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DIGITAL TRANSFORMATION OF BUSINESS PROCESSES OF ENERGY ENTERPRISES AND THE FEATURES OF THEIR LEGAL SUPPORT

ЦИФРОВІ ТРАНСФОРМАЦІЇ БІЗНЕС-ПРОЦЕСІВ ЕНЕРГЕТИЧНИХ ПІДПРИЄМСТВ ТА ОСОБЛИВОСТІ ЇХ ПРАВОВОГО ЗАБЕЗПЕЧЕННЯ

The article highlights the trends of modern functioning of energy enterprises in the conditions of digital transformation. The purpose of the study is to review the current state of digitalization of the energy business, to highlight the organizational, managerial and legal aspects of the digital transformation of energy enterprises. The features of the use of blockchain technology are analyzed. The possibilities and advantages of using blockchain technology by energy enterprises are highlighted. A review of the use of drones, smart meters and elements of artificial intelligence by energy enterprises is carried out. Digital technologies of the «Internet of Things» are being introduced into the activities of energy enterprises. The elements of digitalization that ensure the activities of electric power enterprises in the conditions of the digital economy and affect the state of their economic security have been summarized, allowing the formation of a system of priority (necessary) subsystems of digital transformation. Such subsystems include: digital ecosystem, digital culture, digital competences of personnel, digital infrastructure, digital strategy (as the goal of digital transformation). Digital infrastructure and digital competencies of personnel are considered as tools for implementing the digital strategy of the enterprise.

Keywords: *digital transformation, digitalization, blockchain, Internet of Things, energy enterprises, digital culture, digital infrastructure.*

У статті виокремлено тенденції сучасного функціонування енергетичних підприємств в умовах цифрової трансформації. Метою дослідження є огляд сучасного стану цифровізації енергетичного бізнесу, виокремлення організаційно – управлінських та правових аспектів цифрової трансформації енергетичних підприємств. Цифровізація в енергетиці обумовила можливості для автоматизованого управління бізнес-процесами енергетичних підприємств (діджиталізації) та зміни бізнес-моделей діяльності підприємств (цифрової трансформації). Проаналізовано особливості використання технології блокчейн. Сформовані напрямки використання технології блокчейну, які можуть бути впроваджені в діяльності учасників енергосистеми України. Виокремлено можливості та переваги використання технологіях блокчейн енергетичними підприємствами. Здійснено огляд щодо використання енергетичними підприємствами дронів, розумних лічильників та елементів штучного інтелекту. Узагальнено елементи цифровізації, які забезпечують діяльність підприємств електроенергетики в умовах цифрової економіки та впливають на стан їх економічної безпеки дозволили сформувати систему пріоритетних підсистем цифрової трансформації. До таких підсистем віднесено: цифрову екосистему, цифрову культуру, цифрові компетенції персоналу, цифрову інфраструктуру, цифрову стратегію (як мету цифрової трансформації). Розглянуто цифрову інфраструктуру та цифрові компетенції персоналу як інструменти реалізації цифрової стратегії підприємства. Запропоновано визначення цифрової екосистеми підприємства як сукупності взаємопов'язаних цифрових технологій, обладнання, пристроїв, цифрової структури, персоналу, цифрових повноважень, системи взаємовідносин, яка спрямована на збір цифрових даних та на їх основі управління операціями, процесами підприємства з метою безпечного та ефективного функціонування в умовах наявності небезпек та ризиків для діяльності підприємства. Наголошено на значенні цифрових трансформацій у сфері енергетики, що змінили не лише бізнес-процеси учасників енергоринку, але вплинули й на організацію системи відносин між постачальниками та споживачами енергетичних послуг.

Ключові слова: *цифрові трансформації, цифровізація, блокчейн, інтернет речей, енергетичні підприємства, цифрова культура, цифрова інфраструктура.*

Problem statement. The recovery of Ukraine is closely related to the development of the energy sector and the provision of transparent and favorable conditions for the implementation of activities to energy enterprises. It is energy enterprises that are today tasked with forming a digital space, which will further provide conditions for the stable development of the country's energy sector and Ukrainian enterprises. The digitalization of the Ukrainian energy sector in the context of the implementation of the intentions to join the EU must correspond to the set of EU measures to implement the "energy transition" policy. Accordingly, the architecture of the EU and Ukrainian power systems must be based on the principles of smart grid technologies, storage and smart consumption of electricity. Digitalization in the energy sector has provided opportunities for automated management of business processes of energy enterprises (digitalization) and changes in the business models of enterprises (digital transformation). This study is devoted to highlighting certain aspects of digitalization and digital transformation of energy enterprises.

