thereby ensuring a stable level of financial security for alternative energy enterprises, even in the face of increased levels of national security threats.

Chen and Lei (2018) explored the impacts of renewable energy and technological innovation on the environment-energy-growth nexus using panel quantile regression. Their research corroborates our emphasis on technological innovation in the energy sector. While their study highlights the macroeconomic benefits of renewable energy, our work provides a strategic framework at the microeconomic level, focusing on the practical implementation of financial assistance for critical infrastructure enterprises. Ding et al. (2020) assessed industrial circular economy performance using an extended Malmquist index based on cooperative game network DEA. Their methodological rigor in evaluating dynamic performance aligns with our structured approach using the IDEF0 method. Both studies emphasize the need for comprehensive and dynamic modeling to enhance performance and efficiency in their respective domains. Kopytko et al. (2024) proposed a methodological approach to optimizing financial resources to increase economic security in a dynamic environment. Their research parallels our study by focusing on financial optimization strategies. However, our work specifically addresses the implementation of state financial assistance in alternative energy, providing a niche application of financial optimization principles.

Rushchyshyn et al. (2021) in their work highlighted the key regulatory aspects of ensuring financial security at the state level. Identifying and considering these aspects is key in the context of our research and our proposed strategy. The results of our study complement this work by suggesting a clearer methodological approach.

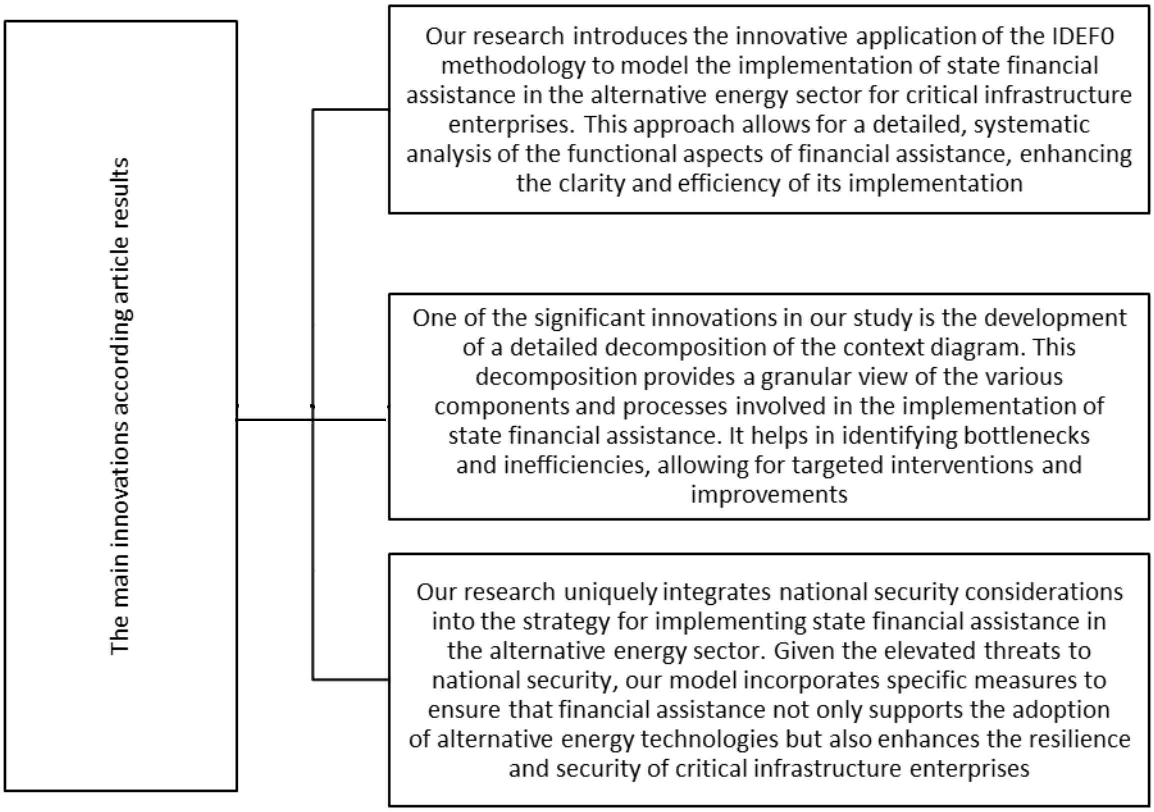
In studies by Sylkin et al. (2021) and Bhargava et al. (2022) study the parameters of economic security and features of the financial behavior of an enterprise in a post-pandemic society. These studies emphasize the importance of achieving higher levels of financial sustainability and strategic management. Our research extends this view by providing a clearer and more actionable strategy for improving financial sustainability through the adoption of alternative energy technologies through obtaining and optimizing financial support.

