ISSN 1648-2603 (print)
ISSN 2029-2872 (online)

VIEŠOJI POLITIKA IR ADMINISTRAVIMAS
PUBLIC POLICY AND ADMINISTRATION
2020, T. 19, Nr. 2 / 2020, Vol. 19, No 2, p. 191–204.

DIGITALIZATION OF THE ENERGY INDUSTRY AS A DIRECTION FOR ENSURING THE GROWTH OF ENERGY EFFICIENCY AND THE ENERGY SECURITY OF THE STATE

Ivan Kapitonov

Higher School of Tariff Regulation
Plekhanov Russian University of Economics
117997, 36 Stremyannyi Lane, Moscow, Russian Federation
Department of Energy Policy
Institute of Economics of the Russian Academy of Sciences
117218, 32 Nakhimovsky Ave., Moscow, Russian Federation

Vladimir Voloshin

Department of Energy Policy
Institute of Economics of the Russian Academy of Sciences
117218, 32 Nakhimovsky Ave., Moscow, Russian Federation

Tatiana Filosofova

Institute of Trade Policy
National Research University Higher School of Economics
101000, 20 Myasnitskaya Str., Moscow, Russian Federation

Dmitry Syrtsov

Department of Applied Economics
National University of Science and Technology MISiS
119991, 4 Lenin Ave., Moscow, Russian Federation

DOI: 10.13165/VPA-20-19-2-03

Abstract. *Issues of the efficiency of the energy industry are connected with the high cost of energy resources and the negative impact that generating energy has on the environment. The energy industry-related security of the state is closely associated with addressing the demand for domestic energy generation, including the security of such generation. Digitalization in the energy industry is aimed at solving these problems, allowing us to increase efficiency and subsequently improve the security of the electric energy industry. The purpose of this paper is to analyze and identify the directions for the development of digitalization* *in the energy industry in Russia as a direction of its overall development, ensuring the growth of energy efficiency and of the energy security of the state. It was determined that the "fourth energy transition" is currently taking place globally, being associated with the aim of increasing energy efficiency alongside the digitalization, decentralization, and decarbonisation of energy industry.*

Keywords: *energy industry digitalization, energy efficiency, energy security, information systems.*

Raktiniai žodžiai: *energetikos pramonės skaitmeninimas, energijos vartojimo efektyvumas, energetinis saugumas, informacinės sistemos.*

Introduction

The electric energy industry is one of the most important sectors of the economy, and the development of industries, trade, services, and transport, including the quality of life of the population, depend on the functioning of this industry. It also determines the security of the state. In a modern context, increasing the efficiency of the energy industry while reducing resource costs for energy generation, including reducing emissions of greenhouse gases into the atmosphere, has become an urgent issue. At the same time, it is crucial to ensure the security of states' energy industries when the energy industry and system is capable of producing the volumes of energy necessary for the economy, as well as ensuring that the generation, transportation, and subsequent consumption of energy is technically safe for both the producers and consumers as well as the environment. This is why the issues of energy efficiency and energy safety are of particular relevance. Digitalization in the energy industry sector, as the most important area of modernization, is aimed precisely at improving both energy efficiency and security.

The purpose of this paper is to analyze and determine directions for the development of digitalization in the energy industry sector of Russia as a direction of its overall development, ensuring the growth of energy efficiency and the energy security of the state, specifically, the Russian Federation. Accordingly, the target of this research is the energy industry sector (the electric power industry and the production, transportation, and distribution of electric energy) in the Russian Federation.

Literature Review

In scientific literature, energy efficiency is understood to be the use of less fuel or the reduction of fuel costs to generate the same amount of energy, or the use of less energy for the same utility or production tasks. Energy efficiency is aimed at both reducing resource consumption and increasing the quality of the final product – that is, the energy generated (Shamarova 2015; Sergeev 2013).

It is noted that energy efficiency is a growing process of energy conservation that is decreasing in cost terms (Daus et al. 2018). Its use is increasingly motivated by positive external factors, but is held back by strong and complex market failures which often require political intervention and business innovation (Lovins 2018). M. Du, B. Wang, and N. Zhang (2018) indicate that improving energy efficiency is critical to saving energy and reducing pollutant emissions. Increased investment in basic research can promote innovative energy technologies that increase energy efficiency.

