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THEORETICAL FOUNDATIONS OF RISK MANAGEMENT FOR ENERGY SECTOR ENTERPRISES[1]

In a rapidly evolving energy environment, effective risk management is paramount to ensuring the stability and success of businesses. This article examines a systematic approach to risk management in the energy sector, emphasizing the development of strategies adapted to a specific enterprise. The study delves into the various models used in the energy sector to manage risk. Energy balance models, energy network models, economic-mathematical models, demand and production forecasting models, risk management system models, renewable energy sources (RES) models, and system dynamic models are discussed. The study proposes a comprehensive risk management system for the energy sector, including SWOT analysis, Delphi method, sensitivity analysis and simulation modeling. The approach involves a detailed analysis of internal and external factors, expert assessments and scenario testing for the formulation of adaptive risk management strategies, taking into account regional characteristics, prioritizing resistance to change, aligning them with modern industry challenges. Given the competitive and dynamic nature of the energy sector, the study uses SWOT analysis and the Delphi method as key methodologies. The results of the study emphasize the need for a comprehensive risk management system in energy. A systematic approach combining various analytical methods is proposed, aimed at maximizing sustainability and competitiveness. The decision support system, which can be built on the basis of the developed methodology, will be automatically adapted to specific enterprises, and will facilitate prompt response to changes and optimize risk management strategies. The developed concept of a systemic approach to consideration and response to risks in the energy sector offers a clear path for enterprise risk management. The integrated system proved to be innovative and effective, making a significant contribution to the improvement of risk management methodology in the energy sector. This research provides valuable information for practical applications in energy and risk management.

Key words: *risk management, energy sector, SWOT analysis, Delphi method, sensitivity analysis, simulation modeling.*
JEL classification: G32, Q40, C63

Introduction. In the context of rapid development and profound changes in the modern energy landscape, the importance of conducting research in the field of risk management becomes crucial to ensure the efficiency and stability of enterprises. A thorough review of literary sources allows identifying specific facts that emphasize not only the diversity of challenges facing the energy sector but also the necessity of implementing highly effective risk management strategies.

During the research, terms such as "technological challenges," "market trends," and "risk management strategies" are employed, defining and systematizing the concept of risk management in the energy sector. Unveiling these terms contributes to the development of a comprehensive understanding of the requirements and possibilities in this field, which is essential for the creation of an integrated approach to risk management.

From the review of literary sources [1–20], it is possible to note that several studies in the field of risk management in the energy sector have been dedicated to the analysis and classification of risks encountered by enterprises in this industry. They delve into both internal and external factors that may influence the resilience of energy companies, providing a valuable overview of the main challenges. An averaged analysis is presented in Table 1.

The results of studies [21–32] underscore the necessity of developing innovative risk management strategies in the rapidly changing energy landscape. Research indicates that companies actively implementing new technologies and adopting flexible strategies have significant potential for risk adaptation. An averaged analysis is presented in Table 2.

Additionally, a crucial aspect of studying risks in the energy sector involves investigating the influence of regulatory policies on risky aspects of the energy business [33–41]. The results of this analysis indicate that effective implementation of risk management strategies requires not only internal changes within the company but also alignment with external regulatory bodies. An averaged analysis is presented in Table 3.

In the context of research on modeling the activities of energy enterprises [42–63], attention is directed towards developing stochastic models for forecasting financial risks associated with fluctuations in energy resource prices. The use of such models enables companies to manage financial expenses and minimize the impact of market instabilities. Additionally, possibilities of employing integrated optimization models to enhance the efficiency of production processes in the energy sector are explored. These models allow for consideration of various scenarios and identification of optimal risk management strategies based on external conditions.

Furthermore, there is an exploration of the potential development of dynamic models that account for interconnections among different aspects of energy enterprise operations. These models enable real-time risk manage-