Analysis of recent research and publications. The works of L. Blagomir are devoted to the study of the definition, key aspects, technology and stages of implementation of digital transformations. The terminology of ecosystem as structure was considered by R. Adner. At the same time, a wide range of issues related to the digital transformation of energy enterprises remains open.

Formulating the purposes of the article. The purpose of the article is to study the current state of digitalization of the energy business, to identify organizational, managerial and legal aspects of the digital transformation of energy enterprises.

Methodology. The methods of the system analysis, analysis and synthesis are used in the article.

Presentation of the main research material. Digital transformation is based on digitalization, but compared to digitalization, it covers not functional, but strategic levels of management of an energy enterprise, since it is associated with a change in the business model of the enterprise and the emergence of new business development strategies. Digitalization in the energy sector allows you to reduce losses, increase the profitability of energy market participants, develop the market for auxiliary services and electricity storage services, effectively manage data and based on them form forecasts.

The main tools that have ensured the development and gradual digital transformation in all sectors of activity, including energy, are the emergence of computers, the Internet, the development of software, devices and sensors. The development of the above-mentioned digital transformation tools in the era of Industry 4.0 has radically changed all business processes in the energy sector. The evolution of Industry 4.0 has also led to the evolution of digital transformations in the energy sector. Blockchain technology is a decentralized digital register of transactions of network participants. Blockchain provides transaction storage and data transmission in the network. Taking into account blockchain technology, all information data in such a network cannot be falsified, which increases the level of information security of energy enterprises. In addition, the blockchain eliminates the possibility of unauthorized access by third parties.

Blockchain platforms provide automatic billing throughout the entire electricity supply chain – from generators to end users – and provide broad protection against unauthorized access to data at all levels. The system allows you to create records not only by the amount of energy resources, but also for a certain period of time, makes it possible to control all changes to the meter software and change their settings "from below". Blockchain technology makes it possible to establish direct contractual relations between consumers and producers of electricity.

The key advantage of conducting transactions via blockchain is that all electricity supplied to the network can be uniquely distributed to the accounts of specific consumers in a very short time. In this case, billing for all generated and consumed electricity at variable prices can be very accurate. A simplified settlement process will reduce the amount of balancing energy charged to market participants. More complex smart distributed energy models are now integrated with electricity metering and remote data collection software.

Using blockchain together with the Internet of Things, big data, and machine learning will allow achieving the following system-wide effects: establishing civilized relations between all participants in the chain of electricity value-added generation and energy resource consumption; controlling the authenticity of the amount of energy resources submitted for payment by the supplier; saving budget and consumer funds for paying for resources; increasing the flexibility and efficiency of the country's energy system.

In various spheres of economic activity, directions for using blockchain technology have been formed, which can be implemented in the activities of participants in the energy system of Ukraine. Today, blockchain technologies are widely used in the system of relations with external participants in the energy system and in internal business processes of energy enterprises. In particular, blockchain is effectively used in managing the movement of goods and services, which allows you to reduce the time spent on tracking their trajectory.

As for the legal aspects of using blockchain technology, it is used to develop smart contracts, which reduces the time for concluding agreements. The use of blockchain technology will provide consumers with a higher level of transparency of transactions. Consumers have the opportunity to track the place of production of the electricity they purchase. The above examples of using blockchain in various sectors of the economy can be further used in the energy sector in the process of implementing the strategy of digitalization of business processes.

The use of blockchain in the energy sector is directly related to increasing the economic security of the activities of its participants, as it allows reducing losses in the electricity supply chain, providing early warning of technological equipment breakdowns, increasing the level of transparency of activities, reducing costs for repairing energy equipment, increasing the efficiency of activities, etc.