The term *energy security* appeared after the 1973 oil crisis, and is defined as "confidence that energy will be available in the quantity and quality that are required under given economic conditions" (Sviderskaya 2017). If we summarize the definitions of such scientists as T. Fang (2012), E. Kiriyama and Y. Kajikawa (2014), A. Azzuni and C. Breyera (2018), we can conclude that energy security is a threat to a country's fuel supply, and it may be related to a dependence on fuel imports in general, and the share of imports from individual countries in particular. Digitalization of the energy sector involves the introduction of a risk-based management model based on digital technologies to minimize the total cost of ownership in the electric power industry, so as to reduce the working cost of kilowatt-hours for a given level of reliability and an acceptable level of tariff load (Grabchak 2018).

Digital transformation in the energy sector helps to create a single information space "as an environment and a common language of interaction for various platforms and technologies" (Samarin et al. 2019). S. Kloppenburg and M. Boekelo (2019), upon describing the possibilities of energy digitalization, consider the possibility of using digital platforms that allow us to factor in the electricity flows, ensure that consumers buy energy from different suppliers, and transfer energy from "home" generation (for example, from solar or wind generators) into a common grid, thereby effectively using this energy and minimizing its losses (which is not possible when charging and storing batteries) whilst receiving certain charges for this from the network company.

T. S. Remizova and D. B. Koshelev (2018) point out that digitalization in the energy industry sector should be aimed at "creating a digital infrastructure (creating digital substations, digital power distribution zones, digital smart metering devices, etc.) and a smart digital infrastructure management system." The purpose of all of this is to increase the observability and controllability of the energy industry system. A. Booth, P. Peters, and de E. Jong (2018) indicate that the digitalization of energy generation helps in saving generating capacities from overloads, and allows the energy consumers to add power if necessary, since during peak hours such systems themselves change energy flows by buying additional energy – this, in particular, is the basis for the work of "virtual power plants."

The use of the digital energy industry also facilitates control of the use of energy feedstock. A. V. Goncharuk (2018) considers the use of blockchain in nuclear energy, when "in the form of transactions it would be possible to record the entire life cycle of fissile material with an indication of quantitative characteristics and isotopic composition."

Materials and Methods

The analytical part of the study conducted in this paper is based on the study of statistical data directly related to the issues of energy efficiency of Russia, the energy security of Russia, and digitalization in the field of the energy industry in Russia. Based on statistics, it is proposed to study the following: the dynamics of electricity production; energy capacities; the structure of energy generation and energy capacities; the volumes of electricity consumption, losses, exports, and imports; and the share of electricity losses, including the monetary value of electricity losses in Russia. It is also necessary to study qualitative characteristics related to the development of digital technologies in the energy sector, including the quality of grid infrastructure in Russia and pilot projects associated with the implementation of digital technologies in the energy sector in Russia. The period studied is 2014–2018.

The analysis of statistical indicators (quantitative analysis) involves the use of a dynamic analysis of: indicators of electricity generation in Russia; purchase and sale of electricity by the Russian Federation; indicators of electricity losses; and indicators (absolute and cost) related to the development of digitalization in Russia. Qualitative analysis involves the study of the main problems of the development of the energy industry in Russia in a modern context, including the issues of creating and developing digital technologies in the energy sector in Russia at the present stage.

Methods of horizontal and vertical analysis were applied in the analysis of statistical data (the analysis of dynamics, namely, growth and increment rates and absolute changes; and structure analysis, respectively). During qualitative analysis, reports on the development of renewable and alternative energy in the world, the European Union (EU), and Russia were used, and decisions of authorities on the support and application of various regulatory tools for the development of this field were then compared.

Results

First and foremost, it is necessary to present the dynamics of electricity generation in Russia, including the structure of this generation and the change in the power of power plants (Table 1):

Table 1. **Electricity production and capacity of power plants in the Russian Federation in 2014–2018**

Indicators	2014	2015	2016	2017	2018	Increment, %
Electricity production, billion kWh	1,064.2	1,067.5	1,091.1	1,094.3	1,112.9	4.58
Thermal	707.1	700.8	706.0	703.1	713.2	0.87
Hydro	175.2	170.0	187.0	187.1	193.3	10.32

