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USING DIGITAL TECHNOLOGIES IN ENERGY INDUSTRY

Abstract

Within the framework of one of the main directions of the implementation of the state program “Digital Kazakhstan”, the digitalization of the economic sectors is envisaged, the tasks of which include the construction and effective functioning of an intelligent energy system. The modern global economy is undergoing a cultural shift towards digital transformation, where the main processes are being transferred to digital businesses, which are providing technical optimization, new revenue streams and opportunities for creating value. The authors of the article consider the issues of introducing digital technologies into the activities of enterprises in the energy industry. It is noted that, despite the understanding of the relevance of digitalization, the digital maturity of industry enterprises is still insufficient, which increases the importance of combining industry enterprises in a consortium. This article substantiates the use of digital technologies in the energy sector to solve traditional problems: coverage of services of energy companies in all regions of the country, ensuring an uninterrupted and sufficient volume of energy supply services, reducing the price level and protecting the environment. The authors identified and substantiated the main factors of the digital transformation of energy systems: digitalization, decentralization and decarbonization. The article formulates the criteria for the transition of an enterprise to the digital status and notes its advantages. The article outlines the main digital transformation technologies and their application features: artificial intelligence, blockchain, Big Data and data management. It presents the facts of foreign practice of digitalization of the energy industry.

Key words: digitalization, energy industry, digital transformation, digital technologies, intelligent power system, power supply, consortium.

The development and survival of modern enterprises nowadays is largely due to the degree of their digital processing, which is defined as the use of digital technologies to change business processes and increase efficiency and income; it is the process of going digital. It is customary to distinguish it from the concepts of “digitization” and “digital transformation”. Digitization is the process of going from analog to digital (digital inclusion). In other words, digitization takes an analogue process, and converts it to digital form without any changes in the essence of the process itself. Digital transformation is about using digital technologies to change the business model for generating new income and creating possible value [1].

The use of digital technologies allows companies to optimize resource conservation, reduce costs, increase labor productivity and employee efficiency, optimize the supply chain, and increase customer loyalty and satisfaction [2].

Digital transformation of a business is seen as a set of seven elements, which includes:

- ◆ business model;
- ◆ organizational structure;
- ◆ digital skills of employees;
- ◆ digitization of business processes;
- ◆ IT infrastructure;
- ◆ digitization of goods / services;
- ◆ digital channels for customer interactions.

Leaders in most industries are forced to acknowledge the shift in the role of digital technology from marginal efficiency to fundamental innovation. Digitalization has become the basis for large-scale and radical transformation in many aspects of business.

In 2015, the World Economic Forum, as part of the Internet Global Challenge of the Fourth Industrial Revolution, launched a large-scale Digital Industry Transformation (DTI) project. The main

idea of the DTI project is the cooperation of all stakeholders to obtain maximum benefits, both for society and for business over the next decade as a result of the digital transformation of economic sectors [3].

Moving to digital enterprise status requires more extensive changes than just investing in the latest digital technologies. The digital enterprise is constantly striving to implement new and more cost-effective operating models based on flexible business processes and connecting platforms for analytics and collaboration capabilities that increase business efficiency. The digital enterprise identifies and develops new digital business models that are a customer and employee focused.

To ensure the success of digital transformation, it is necessary to create a new corporate culture at the enterprise with the involvement of each employee in the goals and vision of the organization, to encourage collaboration based on departmental teams.

For the energy industry, digitalization is a new direction that requires collective implementation across the entire industry, and not just at individual enterprises. The formation of a digital consortium will allow the industry obtain to many synergistic and advantages effect, which are especially important in an environment where there is a gap between digital technologies and organizations that implement them.

The modern energy sector is rapidly changing due to the need to reduce emissions, the transition to renewable energy sources such as wind and sun, the consumption of which is growing exponentially. By 2050, according to forecasts, electricity production from non-carbon resources will account for almost 70% of total volume. In addition, transport will be electrified [1].