Furuoka (2015) examined the relationship between financial development and energy consumption in Asian countries, highlighting the role of financial development in energy sector growth. This aligns with our findings, which advocate for structured financial assistance to support energy sector advancements. Our research adds to this by providing a specific strategy for critical infrastructure enterprises, ensuring their sustainability and security.

Sylkin et al. (2021) discussed the socio-economic impact of crises, stressing the importance of robust management strategies. Our study reinforces this by providing a practical strategy for state financial assistance, aimed at enhancing the socio-economic resilience of critical infrastructure enterprises in the energy sector. The main innovation we have compared to others is shown in Figure 5 on the next page.

Our innovation lies in its tailored application to the specific context of implementing state financial assistance for alternative energy technologies in critical infrastructure enterprises. This adaptation addresses the unique challenges faced by these enterprises, especially under the current geopolitical circumstances in Ukraine. Due to the rapidly changing environment and limited availability of empirical data in this context, expert input was essential to accurately model the processes involved. These experts provide real-time insights that are critical when empirical data is scarce or outdated. Nonetheless, we recognize the value of incorporating empirical research and assigning weights to individual stimulants such as regulatory factors. In future research, we plan to enhance our model by integrating qualitative and quantitative data to assign appropriate weights, thereby increasing the model's precision and effectiveness.

Figure 7: Innovativeness of the research results we have achieved



Source: Authors own work.

Conclusions

In this study, we developed an innovative methodological approach to formulate effective strategies for implementing state financial assistance in the adoption of alternative energy technologies at critical infrastructure enterprises. Utilizing the IDEF0 modeling method, we constructed a robust model that enables a more systematic application and distribution of financial support in a sector crucial to the country's well-being. The research led to the creation of a detailed decomposition of the context diagram, which enhances the efficiency and transparency of implementing and distributing government financial support. This model aids in addressing complex, industry-specific challenges faced by modern critical infrastructure enterprises in Ukraine by providing a detailed strategic path that aligns with national security needs amidst numerous threats and challenges.

The findings of this study play a crucial role in developing an effective strategy for implementing state financial assistance aimed at adopting alternative energy technologies within critical infrastructure enterprises, especially under heightened national security threats. By employing the IDEF0 method, the research provides a robust and systematic model that delineates the essential processes and interactions involved in the allocation and management of financial resources. The proposed decomposition of the context diagram enhances the efficiency of financial assistance implementation by identifying and addressing key components and potential bottlenecks, thereby ensuring that funds are utilized optimally to support sustainable energy initiatives.

Significance and implications

The innovative model offers a structured framework for optimizing financial assistance, facilitating the successful integration of alternative energy technologies. This contributes to increasing the resilience of critical infrastructure, thereby elevating national security and economic stability. While the study focuses on Ukrainian enterprises, the modeling foundation and strategic insights are adaptable, allowing for extension to other countries and industrial sectors.

Limitations of the study

The primary limitation of this study is its focus on the specific activities of Ukrainian critical infrastructure enterprises. This specialization may limit the immediate applicability of the findings to different geopolitical or economic contexts without appropriate adjustments.

Prospects for future research

Future research could explore adapting this model to the context of Polish enterprises, considering their unique economic and geopolitical characteristics. Investigating the model's applicability in other countries and industries would validate its versatility and effectiveness. Further studies might also incorporate additional variables or alternative modeling techniques to enhance the model's robustness. By expanding on this research, scholars can open new scientific horizons, contributing to the global discourse on sustainable energy integration and critical infrastructure resilience.

References

Bazilyuk, Y.B. (2020). Organizational mechanisms to reduce threats to economic security in connection with the introduction of measures to prevent the spread of COVID-19 diseases in Ukraine. National Institute for Strategic Research, Kyiv.