Indicators	2014	2015	2016	2017	2018	Increment, %
Atomic	181.2	195.8	197.0	203.0	204.8	13.04
Renewable energy	0.7	0.9	1.1	1.1	1.6	127.86
Power plant capacity, million kW	255.9	257.0	266.5	272.4	276.3	7.98
Thermal	179.4	179.1	187.6	190.6	190.1	5.96
Hydro	50.8	51.0	51.0	53.2	55.0	8.24
Atomic	25.3	26.3	27.2	27.9	30.1	18.97
Renewable energy	0.4	0.6	0.7	0.7	1.1	183.59

As demonstrated in Table 1, over five years electricity production increased by 4.58%, including the highest increment – for renewable energy, the second highest – for nuclear power plants, and the third highest – for hydroelectric power stations. The table also displays that the capacity of power plants increased by 7.98%. A particularly significant increase in capacity is evident in renewable energy, but capacity in nuclear power plants and hydroelectric power plants has also grown significantly (higher than in thermal). If we consider the structure of generation and capacity for 2018, it can be represented in the form of a graph (Figure 1).

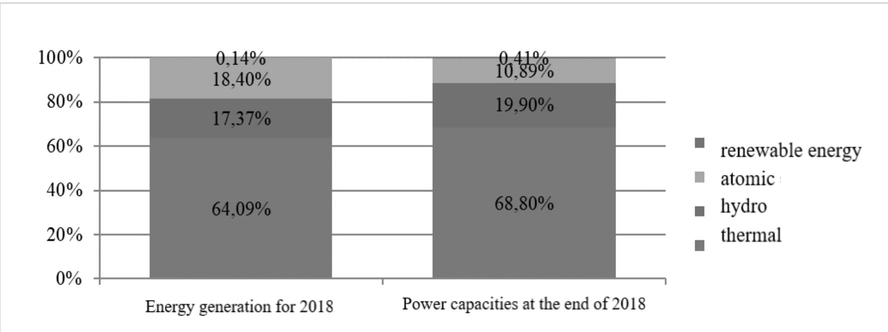

Figure 1. **The structure of energy capacity and electricity generation in the Russian Federation in 2018**

So far capacity and generation are, to a greater extent, associated with thermal power plants, although the shares of nuclear and hydroelectric power stations have become quite large, and the share of renewable energy sources is still extremely low. It is necessary to assess the energy efficiency of the generation itself by means of data on the consumption of equivalent fuel units for the generation of 1 kWh of electricity at power plants (Figure 2).

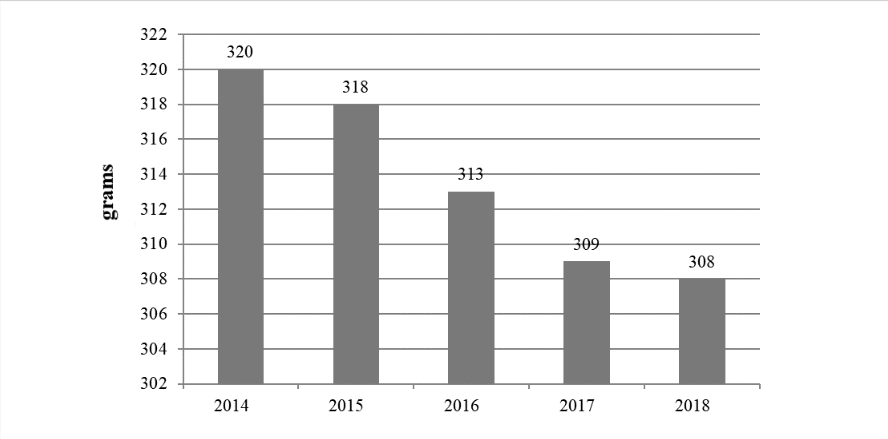

Figure 2. **Specific reference fuel consumption per one kilowatt-hour of electricity supplied to public power plants, per year**

The decrease in specific consumption is associated with changes in the generation structure (faster growth of nuclear and hydropower industries, including renewable energy), with a change in the fuel balance in the thermal power industry (a growing decrease in the share of coal with an increase in the share of natural gas), as well as with the replacement of obsolete equipment. In 2018 alone, according to the Ministry of Energy of the Russian Federation, the commissioning of new capacities at power plants amounted to 5,086.9 MW, including 4,792.1 MW of completely new capacity and an increase in installed capacity of 294.8 MW due to the modernization of equipment (Ministry of Energy of the Russian Federation 2019).