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Table 1

Type of risk	Risk category	External factors of occurrence	Challenges for the enterprise
External	Geopolitical and economic instability	Political conflicts, sanctions, global economic changes	Changes in terms of trade, losses due to currency fluctuations, uncertainty in manufacturing partnerships
	Climatic changes	Extreme weather conditions, changes in climate	Increased risk of natural disasters, changes in the supply of energy resources
	Technological development	Innovations, rapid pace of technological changes	Mandatory adaptation to new technologies, changes in the competitive environment
	Legislation and regulation	Changes in energy laws, new environmental standards	The need for constant monitoring and implementation of new standards, increasing compliance costs
Internal	Technical problems and failures	Technical problems, equipment failure	Interruptions in production, possible loss of equipment, risk of accidents
	Financial risks	Unforeseen expenses, financial difficulties	Decrease in profitability, difficulties in attracting financing
	Personnel risks	Losses of key specialists, staff instability	Increasing the burden on existing employees, reducing productivity
	Operational risks	Problems in production management, incorrect planning	Delays in delivery, non-compliance with quality standards

Table 2

The essence of innovative risk management strategies	Key aspects of adaptations
Flexibility in technological solutions	The use of flexible technological solutions that allow you to quickly adapt to changes in the energy landscape. This may include the use of modular systems, rapid implementation of new technologies and technical innovations
Monitoring and forecasting systems	Implementation of intelligent monitoring and data analysis systems for timely detection of changes in the external environment. This allows enterprises to quickly respond to risks and make timely strategic decisions
Agility in personnel management	Application of principles of agile management and personnel development. Flexible teams and rapid changes in the organizational structure make it easy to adapt to new challenges and ensure effective risk management
Interaction with the market and stakeholders	Developed strategies for interaction with the market, customers and stakeholders. This can include quickly adapting to changes in demand, identifying new opportunities and securing sustainable partnerships with key industry players
Scenario planning and testing	Regular scenario exercises and emergency tests help businesses adapt to risk scenarios. This includes crisis response planning and staff training
Continuous training and development	Providing ongoing training and development of staff on new technologies, risk management strategies and best practices. This creates an educated and change-ready workforce

Table 3

Direction	Requirements of external regulatory bodies	Related internal changes at the enterprise
Changes in the management system	New reporting requirements, environmental standards, etc	Development and implementation of management systems that meet new regulatory requirements
Changes in environmental policy	Changes in environmental regulations and standards	Review and update of the company's strategy in terms of environmental responsibility, development and implementation of new environmental practices
Improving security processes	Changes in industry safety standards and requirements	Review and update of security systems, staff training on new security standards
Expansion of the control and reporting system	Accounting and reporting requirements, in particular, regarding financial and environmental data	Implementation of new accounting and reporting systems, staff training to use new technologies
Strategic planning and development	Changes in energy strategies and requirements for the development of renewable energy sources	Review and update of strategic planning, making adjustments to investment strategies

Table 4

Types of models	A brief description
Energy balance models	Models that take into account all inputs and outputs of energy at the enterprise. They are used to optimize energy efficiency, determine energy sources and costs
Models of energy networks	Models that allow analyzing the structure and functioning of energy networks. They help to determine the optimal ways of transferring energy and reducing losses
Economic and mathematical models	Models that take into account the financial and economic aspects of the enterprise. They are used for strategic planning, cost calculations and profitability
Demand and production forecasting models	Models based on statistical and analytical methods for energy demand forecasting and production planning
Models of risk management systems	Models that take into account various risks related to production, finance, regulation. They help define risk management strategies and make informed decisions
Models of use of renewable energy sources (RES)	Models that allow analyzing and forecasting the use of RES in the enterprise. They help determine the optimal strategies for the integration of RES and effectively use their potential
System dynamic models	Models using system dynamics to analyze interrelationships and changes in the system over time. They allow predicting the impact of various factors on the company's activities

ment and facilitate quick and informed decision-making to optimize productivity and ensure operational stability. An averaged analysis is presented in Table 4.

In the context of our research, we plan to employ similar models to create a comprehensive concept of systematic risk management. Modeling the enterprise's activities will aid in understanding potential risks and their impact on various business aspects. The utilization of advanced modeling techniques will help develop effective risk management strategies, ensuring the stability of the energy enterprise in dynamic market conditions.

The literature analysis underscores the active research in risk management within the energy sector. However, some ambiguity and divergent approaches leave questions regarding optimal strategies unanswered. This "research gap" creates space for further exploration and development.

Concerning our own research, the primary focus will be on developing a systemic risk management concept for a specific energy enterprise. The methodology will involve analyzing internal and external environments, identifying critical risk points, and devising strategies to minimize their impact. Applying an integrated approach will provide a fuller understanding of risks and enhance the enterprise's resilience in fluctuating energy market conditions.