Such dramatic changes in the energy system are made possible by advances in digital technologies, or rather, under the influence of three powerful trends: the emergence of digital technologies (digitalization), making more affordable through the distribution system (decentralization) and decarbonization through renewable energy sources and increasing efficiency (Figure 1). These factors are changing the global energy demands towards smaller, cleaner and smarter technologies, amid past demand for energy services.

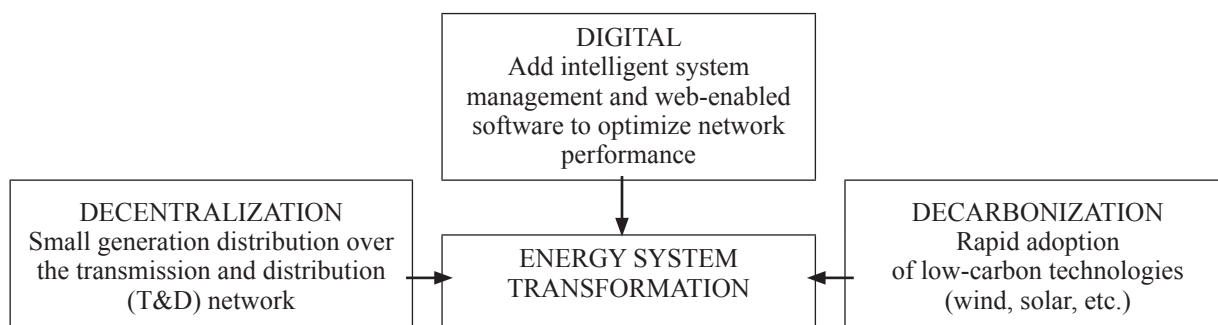


Figure 1 – Factors of transformation of the energy system

Note – Compiled by the authors based on [4].

The concept of a control system for industrial equipment via the Internet (IoT – Internet of Things) was first developed in 1994. Its main idea was to connect sensors to common objects of the system for its connection to the Internet [4]. Improvement of information technologies has allowed the industry to expand the range of applications and their potential for optimizing the energy industry: operation and management of T&D (transmission and distribution) networks, improvement of the characteristics of individual power units and vehicle fleets, optimization of hybrid micro-network systems that help save costs and resources, optimization asset performance. And the maximum of efficiency of integrated energy systems. As modern energy systems become more and more hybrid, the importance of digitalization will only grow. The digitalization of energy provides new opportunities for both consumers and businesses in the electricity value chain. For example, touch lighting, smart controls, and a host of new technological software are helping commercial buildings, retail and industrial sites evolve into smart environments.

The key driving force behind digitalization is the increasingly diverse nature of power generation. It has a number of important characteristics that open up new business opportunities. Electricity is being produced in the distribution network at more nodes than ever before. Currently energy is often intermittent and poorly matched to demand. The nature of the energy produced creates power quality problems at the national and local levels, which requires more attention to the regulation of the frequency, voltage support and local grid overloading. This in turn limits management and reserve capacity. Therefore, a growing international trend is a tendency for the formation of small, decentralized power systems that satisfy local needs for electricity. The number of solar PV and wind systems is growing, especially in remote regions. The increase in combined heat and power generation, trigeneration mode and distributed technologies increases the operating efficiency up to 90%.

The advantageous aspect of distributed power systems is their ability to meet the requirements of industrial production processes for heating and cooling as well as steam requirements. A significant role in ensuring more affordable modular energy is through decentralization of stored energy in energy systems from variable sources of generation and emissions during periods of peak demand. The time shift capability allows fewer distribution systems to meet a wider range of needs. In addition, the growth of distributed generation contributes to the reduction of intermediary costs in energy trade. A practical solution to how discontinuous small-scale generation can be integrated into the system at low intermediate costs is peer-to-peer electricity trading (P2P) [5].