The change in the balance of production, trade, and consumption is presented in Table 2.

Table 2. **Indicators of electric balance of the Russian Federation in 2014–2018, billion kWh**

Indicators	2014	2015	2016	2017	2018	Increment, %
Produced	1,064.2	1,067.5	1,091.1	1,094.3	1,112.9	4.58
Import	8.9	8.8	3.5	6.4	6.5	-26.97
Export	8.1	16.1	16.0	11.6	12.9	58.98
Consumption (losses excluded)	958.1	953.6	971.2	983.8	1000.0	4.38
Energy losses	106.9	106.6	107.2	105.3	106.5	-0.39

As is evident from Table 2, electricity consumption in the Russian Federation is lower than production volumes, even factoring in energy losses. With that, imports are much lower (almost half) than electricity exports. Imports are also associated with the purchase of energy in border regions (mainly in the CIS countries). Coverage of energy consumption by internal production, along with a significant excess of electricity exports over imports in Russia positively characterizes the country's energy security. It is important to note that, over the period studied, energy production increased by 4.58% and consumption by 4.38%, with a 26.97% decrease in imports and an increase in exports by 58.98%. However, electric energy losses decreased only by 0.39%.

A significant part of consumption (over 76%) is consumption for production needs (most of which, as follows from the statistics reports, is for manufacturing, mining and energy). In 2018, only 14.28% accounts for consumption by the population. With that, a significant part of the energy is accounted for by energy losses. This figure was 9.62% in 2018, a huge amount that is only slightly less than the energy consumed by the population. The reduction in the share of these losses from 10.04% to 9.62% is largely due to the development of grid infrastructure. With that, in 2018, according to the Ministry of Energy of the Russian Federation, transformer capacities of 13,303 MVA were commissioned (which is small, since it only amounts for 64% of the plan) along with a 29,965 km long electric grid (which exceeds the annual plan by 3%; Ministry of Energy of the Russian Federation 2019). In general, the depreciation of the grid infrastructure in Russia is quite high. According to the Ministry of Energy of the Russian Federation at the beginning of 2018, only 13.01% of grids (110 V electric energy transmission lines) are rated as being in very good condition, another 37.40% as being in good condition, 31.71% are satisfactory, and 17.89% are in an unsatisfactory condition. With regard to the 220 V electric energy transmission line, the share of grids in an unsatisfactory state is slightly lower at 3.28%, but there 1.64% of grids are recognized as "critical." The grids in the worst condition are in the North Caucasus, the Urals, the Leningrad Region, the Tyumen Region, in the south of Russia, and in the Kaliningrad Region, including in the center of Russia. The worst condition can be found in the grids serviced by JSC MRSK Urala (Ministry of Energy of the Russian Federation 2018).

With that, the growing age of fixed assets along with the dynamics of energy demand necessitates the start of a new investment cycle in the electric power industry in 2022–2025 in Russia, as a significant modernization of capacities will be required. This is estimated to require around 200–250 billion US dollars (Knyaginin and Kholkin 2017)

The cost of electricity losses in 2018, with the average cost of 1 kWh of energy in Russia for citizens at 3.4 rubles, amounted to 362.1 billion rubles (3.4 ×* 106.5). If we compare this with the indicator in 2014, when the average cost of 1 kWh was 3.03 rubles, then the losses in 2014 amounted to 323.9 billion rubles (3.03 ×* 106.9). As a result, the increase in cash losses amounted to 38.2 billion rubles, i.e., losses increased by 11.79 %, which is significant. For comparison, the share of energy losses in other countries is much lower. Figure 3 presents statistical indicators of energy losses from grids in 2018 in Russia and a number of other countries.

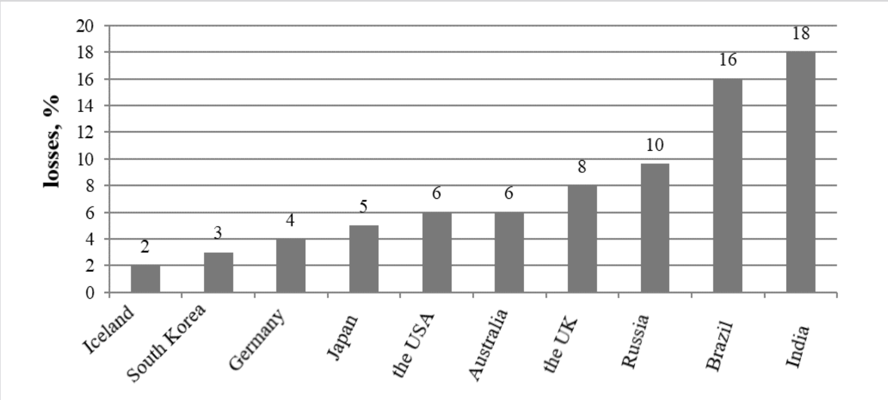

Figure 3. **Energy losses from grids in Russia compared to other countries in 2018 (share, %)**