The existing centralized power supply system has significant shortcomings, as electricity losses reach 30–40% per year, the cost of services is constantly growing. The accounts receivable of energy system participants is growing. In addition, the costs of enterprises to ensure the operation of a single energy system are increasing. The main reasons for these problems were outdated electricity generation technologies, a significant share

of material-intensive production technologies (thermal power plants, CHP), the absence of a system of strict control over electricity consumption, a decrease in the supply of highly qualified specialists with the necessary level of digital competences, etc. To avoid these shortcomings, the main vector of development of the world energy industry is the transition to distributed generation and the development of the Internet of Things. The introduction of smart meters and other Internet of Things technologies creates a huge market of real data that correspond to a certain point in time. Analysis of such data ensures uninterrupted operation of energy systems, increases the accuracy of building predictive models. Increasing the efficiency of energy infrastructure directly depends on its reliability. Data verification and integrity functions are best implemented on the basis of a distributed ledger.

The construction of distributed generation plants creates a new market model where consumers can also be electricity producers and all participants freely exchange energy resources and services.

Drones and robots in the energy sector help to visually inspect energy facilities and eliminate their breakdowns. In Ukraine, drones are actively used by DTEK, monitoring the state of the power grid, in nuclear generation, drones perform operations that are dangerous to the life of personnel. The use of drones allows you to increase the accuracy of damage detection by 5 times, and, accordingly, prevent repair costs, which increases the economic security of the enterprise. In addition, the use of drones has obvious time and personnel effects, as it allows you to increase the speed of inspection by 2-3 times and change the personnel structure, increasing the share of personnel with a set of digital competencies. The data obtained is analyzed in software complexes, which in turn determine the priority of repairing the detected damage. As a result, the risks of subjectivity in assessment, analysis and decision-making are reduced.

Drones have become widely used by almost all participants in the Ukrainian energy system. In solar energy, drones are used to monitor the temperature of the panel and transmit data to the control system, which allows you to prevent technical hazards, avoid the risks of breakdowns, and accordingly reduce the economic costs of generating enterprises. Special protected drones are used to assess the condition of chimneys and boilers of power plants, which have increased the level of safety of business operations at power plants by reducing the volume of traumatic and risky operations.

Digital technologies of the "Internet of Things" are gradually being introduced into the activities of energy enterprises (the software and hardware ability of devices to transmit data about their functioning to a remote information processing center with the possibility of remote intervention in the system in the event of failures, accidents or errors).

Digital transformations in the energy sector are also accompanied by the active use of robots, which are automatic devices and software processes designed to perform physically complex and toxic operations. Robots are actively used in solar and nuclear energy to control the functionality of energy equipment, take equipment readings, check the integrity of protective fences, etc.

Digital transformations in the energy sector have changed not only the business processes of energy market participants, but also influenced the organization of the system of relations between suppliers and consumers. "Smart networks", such as meters that automatically take readings in real time, have significantly increased the objectivity of information and provided control over the volume of electricity consumption in real time.

The use of artificial intelligence in the energy sector is an indispensable assistant for engineers. AI acquires, processes and applies information, creates special algorithms for analyzing big data.

In the energy sector, AI has been used both in technological processes and in the system of social relations. Thus, at Ladyzhynska TPP, artificial intelligence was used through video cameras to monitor the safety of workers, in particular, compliance with the availability of protective masks, gloves, and the facts of their stay in the danger zone. Based on specially developed algorithms, artificial intelligence collected information from digital cameras, analyzed and transmitted facts about violations to responsible persons. As a result of the use of artificial intelligence, the problem of violation of safety regulations at Ladyzhynska TPP was eliminated.

DTEK's digital transformation project envisaged changing the company's business model by implementing automated management programs for all business processes and was implemented in several stages:

1) implementation of digital security systems and increasing production efficiency;

2) modeling of field development and digitalization of management functions (procurement, analysis, information management);

3) digitalization of customer relations and renewable energy management processes [1].

DTEK's experience demonstrates the importance of digital transformation and the role of its scale in ensuring the sustainability and efficiency of the company's activities. After all, over the 19 years of its operation, the company has carried out a digital transformation of its business by creating a digital ecosystem.

The generalization of digitalization elements that ensure the activities of electric power enterprises in the digital economy and affect the state of their economic security allowed the formation of a system of priority (necessary) subsystems of digital transformation. Such subsystems include: digital ecosystem, digital culture, digital competencies of personnel, digital infrastructure, digital strategy (as the goal of digital transformation).