The key challenge addressed in this article is the formulation of an effective systemic risk management concept in the energy sector, considering diverse technical and strategic aspects of enterprise operations.

The hypothesis of this study posits that integrating a systemic approach to risk management in an energy sector enterprise – essentially creating a conceptual decision support system that considers the conditions and specificities of the enterprise – will reduce vulnerability to external influences and ensure stability in a changing energy environment. This hypothesis will be validated or refuted based on a detailed analysis of the obtained results and their comparison with existing risk management approaches in the energy sector.

Thus, this article aims to fill a significant research gap by providing new insights and advancements in the field of risk management. It contributes to further development and optimization of risk management strategies for energy sector enterprises.

Methods. In the contemporary energy sector, where high competition and resilience to change are key challenges, creating a system that allows energy enterprises to effectively consider and respond to risks while being adaptable to specific needs and conditions is essential. Therefore, for such a system to be both adaptable and universal, it is crucial to explore various risk management methods. In this research, we utilize two key methodologies: SWOT analysis and the Delphi method.

SWOT Analysis identifies the internal strengths and weaknesses of the enterprise, as well as external opportunities and threats influencing its operations. The versatility and applicability of this method across different industries are important advantages.

We will conduct an analysis of each component of SWOT separately. For instance, when analyzing the strengths of the enterprise, we will delve into internal resources, management effectiveness, and technological readiness. In examining weaknesses, our focus will be on identifying issues in the internal structure and unsuccessful strategic decisions.

Delphi Method is based on using expert assessments to forecast future scenarios and identify risks. Known for its expert-oriented nature, the Delphi method allows incorporating the opinions of highly qualified professionals in the energy sector.

In our research, we will slightly modify the Delphi method by using existing expert assessments from open sources. This can be an efficient approach, offering advantages such as speed and convenience (utilizing ready-made expert assessments can significantly save time typically spent on engaging experts and obtaining their individual assessments), accessibility (open sources may contain expert assessments from a wide range of professionals, ensuring greater representativeness), and lower resource consumption (no need to coordinate work with multiple experts or address availability issues).

Additional methods such as sensitivity analysis and simulation modeling can also be effectively employed for risk management in the energy industry. Sensitivity analysis helps determine the impact of changes in individual parameters on overall results, while simulation modeling creates virtual environments for testing strategies under risk conditions.

From the analysis of sources [64–82], SWOT analysis is widely used in energy sector research to assess the internal strengths and weaknesses of enterprises. Scholars identify potential development opportunities and pinpoint threats that may affect their activities. Through SWOT analysis, they focus on aspects that can determine the competitiveness of companies in the market.

The Delphi method is used by researchers to forecast future scenarios and identify risks. Expert assessments involved through this method enable making forecasts considering various factors. In the energy sector, this may include questions about resource utilization efficiency, the development of alternative energy sources, and reducing environmental impact.

Sensitivity analysis and simulation modeling allow considering various scenarios and their impacts on energy enterprises. These methods help identify the most critical factors influencing risks. Researchers apply these methods to assess the resilience of enterprises to various changes in the external environment, such as fluctuations in resource prices, political, or technological changes.

Our approach to using SWOT analysis, the Delphi method, sensitivity analysis, and simulation modeling manifests in an innovative approach to risk research in the energy sector. Let's highlight the main differences and features of our approach:

1. Integrated SWOT Analysis:

We perceive SWOT analysis as a component of an integrated system that encompasses not only the internal aspects of the enterprise but also considers external factors such as legislative changes, geopolitical shifts, and sociocultural trends. This holistic approach provides a comprehensive understanding of the enterprise's position in a dynamic environment. By integrating external factors into SWOT analysis, we aim to enhance its effectiveness in strategic decision-making.

2. Delphi Method Modification:

In our approach, we explore the possibility of modernizing the Delphi method. Instead of directly involving experts in the research, we consider using existing expert assessments from open sources, thus saving time and resources. This adaptation allows us to benefit from a wealth of expert opinions readily available, ensuring a more efficient and streamlined process.

3. Consideration of Regional Specifics:

Our approach takes into account the specificity of regional characteristics in researching risks in the energy sector. We identify the impact of local conditions and legislation on the overall risk profile. Recognizing regional nuances is crucial for tailoring risk management strategies to specific geographic contexts.