The development of digital technologies contributes to the reduction of energy losses (both from the standpoint of energy metering and from the standpoint of monitoring grids and emergency situations). The active digitalization of electric grid infrastructure is performed in Europe. For the development of smart grids, it is planned to replace at least 80% of electricity meters with smart meters in 2020. The European Commission notes that the use of smart meters and grids will help reduce the annual consumption of primary energy in the EU by 9% in 2020, and reduce carbon dioxide emissions into the atmosphere. The realization of these goals will require financial support for research and development in the energy sector. Currently, the EU provides funding for approximately 30% of digital grid projects in Europe. By 2018, EU countries had deployed over 650 new projects for the implementation of "smart grids,", for a cost of over 2.82 billion euros. From 2010 to the present, ongoing projects are being expanded. Most of these projects are implemented in Germany (140) and Denmark (105). In some countries of the EU, individual programs for supporting the development of intelligent grids are being adopted. Thus, Germany, Great Britain, Denmark, France, Austria, Sweden, Slovenia, and Ireland adopted roadmaps and strategies in this field back in 2011–2014. All of these envisage government support, including financing. National strategies provide legal support that would guarantee the security of personal data and the technical readiness of grids, and set targets for the implementation of smart measuring instruments (Grigoryev 2017).

Intelligent grids are also actively being developed in the United States and China. Thus, in the USA about 50% of households are already covered by smart metering devices. Back in 2014, 358 projects in this field were announced in China, and by the end of 2016, 305 of them had already been implemented. Since 2017, growth in investments in digital energy facilities is expected to exceed 77.6 billion US dollars for 10 years. Already by 2018, the penetration rate of smart metering devices in China amounted to 95%. The developments in this area in China are also evidenced in the last two 5-year plans for the social and economic development of the People's Republic of China, and are thus supported at the state level (Grigoryev 2017).

For Russia, the digitalization of energy has become quite relevant, since it is associated with the course taken to develop the digital economy in the implementation of the Digital Economy of the Russian Federation program (approved by order of the Government of the Russian Federation dated July 28, 2017 No. 1632-p). Alongside this, one of the important tasks of the EnergyNet National Technology Initiative was the development of "reliable and flexible grids,", aiming to create competitive technological solutions by 2035. The roadmap of this initiative sets a course for the development of smart metering systems and energy flows, distributed automation systems, monitoring the operational status of energy equipment, the quality of energy supply, and the formation of a digital model for optimal power management. The development of such networking technologies is required to develop new markets where consumers can adjust their energy needs. For this, the network complex must be reliable, affordable, demonstrate minimal energy losses, and be adaptable to different types of energy sources and new participants in this market. Testing of intelligent technologies as part of the EnergyNet initiative involved the implementation of pilot projects in Kaliningrad and Sevastopol, and a number of other cities (Table 3).

Table 3. **Indicators of electric balance of the Russian Federation in 2014–2018, billion kWh**

Region and city	Project participants	Characteristics
Kaliningrad region, City of Kaliningrad	PJSC Rosseti (JSC Yantarenergo), Tavrida Electric	The Digital Power Distribution Zone project: started in 2014, the first stage (of three) has been implemented so far. Stage 1: automation of energy centers and grids (payback 7 years); Stage 2: implementation of intelligent accounting (payback 9 years); Stage 3: increase in the observability and controllability of network objects (grid monitoring) of 0.4–15 V; Expected results: 1) decrease in average recovery timepower supply by 1/5th (up to 49 min). 2) a reduction in the number of de-energized residents by 1/3rd (from 3,000 to 900)
City of Sevastopol	PJSC Rosseti, the administration of Sevastopol	The Digital Power Distribution Zone project: since 2017, the project roadmap has been signed and is in force, the implementation period is 2017–2025. Expected results: an increase in the reliability of the city's power supply, a fivefold reduction in the time for restoration work, a fourfold reduction in the number of de-energized residents of the city.