The world community is facing a serious and urgent global problem of the growth of carbon dioxide emissions, affecting climate change. The solution to this problem lies in decarbonizing the global energy system, which produces 42% of all carbon dioxide emissions. Thus, the use of less carbon-intensive resources allowed the United States to achieve a 25-year minimum of greenhouse gas emissions in 2017 [4]. In addition, decarbonization is fueled by innovation in increasing the productivity of renewable energy technologies and reducing their costs. For example, as the amount of electricity generated increases, the cost of wind energy has dropped from \$ 150 per MWh in 2005 to \$ 50 per MWh in 2018. Over the past five years, the installed cost of solar energy has decreased by about 60%, which is the result of a combination of innovation and the rapid expansion of global capacity, for the production of photovoltaic solar cells [4].

According to the forecasts of the Institute for Energy Research of the Analytical Center under the Government of the Russian Federation, the use of non-carbon energy resources will grow rapidly until 2040 and will provide more than 40% of the increase, and electricity production in developed countries will be more focused on gas and non-carbon generation, while developing countries will continue to be heavily dependent on coal (with all environmental implications) [6].

The fourth industrial revolution blurs the boundaries between the physical and the digital world, it is causing a fundamental shift in energy and the displacement of traditional market players.

While certain technologies are considered mainstream, such as cloud computing, the potential of technologies such as blockchain remains untapped. In addition, there is a gap between reality and the perceived energy impact these technologies can have.

According to foreign experts, despite the existing emphasis on digitalization as the main strategy, only 20% of organizations can be classified as advanced in this aspect [1].

This is especially significant when it comes to understanding and applying new technologies such as blockchain. The upcoming changes in the industry require a willingness to create a more customer-centric, sustainable and efficient operating model, defined by the following parameters: smart energy, smart operations and smart customers.

To enable digitization, the industry needs people with advanced data skills, knowledge of hardware, software, data analysis, process understanding and data interpretation capabilities.

The power system as a complex structure faces the challenge of providing power supply reliability in the presence of complex algorithms and equipment, subject to operational risks in real time. Due to the intrinsic complexity of physical electrical networks, even slight fluctuations can cause massive problems. Therefore, the practical design of a power system requires detailed research and proper design to reduce uncertainties.

Artificial intelligence and other digital technologies can become powerful tools for solving such problems. Intelligent systems help decision-makers make more complex choices in the design, construction, operation and maintenance of electrical grids.

According to the World Economic Forum, the global electricity sector is in need of accelerated digital transformation, requiring more than \$ 1.3 trillion for the industry and \$ 1.7 trillion for global reach from 2016 to 2025. Some social impact is expected in terms of customer value creation (nearly \$ 1 trillion), carbon emissions reduction (nearly \$ 750 billion) and job creation \$ 270 billion) [7].

The electricity industry has three challenges.

1. Revise the design of the power system, taking into account short-term digital and technological innovations, including forecasting and energy storage.

2. Provide the necessary infrastructure to meet future energy demand.

3. Identify the business and operating models to ensure that energy companies receive a greater share of the profits outside the industry pool.

Experts estimate that the total savings from these activities could be in the order of US \$ 80 billion per year over the 2016–2040 period, or about 5% of the total annual electricity generation costs, based on the expanded global deployment of affordable digital technologies for all power plants and infrastructure networks [8].

In this way, digitalization in the energy sector, the main goal of which is to increase the efficiency of the network through better and faster monitoring, ensuring effective exchange of controlled workflow, recovery and maintenance of assets using “smarter” networks, involves the creation and use of computerized information and traffic, as well as the coordination, transmission, processing and storage of huge amounts of data generated at all stages of the energy supply chain, which is very significant for each segment of the energy ecosystem.