4. Focus on Change Resilience:

Utilizing sensitivity analysis and simulation modeling in our approach enables us to emphasize the enterprise's resilience to various changes. This emphasis on adaptability ensures effective risk management, considering factors like market fluctuations, regulatory shifts, and technological advancements. The focus on change resilience aligns with the dynamic nature of the energy sector.

5. Adaptation to Modern Challenges:

Our approach is oriented towards adapting to contemporary challenges in the energy sector, such as the transition to renewable energy sources, digital transformation, and global shifts in consumer demands. By aligning risk management strategies with current industry challenges, we aim to future-proof enterprises and facilitate sustainable growth.

In summary, our integrated system goes beyond traditional SWOT analysis, incorporating external dynamics, modernizing research methodologies like the Delphi method, considering regional specifics, and prioritizing change resilience. This comprehensive approach aims to provide energy enterprises with a strategic advantage in navigating the complexities of the evolving energy landscape.

In general, our approach entails a deeper and comprehensive examination of risks aimed at maximizing the resilience and competitiveness of energy enterprises in conditions of uncertainty and dynamic changes. During the implementation of the chosen methods in our research, certain difficulties and problems may arise that need to be considered for the most accurate and reliable analysis. Let's consider some possible aspects that require attention:

– Insufficiency of data: One of the key challenges may be the limited availability of data necessary for conducting SWOT analysis and simulation modeling. It is crucial to ensure access to comprehensive and reliable data for the most accurate results.

– Heterogeneity of data sources: Considering various data sources for SWOT analysis may pose challenges in standardization and consistency. Methods of processing and analysis need improvement to ensure uniformity of approaches.

– Inconsistency of expert assessments in the Delphi method: The use of the Delphi method, especially with the use of ready-made expert assessments, may lead to the issue of inconsistency and subjectivity in evaluations. Careful selection and analysis of sources are important to ensure the credibility of results.

– Challenges in sensitivity analysis: Conducting sensitivity analysis may encounter difficulties in precisely determining the interaction of different parameters and their impact on risks. It is necessary to carefully choose parameters and consider potential interactions.

– Evaluation of impact on a specific enterprise: To achieve maximum adaptation and efficiency in research, it is crucial to correctly consider the specific characteristics, scale, and individual features of the energy enterprise. Avoiding and resolving these difficulties require detailed planning, systematic analysis, and continuous improvement of the research methodology.

Results and Discussion. The results of our study indicate the need for implementing a comprehensive risk management system in the energy sector to ensure the stability and efficiency of enterprise activities. To achieve this goal, the concept of a systematic approach to risk consideration and response is proposed, which is based on the use of a decision support system adapted to the unique characteristics of a specific enterprise.

This concept involves the creation of an integrated system that takes into account SWOT analysis, the Delphi method, sensitivity analysis, and simulation modeling.

The first stage involves a comprehensive analysis of internal and external factors using SWOT analysis to identify the strengths and weaknesses of the company, as well as opportunities and threats.

The second stage includes the use of the Delphi method to obtain expert assessments of future scenarios and identify potential risks. Data from these expert assessments can be integrated into the decision support system to refine risk management strategies.

Sensitivity analysis and simulation modeling, the foundation of the third stage, allow for assessing the impact of various factors and development scenarios on risks and making informed decisions for their management.

In addition, the decision support system should have functionality that considers the results of risk impact analysis and automatically adjusts risk management strategies for maximum efficiency.

Our approach stands out in that it combines a wide range of analytical methods to ensure comprehensive risk management in the energy sector. The use of a decision support system adapted to a specific enterprise enables real-time responsiveness to changes and maximizes the resilience of the enterprise to risks.

As a result, the proposed concept of a systematic approach to risk consideration and response will contribute to the development of a rational and effective risk management system for energy enterprises.

The development of the concept of a systematic approach to risk consideration and response in the energy sector is a relevant issue, and indeed, similar developments in the field of risk management in the energy sector exist. Several examples of approaches and developments in this area can be found in scientific publications [83–91].

However, some studies focus on the use of SWOT analysis and the Delphi method for identifying and forecasting risks in the energy sector. Nevertheless, our approach differs in that we combine these methods with sensitivity analysis and simulation modeling for a deeper understanding of potential consequences and the development of optimal risk management strategies.