Region and city	Project participants	Characteristics
Republic of Bashkortostan, Ufa	BESK JSC, Siemens LLC	Intellectual accounting system implementation project (until the end of 2019, up to 35% of all accounting points are planned), grid automation, the use of smart grid elements in grid management (monitoring, accounting). Expected results: an increase in the reliability of power supply and reliability of grids, a decrease in the level of energy losses from 15.6% to 8.7%, improved grid automation (700 medium-voltage switchgears are being introduced), and a reduction in the cost of grid maintenance by up to 20%.
City of St. Petersburg	Lenenergo PJSC, Siemens LLC	Electricity power grid modernization project: an agreement was signed between the companies in 2016, work has begun. It is planned to modernize grids, introduce intelligent accounting and monitoring, smart grid elements.

Discussion

The acceleration of digitalization processes is, evidently, is a pressing need for Russia today. A study of analytical materials, in particular those prepared by Skolkovo experts, the Analytical Centre under the Government of the Russian Federation, and experts from the EnergyNet initiative, suggests that the so-called "fourth energy transition" is underway (Knyaginin and Kholkin 2017). The factors behind this transition are the commercialization of unconventional energy resources and technologies, including wind and solar power plants, energy accumulators, and more. The share of renewable energy (excluding hydropower) in the amount of energy consumed in the world is already more than 8% (Enerdata 2018), and is rapidly growing (in 2014 this was only 3%). To ensure the growth of national economies and accelerate economic growth, it is necessary to create universal access to affordable electricity, especially for industrial consumers. All of this is also closely related to the desire to ensure energy security by reducing dependence on imports of both energy and hydrocarbons for energy production in thermal power plants.

From a technological standpoint, the fourth energy transition is a global transformation of energy industry systems, which includes elements such as: energy efficiency; decarbonisation (reduction of greenhouse gas emissions of elements into the atmosphere); decentralization; and digitalization.

Before the start of a new large investment cycle in Russia, it is necessary to form a scientific, technological, and industrial base for innovative development within the framework of the new energy paradigm (the fourth energy transition). This will reduce the financial burden on consumers in the future (first and foremost, it is relevant for industrial consumers, especially energy-intensive industries), since tariffs will not be required due to the return on investment of energy companies. This return on investment will come about as it is possible to more efficiently manage existing capacities, reducing losses due to optimization of grid infrastructure and energy flows.

Therefore, the following areas should be prioritized: 1) the development of open modular digital platforms so as to organize cyberphysical systems and environments in the electric power industry on their basis; 2) the introduction of intelligent multi-agent control systems; 3) the creation and development of energy storage systems (both batteries for the domestic sector and large-capacity electricity storage systems, including in the hydrogen cycle); 4) the development of promising high-voltage and high-frequency power electronics; 5) the development of the IoT-technologies (digital transducers, sensors, actuators, and communication tools); 6) the development of digital financial technologies (blockchain, smart contracts, and decentralized autonomous organizations; Knyaginin and Kholkin 2017).

According to experts, whose opinion we support, this package of technologies will be fully formed, and will become the basis of the new electric power industry in Russia within the next 5 years. However, as noted by specialists, a change in the architecture of managing the retail energy market, the deregulation of economic relations between entities in it, the simplification of the interfaces of technological and informational interaction between distribution energy facilities and a single energy system, and the formation of mechanisms for distributing a systemic economic effect in the energy sector should also become determining conditions for Russia.

Conclusions

1. Digitalization in the electric power industry involves the development of digital technologies in the transmission of electricity, data on the expenditure (consumption) of electricity, and grid monitoring. Digitalization is aimed at increasing the reliability of the energy supply, reducing the time it takes to eliminate accidents, and reducing the potential for accidents themselves. Perhaps its most important purpose is to reduce energy losses in grids, and countries where the digitalization of the energy industry is developing more intensively than in Russia have achieved a decrease in these indicators to the point that they are now at a level half that of Russia.
2. Digitalization of the electric power industry has become an urgent area within the framework of the "fourth energy transition," i.e., switching from analogue to digital energy, and the components of the new energy industry are: energy efficiency, decentralization, digitalization, and decarbonisation. This transition is possible thanks to the active development of energy generation from renewable sources, the development of energy storage systems, and the development of information systems in general.
3. In Russia, there are currently quite high energy losses in grids. These are decreasing, but the level is much higher than that in the United States, EU countries, Japan, and Korea. It is necessary to accelerate these processes, since before the start of a new investment cycle in the Russian energy industry it is necessary to create the conditions for intensification in this field. This will reduce the volume of final investment and avoid a sig-

nificant increase in the costs of energy and network companies, and, therefore, reduce tariffs for energy consumers.

