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USING ARTIFICIAL INTELLIGENCE TO ENSURE ENERGY SECURITY IN POLAND

Magdalena Gorska, Oleksandr Levochko
[1]*Mgr. (Economics), Founder, WSHIU University, Poznan, Poland, ORCID: https://orcid.org/0000-0002-5208-1637*
[2]*Bachelor's student of the Management program, WSHIU University, Poznan, Poland*

Abstract. Energy security is a critical element of sustainable national development, especially in the context of global geopolitical instability, increasing demand for energy, and the need to transition to environmentally responsible energy systems. Poland faces a complex combination of challenges related to diversification of energy sources, modernization of energy infrastructure, reduction of dependence on fossil fuels, and integration of renewable energy technologies. Artificial intelligence is becoming an essential tool for addressing these challenges. AI systems support the optimization of energy production and consumption, forecasting of demand, automation of infrastructure management, and detection of system vulnerabilities. The application of AI in the Polish energy sector contributes to increasing the efficiency, reliability, and resilience of the national energy system while supporting the achievement of climate and innovation goals.

The objective of this research is to analyze the role of artificial intelligence in strengthening energy security in Poland, identify key applications of AI technologies in energy systems, and determine the advantages and limitations of their practical implementation.

The study is based on a systematic review of academic publications, governmental strategies, sectoral reports, and analytical data from Polish and international organizations specializing in energy management and digital innovation. Methods of system analysis, comparative evaluation, and scenario forecasting were applied to examine the effects of implementing AI tools in energy production, transmission, and distribution. Case examples of AI implementation in smart grids, renewable energy forecasting systems, and energy network monitoring were also examined. Attention was paid to regulatory and economic factors influencing the expansion of AI in the Polish energy sector.

The study identifies several directions in which artificial intelligence contributes to strengthening energy security in Poland. First, AI facilitates renewable energy integration by providing high-accuracy forecasting of solar and wind power generation, which reduces volatility and supports grid stability. Second, AI-driven smart grid systems enhance the monitoring and real-time management of energy flows, allowing rapid detection and correction of network disturbances. Third, AI supports predictive maintenance of energy infrastructure, reducing equipment failure rates and extending asset lifecycle. Fourth, AI models improve strategic energy planning by modeling demand scenarios and assessing the impact of energy policies. Fifth, AI enhances cybersecurity in the energy sector through automated detection of abnormal system behavior and rapid threat response. Despite these advantages, challenges remain. These include limited data integration across energy companies, the need for specialized personnel, high initial implementation costs, and ethical and regulatory concerns related to automated decision-making processes.

Artificial intelligence has significant potential to enhance energy security in Poland by supporting efficiency, stability, and strategic sustainability of the national

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energy system. The implementation of AI technologies strengthens the resilience of energy networks, facilitates the transition to renewable energy sources, and supports informed policy and investment decisions. However, the full realization of these benefits requires coordinated policy support, investment in training and infrastructure, and development of unified standards for data management and system interoperability.

Future research should focus on evaluating the socioeconomic effects of AI adoption in the energy sector, developing models for intersectoral integration of energy and digital infrastructures, assessing public trust in AI-based energy systems, and identifying mechanisms for strengthening international cooperation in energy cybersecurity.

Keywords: artificial intelligence; energy security; Poland; smart grids; renewable energy forecasting; predictive maintenance; digital infrastructure; cybersecurity; energy policy;, system resilience.

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