The digital ecosystem of an enterprise is a set of interconnected digital technologies, equipment, devices, digital structure, personnel, digital powers, a system of relationships, which is aimed at collecting digital data and, on their basis, managing operations and processes of the enterprise for the purpose of safe and effective functioning in conditions of dangers and risks for the enterprise's activities. The concept of a digital ecosystem is not new in economic science, but it has not acquired applied significance and is not characterized by the depth of scientific development. Thus, in [2] a broad understanding of the concept of a digital ecosystem is given, but technical content is embedded in it. The importance of the concept of a digital ecosystem and its economic content is evidenced by the interest shown in it at the World Economic Forum in Davos, where a digital business ecosystem was defined as interactions between hierarchically non-subordinate organizations based on digital platforms.

By generalizing the concepts of a digital ecosystem provided by world leaders in the field of management consulting [3] and startup management [4], Blagomyr L.M. summarizes the following components of an enterprise's digital ecosystem: digital application developers; the digital platform itself; the business ecosystem or the availability of opportunities for commercialization of innovative developments [5].

The European Commission, in the EU Skills Pact "Skills Partnership for the Digital Ecosystem", published on July 18, 2022 [6], presents three main subsectors of the digital ecosystem, which include: information and communication technology manufacturing, ICT and telecommunications services.

Based on the analysis of existing studies of the digital ecosystem, it is worth emphasizing that most of them develop the concept of a digital ecosystem based on the technological coherence of participants in the chain of formation of added value of digital products.

The most complex of the three presented ways of digital transformation of a company is the formation of its own digital infrastructure (creation of a department of IT product developers). An example of a company with its own infrastructure for digital transformation is DTEK, which in 2018 created the Innovation DTEK directorate, and in 2019 launched a digital transformation program called MODUS.

The hostilities affected the stability and efficiency of the DTEK holding company, but did not stop its confident progress towards digital transformation. Thus, according to the Ukrainian IT Association, the IT company Modus X introduced a new industrial IoT platform (Internet of Things) for the DTEK group of companies in February 2024.

"The IoT platform transforms the power plant and solves complex problems, namely:

• Predictive analytics – by anticipating accidents and emergencies, the platform acts as a proactive shield, preventing potential problems in thermal and hydraulic power plants.

• Renewable energy monitoring – the platform provides integrated monitoring of solar and wind power plants, revealing the potential for effective management and optimization of their operation.

• Imbalance analytics – the platform's ability to maintain a stable balance between green energy sources increases the overall efficiency of electricity production.

• Predictive analytics for a greener future – the platform provides high-quality forecasts for electricity production in solar and wind power plants, contributing to strategic planning and sustainable production" [6].

An element of the process of digital transformation of an enterprise is the formation of a digital culture. In the scientific literature, the concept of digital culture is interpreted mostly as an element of the culture of user behavior in the digital and electronic environment. Taking into account the fact that an enterprise is people, objects and means of labor, united by functional processes to achieve common goals, and corporate culture is a type of behavior of the enterprise's personnel, which is formed on the basis of established standards, rules, knowledge and skills, processes, digital culture is an element of corporate culture, this is a type of behavior of personnel, which is based on the awareness of the value of digital processes in creating added value and increasing the efficiency of its activities. The elements of digital culture are: digital competencies of personnel, awareness of inclusion and involvement in the processes of digital transformation. R. Gyr includes the following two elements: digital solutions in all areas of activity; digital software products; data analysis technologies (AI, machine learning, etc.); digital infrastructure [7].

The use of digital products requires appropriate legal support for their implementation, in particular, it concerns the conclusion by enterprises of contracts with the copyright holders of these products for their legal use and payment of the necessary payments. Any program that will be used to improve the management of business processes at the enterprise has copyright holders. It is worth noting that today IT consumers satisfy their needs for digital technologies in various ways: on the basis of direct contracts with manufacturers (purchase of IT products); by outsourcing (purchase of IT services); by creating their own development departments (development of innovative IT products). For enterprises of the energy sector of Ukraine, the use of various of the above methods is characteristic.

At the legislative level, regulatory legal acts related to the digitalization of the Ukrainian economy have been adopted and are being implemented, in particular, the Law of Ukraine "On Stimulating the Development of the Digital Economy in Ukraine" [8], the Law of Ukraine "On Electronic Commerce" [9] and others.