References

1. Azzuni, A., and C. Breyera. 2018. "Energy Security and Energy Storage Technologies." *Energy Procedia* 155: 237–58. https://doi.org/10.1016/j.egypro.2018.11.053.
2. Booth, A., P. Peters, and E. de Jong. 2018. "Powering the Digital Economy." *McKinsey Quarterly*, November 8, 2018. https://www.mckinsey.com/business-functions/mckinsey-digital/our-insights/powering-the-digital-economy#.
3. Daus, Y.V., V.V. Kharchenko, and I. V. Yudaev. 2018. "Managing Spatial Orientation of Photovoltaic Module to Obtain the Maximum of Electric Power Generation at Preset Point of Time." *Applied Solar Energy* 54 (6): 400–405. https://doi.org/10.3103/S0003701X18060051.
4. Du, M., B. Wang, and N. Zhang. 2018. "National Research Funding and Energy Efficiency: Evidence from the National Science Foundation of China." *Energy Policy* 120 (C): 335–46. https://doi.org/10.1016/j.enpol.2018.05.058.
5. Enerdata. 2018. *Global Energy Statistical Yearbook 2018*. Last modified September 16, 2019. https://yearbook.enerdata.net/.
6. Fang, T. 2012. *PRC Energy Policy at the Present Stage*. Moscow: Lomonosov Moscow State University.
7. Goncharuk, A. V. 2018. "Using Modern Digital Technologies to Improve the Safety and Reliability of Nuclear Energy from the Point of View of Nuclear Non-Proliferation." *Глобальная ядерная безопасность [Global Nuclear Safety]* 28 (3): 17–23.
8. Grabchak, E. 2018. "Цифровая трансформация электроэнергетики России [Digital Transformation of the Electric Power Industry in Russia]." Power-Point presentation, March 27, 2018. Accessed November 17, 2019. http://digitenergy.ru/wp-content/themes/energy/img/materials-2018/2/5.pdf.
9. Grigoryev, L. 2017. "Цифровые технологии в сетевом комплексе [Digital Technologies in a Network Complex]." *Энергетический бюллетень [Energy Bulletin]* No. 53: 14–18. http://ac.gov.ru/files/publication/a/14737.pdf.
10. Kiriyama, E., and Y. Kajikawa. 2014. "A Multilayered Analysis of Energy Security Research and the Energy Supply Process." *Applied Energy* 123: 415–23. https://doi.org/10.1016/j.apenergy.2014.01.026.
11. Kloppenburg, S., and M. Boekelo. 2019. "Digital Platforms and the Future of Energy Provisioning: Promises and Perils for the Next Phase of the Energy Transition." *Energy Research & Social Science* 49: 68–73. https://doi.org/10.1016/j.erss.2018.10.016.
12. Knyaginin, V. N., and D. V Kholkin. 2017. *Digital Transition in the Russian Electric Power Industry: Expert and Analytical Report*. Moscow: Center for Strategic Research; EnergyNet.
13. Lovins, A. 2018. "How Big is the Energy Efficiency Resource?" *Environmental Research Letters* 13 (9): 090401. https://doi.org/10.1088/1748-9326/aad965.