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ЭНЕРГЕТИКАЛЫҚ КӘСІПОРЫНДАРДА ЦИФРЛЫҚ ТЕХНОЛОГИЯЛАРДЫ ҚОЛДАНУ

Аңдатпа

«Цифрлық Қазақстан» мемлекеттік бағдарламасын іске асырудың негізгі бағыттарының бірі шеңберінде зияткерлік энергетикалық жүйенің құрылысы мен тиімді жұмыс істеуі кіретін экономика салаларын цифрландыру қарастырылған. Қазіргі жаһандық экономика цифрлық трансформацияға мәдени ауысуды бастан кешіруде, негізгі процестер цифрлық бизнеске ауысуда, техникалық оңтайландыру, кірістердің жаңа ағындары және құндылық құруға мүмкіндіктер қарастырылған. Мақала авторлары цифрлық технологияларды энергетика саласындағы кәсіпорындардың қызметіне енгізу мәселелерін қарастырады. Цифрландырудың өзектілігін түсінгенімен, салалық кәсіпорындардың цифрлық жетілуі әлі де жеткіліксіз екендігі атап өтіледі, бұл салалық кәсіпорындарды консорциумға біріктірудің маңыздылығын арттырады. Бұл мақала дәстүрлі мәселелерді шешу үшін энергетика саласында цифрлық технологияларды қолдануды негіздейді: елдің барлық аймақтарындағы энергетикалық компаниялардың қызметтерін қамту, энергиямен жабдықтау қызметтерінің үздіксіз және жеткілікті көлемін қамтамасыз ету, баға деңгейін төмендету және қоршаған ортаны қорғау. Авторлар энергетикалық жүйелерді цифрлық қайта құрудың негізгі факторларын анықтады және негіздеді: цифрландыру, орталықсыздандыру және декарбонизация. Мақалада кәсіпорынның цифрлық мәртебеге көшу критерийлері тұжырымдалған, оның артықшылықтары атап өтілген. Мақалада цифрлық трансформацияның негізгі технологиялары және олардың қолдану ерекшеліктері көрсетілген: жасанды интеллект (Artificial Intelligence), блокчейн, үлкен деректер (Big Data) және деректерді басқару, энергетика саласын цифрландырудың шетелдік тәжірибесінің фактілері келтірілген.

Тірек сөздер: цифрландыру, энергетика саласы, цифрлық трансформация, цифрлық технологиялар, жасанды энергожүйе, энергиямен жабдықтау, консорциум.

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ПРИМЕНЕНИЕ ЦИФРОВЫХ ТЕХНОЛОГИЙ НА ЭНЕРГЕТИЧЕСКИХ ПРЕДПРИЯТИЯХ

Аннотация

В рамках одного из основных направлений реализации государственной программы «Цифровой Казахстан» предусмотрена цифровизация отраслей экономики, в задачи которой включены построение и эффективное функционирование интеллектуальной энергосистемы. Современная мировая экономика переживает культурный сдвиг в сторону цифровой трансформации, основные процессы переводятся в цифровой бизнес, обеспечивая техническую оптимизацию, новые потоки доходов и возможности создания ценности. Авторы статьи рассматривают вопросы внедрения цифровых технологий в деятельность предприятий энергетической отрасли. Отмечается, что, несмотря на понимание актуальности цифровизации, цифровая зрелость предприятий отрасли еще недостаточна, что усиливает значимость объединения предприятий отрасли в консорциум. В данной статье обосновывается использование цифровых технологий в энергетике для решения таких традиционных проблем, как охват услугами энергетических компаний всех регионов страны, обеспечение бесперебойного и достаточного объема услуг энергоснабжения, снижение уровня цены и защита окружающей среды. Авторами определены и обоснованы основные факторы трансформации энергетических систем: цифровизация, децентрализация и декарбонизация, сформулированы критерии перехода предприятия в статус цифрового, отмечены его преимущества. В статье обозначены основные технологии цифровой трансформации и особенности их применения: искусственный интеллект (Artificial Intelligence), блокчейн, большие данные (Big Data) и управление данными, приведены факты зарубежной практики цифровизации энергетической отрасли.

Ключевые слова: цифровизация, энергетическая отрасль, цифровая трансформация, цифровые технологии, интеллектуальная энергосистема, энергоснабжение, консорциум.