According to the Digital Competency Framework [10], developed in 2019, digital competence is defined as "the ability to search, understand, systematize, evaluate, create and disseminate data using digital technologies". The requirements for the set of digital competencies of personnel are different and are determined by:

– the type of economic activity of the enterprise;

– the functional obligations of the employee of the enterprise;

– the level of digitalization of the enterprise's business processes;

– the technological structure of production at the enterprise;

– strategic guidelines for the digital development of the enterprise.

In the context of this study, it is worth noting that the product created in the Ukrainian energy system is neither high-tech nor innovative, but one that has retained its form and functionality since its invention by Thomas Edison. The processes of electricity production also remain practically unchanged. However, despite such product stability, energy enterprises in Ukraine are high-tech due to the widespread implementation of innovative processes based on digital technologies to ensure electricity production. Taking into account the role of the participant in the energy system (type of generation, distribution, supply), the requirements for advanced (advanced) competencies of personnel will be different. Instrumental competencies and the attitude of personnel to digitalization at energy enterprises are determined by the basic set of requirements for the user of digital infrastructure.

The method of forming the necessary set of advanced skills for the implementation of the relevant digital competencies is:

1) hiring personnel with a ready-made set of instrumental and advanced skills and knowledge;

2) using the services of recruiting companies to search for personnel who possess the necessary advanced skills;

3) training and improving the level of digital instrumental and advanced knowledge and skills.

A mandatory element of the digital transformation of energy enterprises is the formation of digital infrastructure. Digital infrastructure is a set of technologies, products and processes on a digital basis that serve the processes of production, management and sales of electricity [11]. The components of the digital infrastructure of an energy enterprise are: infrastructure for implementing the "Internet of Things"; infrastructure for controlling technological equipment and performing individual operations (drones, robots, artificial intelligence); infrastructure for computing, virtualization and data storage) (cloud and on-premises technologies); cybersecurity infrastructure; network infrastructure ("smart" network); client infrastructure (applications, chatbots, websites); blockchain infrastructure; big data analysis infrastructure; infrastructure for machine learning and machine interaction.

The digital infrastructure is formed for specific tasks of digital transformation and stages of its implementation. The higher the level of digital transformation, the more complex the digital infrastructure and digital competencies of the enterprise's personnel.

The digital infrastructure and digital competencies of the personnel are formed as tools for implementing the enterprise's digital strategy. The concept of "informatization strategy" appeared in the scientific literature in the 1980s, and the interpretation of the essence of "digital business strategy" was proposed in 2010 by S. Mitas and G.S. Lucas [12]. According to the authors, digital strategy is the digitalization of organizational processes, business models, and customer interaction. S. Mitas and G. S. Lucas emphasized that digital strategy is one of the functional strategies that are developed within the framework of the implementation of the enterprise's corporate strategy.

At the moment of digital evolution in economic science, the digital strategy of an enterprise is interpreted as a plan for using digital technologies in business. Analysis of the stories of digital transformations at energy enterprises revealed their longevity, dynamism and permanence. The longevity of digital transformation is due to the presence of a number of factors that shape it, in particular:

1) the period between the owner's consent and the accumulation of funds for the project;

2) the period between making a decision and finding a developer. The duration of this period depends on the complexity of the digital infrastructure being implemented;

3) the period between concluding a contract with the developer and signing the act of work performed.

Conclusions. The functioning of energy enterprises in the current rapid development of digital technologies is complicated by the need to quickly adapt to changes in the security situation in the country. It can be argued that digital transformations are taking place at different enterprises within the framework of the implementation of different digital strategies. Digital transformations and their implementation provide, first of all, the opportunity to scale the company's activities, reduce the costs of managing business processes, and increase the level of service to the end consumer of electricity.

The dynamism of digital transformation lies in the dependence of digital processes at enterprises on the state of development of the information technology sector. In addition, the gradual development of new IT leads to rapid obsolescence of digital software products and the need to replace them with new ones. The incompleteness of digital transformation processes is due to the fact that the rapid development of IT encourages the constant development of the digital infrastructure of the enterprise. Promising avenues for further research include the study of the EU energy market and regulatory framework for the implementation of digital transformations, and the study of managerial approaches in the management of energy enterprises.

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