14. Ministry of Energy of the Russian Federation. 2018. "Indicator of the Technical Condition of Electric Power Facilities (Physical Deterioration)." Accessed November 16, 2019. https://minenergo.gov.ru/node/11201.
15. Ministry of Energy of the Russian Federation. 2019. "The Main Characteristics of Russian Energy." Accessed November 18, 2019. https://minenergo.gov.ru/node/532.
16. Remizova, T. S., and D. B. Koshelev. 2018. "The Use of Digital Technology to Modernize the Infrastructure of the Electric Power Industry in Russia." *Проблемы современной экономики [Problems of the Modern Economics]* 66 (2): 31–35.
17. Samarin, I. V., A. Y. Strogonov, and S. Y. Butuzov. 2019. "Evaluation Model of Integrated Safety of Fuel and Energy Complex Facilities." *International Journal of Engineering and Advanced Technology* 8 (5): 2162–67.
18. Sergeev, N. N. 2013. "Theoretical Aspects of Energy Conservation and Energy Efficiency of Industrial Enterprises." *Bulletin of the Astrakhan State Technical University. Series: Economics* 1: 29–37.
19. Shamarova, N. A. 2015. "Theoretical Aspects of the Concept of Energy Efficiency." *Innovative Science* 11–1: 186–9.
20. Sviderskaya, N. Yu. 2017. "Energy Security of Russia." *Achievements of Science and Education* 9 (22): 10–13.

Ivan Kapitonov, Vladimir Voloshin, Tatiana Filosofova,
Dmitry Syrtsov

Energetikos pramonės skaitmeninimas kaip kryptis užtikrinant energijos vartojimo efektyvumo augimą ir valstybės energetinį saugumą

Anotacija

Energijos pramonės efektyvumo klausimai susiję su aukštomis energijos išteklių kainomis ir energijos gamybos neigiamu poveikiu aplinkai. Su energetikos pramone susijęs valstybės saugumas yra glaudžiai susijęs ir su vidaus energijos gamybos poreikio tenkinimu, įskaitant tokios gamybos saugumą. Šias problemas siekiama išspręsti skaitmenizuojant energetikos pramonę, taip leidžiant padidinti efektyvumą bei vėliau sustiprinti elektros energijos pramonės saugumą. Šiuo straipsniu siekiama išanalizuoti ir identifikuoti Rusijos energetikos pramonės skaitmeninimo plėtros kryptis kaip pačios pramonės plėtros kryptį, užtikrinant energijos efektyvumo augimą ir energetinį valstybės saugumą. Nustatyta, kad šiuo metu pasaulyje vyksta „ketvirtasis energijos perėjimas“, susijęs su tikslu padidinti energijos vartojimo efektyvumą per energetikos pramonės skaitmeninimą, decentralizavimą ir dekarbonizavimą.

Ivan Kapitonov – PhD in Economics, associate professor, deputy director of the Higher School of Tariff Regulation, Plekhanov Russian University of Economics; senior researcher at the Department of Energy Policy at the Institute of Economics of the Russian Academy of Sciences, Russian Federation.
E-mail: kapitonov_ivan@tanu.pro

Vladimir Voloshin – PhD in Economics, head of the Department of Energy Policy at the Institute of Economics of the Russian Academy of Sciences, Russian Federation.
E-mail: vivoloshin@uohk.com.cn

Tatiana Filosofova – PhD in Economics, professor at the Institute of the Trade Policy at the National Research University's Higher School of Economics, Russian Federation.
E-mail: tphil@ust-hk.com.cn

Dmitry Syrtsov – PhD in Economics, lecturer at the Department of Applied Economics at the National University of Science and Technology MISiS, Russian Federation.
E-mail: dmitry_syrtsov@nuos.pro

Ivan Kapitonov – ekonomikos mokslų daktaras, docentas, Plekhanovo vardo Rusijos ekonomikos universiteto Aukštosios tarifų reguliavimo mokyklos direktoriaus pavaduotojas; Rusijos Federacijos Rusijos mokslų akademijos Ekonomikos instituto Energetikos politikos skyriaus vyresnysis mokslo darbuotojas.
El. paštas: kapitonov_ivan@tanu.pro

Vladimir Voloshin – ekonomikos mokslų daktaras, Rusijos Federacijos Rusijos mokslų akademijos Ekonomikos instituto Energetikos politikos skyriaus vadovas.
El. paštas: vivoloshin@uohk.com.cn

Tatiana Filosofova – ekonomikos mokslų daktarė, Rusijos Federacijos Nacionalinio tyrimų universiteto „Aukštoji ekonomikos mokykla“ Prekybos politikos instituto profesorė.
El. paštas: tphil@ust-hk.com.cn

Dmitry Syrtsov – ekonomikos mokslų daktaras, Rusijos Federacijos Nacionalinio mokslų ir technologijų universiteto „MISiS“ Taikomosios ekonomikos skyriaus lektorius.
El. paštas: dmitry_syrtsov@nuos.pro