

List of references

1. Mazanyi, V. (2012). Monitoring the environment in the thirty-kilometer zone of Rivne NPP [Electronic source]. Ukrinform. https://www.ukrinform.ua/rubric-other_news/1344464-monitoring_dovkilliya_u_tridtsyatikilometroviy_zoni_rivnenskoi_aes_zdiysnyue_avtomatizovana_sistema_1722859.html
2. Energoatom. (2023). Carbon measurement system at Khmelnytskyi NPP [Electronic source]. <https://energoatom.com.ua/news/na-hmelnickij-aes-vprovadzhuyut-sistemu-vimiryuvannya-vuglecyu>
3. Radio Svoboda. (2022). Why is the monitoring system in the Chornobyl Exclusion Zone not working? [Electronic source]. <https://www.radiosvoboda.org/a/news-monitorynh-chaes-ne-pratsiuie/31778214.html>

UDC 341.1

Kotsyubynsky O. PhD student,
Vasyl Stefanyk Precarpathian National Unive
Herasymenko Bogdan, PhD student,
Ivano-Frankivsk National Technical University of Oil and Gas

INDUSTRY 4.0 IN THE TRANSFORMATION OF THE ENERGY SECTOR AND ENHANCEMENT OF ENERGY EFFICIENCY

The implementation of Industry 4.0 technologies is fundamentally changing traditional approaches to energy system management. Smart grids with automated load balancing optimize energy distribution and integrate renewable sources, which is critical for Ukraine's energy transition. Digital twins of energy facilities provide predictive analytics and preventive maintenance, reducing unplanned equipment downtime by 25-30%.

IoT sensors integrated into production processes create a continuous flow of data for real-time energy consumption analysis. The implementation of such systems at Ukrainian enterprises demonstrates the potential to reduce energy consumption by 15-20% through identifying hidden losses and optimizing equipment operation modes. The use of AI for automatic regulation of energy consumption depending on production load and external conditions is becoming particularly relevant.

Blockchain technology enables the creation of local energy communities with peer-to-peer energy trading, which is especially important for enhancing the resilience of Ukraine's energy system. Smart contracts ensure transparency of transactions and automatic execution of agreements between energy producers and consumers, promoting decentralization and democratization of the energy market.

The increasing level of digitalization of energy infrastructure increases its vulnerability to cyber attacks. Protecting critical energy facilities requires a multi-

layered approach using advanced anomaly monitoring technologies and artificial intelligence to detect threats. It is necessary to improve the legislative framework and cybersecurity standards, taking into account the specifics of Ukraine's energy sector.

Government policy should promote investments in the digital transformation of the energy sector through tax incentives and targeted funding programs. It is necessary to develop a national roadmap for implementing Industry 4.0 technologies in the energy sector with clear efficiency indicators. International cooperation and exchange of experience should become catalysts for innovative development of Ukrainian energy in the context of European integration.

References

1. Polyanska A., Pazynich Y., Mykhailyshyn K., Buketov V. Energy transition: the future of energy on the base of smart specialization. *Scientific Bulletin of National Mining University*. 2023. (4).
2. Kraus K., Kraus N. The nature of digital transformation. Energy of the economy. How to feel, understand and use it. 2023

UDC 504.5:662.76:631.46

Lynnyk D. student IFNTUOG

Vavrykiv V. Student IFNTUOG

Lopushniak V. I., Doctor of Agricultural Sciences,
Professor, Department of Technology of Protection
of Environmental Protection and Labor Safety,
Ivano-Frankivsk National Technical
University of Oil and Gas of Ukraine,

Hoysan T.I., Lecturer at the Department of English Language
Ivano-Frankivsk National Technical
University of Oil and Gas.

COMPARATIVE ANALYSIS OF NATURAL SORBENTS IN THE PROCESSES OF BIOREMEDIATION OF OIL-CONTAMINATED SOILS

The problem of oil contamination of soil is one of the leading anthropogenic impacts on the environment. Spills of oil and oil products during their extraction, transportation, processing and storage lead to disruption of natural ecosystems, loss of land fertility and pose a threat to human health. In this context, the development and implementation of effective, economically feasible and environmentally friendly technologies for cleaning up contaminated areas is an urgent scientific and practical task [1, 4].

The aim of the study is to investigate the effectiveness of using sorbents based on natural materials for soil cleanup from oil contamination, taking into account