Borysiak, O. & Brych, V. (2021). Methodological Approach To Assessing The Management Model Of Promoting Green Energy Services In The Context Of Development Smart Energy Grids. Financial and Credit Activity Problems of Theory and Practice, 4(39), 302-309.

Bhargava, M., Sharma, A., Mohanty, B. & Lahiri, M.M. (2022). Moderating role of personality in relationship to financial attitude, financial behaviour, financial knowledge and financial capability. International Journal of Sustainable Development and Planning, 17(6), 1997-2006.

Blikhar, V., Kopytko, M., Patsula, O., Synenkyi, V. & Bulachek, V. (2022). Management And Legal Aspects Of Economic Security Of Enterprises In The Process Of Innovation. Financial and Credit Activity Problems of Theory and Practice, 6(41), 360-368.

Blikhar, V., Kopytko, M., Lychenko, I., Vinichuk, M. & Polishchuk, R. (2021). Assessment of the level of economic security of innovative enterprises: economic and legal aspect. Financial and Credit Activity Problems of Theory and Practice, 3(38), 240-248.

Bojnec, Š. & Papler, D. (2011). Economic efficiency, energy consumption and sustainable development. Journal of Business Economics and Management, 12(2), 353-374.

Brunnschweiler, C.N. (2010). Finance for renewable energy: an empirical analysis of developing and transition economies. Environment and Development Economics, 15(3), 241-274.

Chen, W. & Lei, Y. (2018). The impacts of renewable energy and technological innovation on environment-energy-growth nexus: New evidence from a panel quantile regression. Renewable Energy, 123, 1-14.

Ding, L.L., Lei, L., Wang, L. & Zhang, L.F. (2020). Assessing industrial circular economy performance and its dynamic evolution: An extended Malmquist index based on cooperative game network DEA. Science of the Total Environment, 731, 1-25.

Furuoka, F. (2015). Financial development and energy consumption: Evidence from a heterogeneous panel of Asian countries. Renewable and Sustainable Energy Reviews, 52, 430-444.

Kopytko M., Sylkin O. & Ruda I. (2024). A methodological approach to optimizing financial resources to increase the level of economic security in a dynamic external environment. Financial Internet Quarterly 20(1), 29-38.

Lapinskaitė, I. & Skvarciany, V. (2023). Sustainable metamorphosis: examining sustainability transformation into value of financial institutions. Journal of Business Economics and Management, 24(5), 923–938.

Lezgovko, A. (2007). Financial reinsurance: the effective tool of insurance company's stability management. Business: Theory and Practice, 8(2), 112-118.

Oke, S.A. & Oyedokun, O.I. (2007). Development and application of a mathematical model for evaluating extra energy cost due to disproportional energy consumption. Journal of Business Economics and Management, 8(2), 155-161.

Rushchyshyn, N., Medynska, T., Nikonenko, U., Kostak, Z. & Ivanova, R. (2021). Regulatory and legal component in ensuring state's financial security. Business: Theory and Practice, 22(2), 232-240.

Shi, S. & Deng, J.J. (2020). Impacts of financial development on energy consumption structure: New evidence from panel threshold regression model. International Journal of Sustainable Development and Planning, 15(3), 353-359.

Spanidis, P.M., Pavloudakis, F. & Roumpos, C. (2021). Introducing the IDEF0 methodology in the strategic planning of projects for reclamation and repurposing of surface mines. Materials Proceedings, 5(1), 26-34.

State Statistics Service of Ukraine. (2023). Activities of small and medium-sized enterprises. https://www.ukrstat.gov.ua/ (Accessed: 10.08.2024).

Sylkin, O., Bosak, I., Homolska, V., Okhrimenko, I. & Andrushkiv, R. (2021). Intensification of Management of Economic Security of the Enterprise in the Post-Pandemic Space. Postmodern Openings, 12(1), 302-312.

Sylkin, O., Buhel, Y., Dombrovska, N., Martusenko, I. & Karaim, M. (2021). The Impact of the Crisis on the Socio-Economic System in a Post-Pandemic Society. Postmodern Openings, 12(1), 368-379.

Sylkin, O., Shtangret, A., Ogirko, O. & Melnikov, A. (2018). Assessing the financial security of the engineering enterprises as preconditions of application of anti-crisis management: practical aspect. Business and Economic Horizons, 14(4), 926-940.