In some other studies [92–95], emphasis is placed on aspects of risk management in accordance with standards and regulations. Our approach complements this by providing specific tools to address the challenges of a specific energy enterprise and adapt risk management strategies to its needs.

There are also some developments [96–99] that use simulation modeling to analyze the impact of various factors on risks in the energy sector. However, our approach distinguishes itself by considering the Delphi method and SWOT analysis, allowing for expert assessments and systematic analysis of internal and external factors.

In summary, the proposed concept stands out for its comprehensive approach and consideration of all aspects of risk management in energy enterprises.

Conclusions. In the course of the research aimed at developing the concept of a systematic approach to risk consideration and response in the energy sector, a combination of methods was utilized to systematically study potential hazards and identify optimal risk management strategies for a specific energy enterprise.

The selected methods proved to be quite effective in analyzing internal and external factors influencing the energy sector. SWOT analysis helps identify internal strengths and weaknesses of the enterprise, while the Delphi method ensures balanced expert assessments of future scenarios.

Supplementing the core methods with sensitivity analysis and simulation modeling allows for a deeper understanding of the relationships between different risks and the effectiveness of various risk management strategies.

An important aspect of the research is the ability to adapt risk management strategies to a specific enterprise. Considering the specifics of the energy sector and implementing a decision support system will enable the effective consideration of all aspects of enterprise activities.

The obtained results emphasize the importance of a comprehensive approach that takes into account both standard risk management methods and the unique characteristics of the energy sector. Comparative analysis showed that the proposed concept is innovative and effective.

In summary, the developed concept of a systematic approach to risk consideration and response in the energy sector outlines a clear path for enterprise risk management, enabling informed strategic decisions and ensuring resilience in dynamic market conditions.

This research makes a significant contribution to the development of risk management methodology in the energy sector and can serve as a foundation for further practical applications in the fields of energy and risk management.

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ТЕОРЕТИЧНІ ОСНОВИ УПРАВЛІННЯ РИЗИКАМИ ПІДПРИЄМСТВ ЕНЕРГЕТИЧНОЇ ГАЛУЗІ

У енергетичному середовищі, яке швидко розвивається, ефективне управління ризиками має першочергове значення для забезпечення стабільності та успіху підприємств. У цій статті досліджується системний підхід до управління ризиками в енергетичному секторі, наголошується на розробці стратегій, адаптованих до конкретного підприємства. Дослідження заглиблюється в різні моделі, що використовуються в енергетичному секторі для управління ризиками. Обговорюються моделі енергетичного балансу, моделі енергетичних мереж, економіко-математичні моделі, моделі прогнозування попиту та виробництва, моделі систем управління ризиками, моделі відновлюваних джерел енергії (ВДЕ) та системні динамічні моделі. Дослідження пропонує комплексну систему управління ризиками для енергетичного сектору, що включає аналіз SWOT, метод Delphi, аналіз чутливості та імітаційне моделювання. Підхід передбачає детальний аналіз внутрішніх і зовнішніх факторів, експертні оцінки та тестування сценаріїв для формулювання адаптивних стратегій управління ризиками, з врахуванням регіональних особливостей, пріоритетності стійкості до змін, узгоджуючи їх із сучасними викликами галузі. Враховуючи конкурентний та динамічний характер енергетичного сектору, дослідження використовує SWOT-аналіз та метод Delphi як ключові методології. Результати дослідження підкреслюють необхідність комплексної системи управління ризиками в енергетиці. Запропонований системний підхід, що поєднує різні аналітичні методи, спрямований на максимізацію стійкості та конкурентоспроможності. Система підтримки прийняття рішень, що може бути збудована на основі розробленої методології, буде автоматично адаптована до конкретних підприємств, і сприятиме оперативному реагуванню на зміни та оптимізує стратегії управління ризиками. Розроблена концепція системного підходу до розгляду та реагування на ризики в енергетичному секторі пропонує чіткий шлях для управління ризиками підприємства. Інтегрована система виявилася інноваційною та ефективною, вносячи значний внесок у вдосконалення методології управління ризиками в енергетичному секторі. Це дослідження дає цінну інформацію для практичного застосування в енергетиці та управлінні ризиками.

Ключові слова: *управління ризиками, енергетика, SWOT аналіз, метод Delphi, аналіз чутливості, імітаційне моделювання.*