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Readiness Level Evaluation of the Electric Power Industry for the Implementation of Digital Innovations

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Abstract. This article reveals the problem of implementing and evaluating the readiness of the energy industry to implement digital innovations in the countries of the world. Qualitative and quantitative methods were used to achieve the purpose of this study, namely, the indicator system development to evaluate the level of readiness of certain countries for the potential digitalization of the energy industry. System, comparative and content analysis are the qualitative methods used in this work. The quantitative methods include collecting and processing statistical information, and fuzzy logic. As a result of the study, a list of indicators for monitoring was determined, and based on them, a scale for evaluating readiness of the energy industry for digitalization in the countries under consideration was formed. Based on the formed pool of indicators, a quantitative evaluation of the level of readiness of the electric power industry in 10 countries was carried out and presented as an aggregated indicator of the overall evaluation for each of the studied countries – Japan, Estonia, Iceland, Finland, Denmark, Russia, Tanzania, Belarus, UAE, and Sweden. The uniqueness and novelty of this study lies in the fact that based on the analysis carried out using the fuzzy logic method, there has been formed an approach to the overall evaluation and subsequent monitoring of the level of readiness of the energy industry for digitalization in the countries of the world.

Keywords: Electric power industry; Energy digitalization; Fuzzy logic; Indicators; Readiness for digitalization

1. Introduction

A feature of today's days is the penetration of information technologies into all aspects of human life. Digital innovations play a huge role in the global world and extend to almost all spheres of life. Technologies have entirely penetrated not only into the social sphere – in the form of communication technologies and communications via Internet, when almost every person in the world is connected to a single digital space, but also in all sectors of the economy. The energy industry is one of the most basic sectors in the economy of the Russian Federation and has a significant impact on the country's welfare. The comfort of people's lives depends on the quality of the electricity supply (Kelly & Fussell, 2019).

Digital energy is a major part of the digital economy (Nosova et al., 2018). The essence of digital energy is the creation and development of new producing and economic relations based on digital approaches and means. As is already known, the emergence of digital platforms in any industry reduces transaction costs associated with the contract conclusion,

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information processing, negotiations, decision-making, etc. Therefore, the main task of digital energy is to reduce the rapidly growing costs of integration of the distributed energy and market transactions (Hui et al., 2022). First, digital transformation in energy is the creation of new business models based on the capabilities of the digital economy (Babkin et al., 2021) in all three sectors of the fuel and energy complex (FEC): fuel industry, electric power industry and transportation of fuel and refined products, heat, and energy. The main task of digital transformation in electric power industry is to increase the reliability of electricity supply, to limit the growth of electricity prices, as well as to develop new formats (services) of interaction with consumers. The main goal here is to create new "smart" networks that will contribute to the competent and ecological distribution of electricity to consumers. Digital technologies open up new opportunities and various benefits for the electric power industry: enhancing stability in the operation of power systems, prospects for expanding the use of distributed generation from one station up to an entire network with many different facilities (including those using renewable energy sources as the main fuel), reduction of accident rates and annual electricity losses due to improved systems of monitoring and control of the condition of equipment and facilities, etc. (Mohd Roseny et al., 2021).

Today there is a global energy transition and the conventional energy system transformation. The introduction of new digital technologies and solutions, starting with "green" energy and ending with intelligent "smart" electric networks and technologies in the form of the "Internet of Things" (IoT) as consumer services, causes an increase in investment costs in R&D of this industry, as well as an increase in financing and the need for various other developments. Nevertheless, new technologies boost to the modernization of the energy system. For example, blockchain technology in the energy sector using to make purchase and sale transactions between energy producers and consumers, which will make the electricity market more accessible to consumers in the future. To monitor the readiness of Russia and other countries for energy digitalization and implementation of goals in this area, a set of qualitative and quantitative indicators is needed that track the results achieved and development trends. State and non-state institutions, international organizations, and scientists around the world are developing and promoting various methods for evaluating the country's readiness for a digital transition in energy, as well as the level of energy digitalization at the moment.

The country's readiness for energy digitalization can be explained in many ways: by evaluating the readiness of the country itself for the energy transition, by demonstrating the dependence and influence of the energy digitalization indicators of enterprises on the industry, the industry on the country, as well as by evaluating the performance indicators of the digital transformation of the country's energy.

When forming an approach to evaluate the country's readiness for digitalization of the power energy industry, the following market and technological trends should be taken into account:

1. The advent of an increasing number of advanced consumers who actively participate in the production of goods that they consume on their own (in Russia, electricity consumers are allowed to sell electricity to a shared network of up to 15 kW).

2. The advent of smart contracts – new financial technologies that allow for direct settlement between generation and consumers of electricity (appearance in Russia at the end of 2019).

3. The trend towards decentralization of electricity supply (reduction of the energy component of the cost of production) due to the ease of maintenance of the DG (distributed

generation) based on natural gas and renewable energy sources (RES) generation facilities and the annual growth of tariffs outpacing the rate of inflation for consumers.

4. Development and distribution of digital intelligent control systems of the active energy complex (AEC), which make it possible automatically solve all the tasks of the Operations and Technology Directorate (OTD) and manage energy regimes.

In this study, the electric power industry will be taken as a basis, since it is the basic industry among the rest due to the provision of electricity to the remaining ones. Based on the trends mentioned earlier, it is possible to identify four areas (blocks) by which it is necessary to evaluate the country's readiness for energy digitalization:

1. "Regulation and provision of the electric power industry" that will be presented in the form of political resolve and transparency of the country, as well as the availability of electric energy.

2. "Safety and sustainability of the electric power industry", which will be expressed in the following areas: environmental sustainability and reliability, quality of energy supply.

3. "Electricity generation", where the main component will be the structure of the electric power system.

4. "Science and Innovation", the directions of which are as follows: human capital and operational and investment efficiency of the country.

Therefore, the purpose of this paper is to develop a system of indicators to evaluate the level of readiness for the potential digitalization of their electric power industry.

2. Methods

The methods used to achieve the purpose of this study include systematic, comparative, and content analysis, which belong to the category of qualitative methods. Collecting and processing statistical information, expert procedures, fuzzy logic were used as the methodological basis of the calculations performed in the article (Zadeh, 1965).

The sequence of steps to achieve the study purpose:

1. Determination of the composition and quantitative and qualitative indicators characterizing the degree of readiness of the country's energy industry for digitalization.

2. Introduction of a linguistic variable and formation of scales to evaluate the level of readiness of the country's energy industry for digitalization.

3. The indicator setting and formation of the factor value matrix.

4. Calculation of the aggregated indicator of the readiness of the country's energy industry for digitalization.

In this study, the electric power industry of the Russian Federation was taken as a study object since it is the basic industry among the rest due to electricity supply to the remaining ones.

At the first stage of the study, in order to create and develop a single indicator to evaluate the readiness of the country's energy industry for digitalization for each of the mentioned areas (blocks), the main (common) indicators were identified, which are proposed by international organizations and used in similar studies, articles and other sources (Table 1) (Karanina & Bortnikov, 2020; Kholkin & Chausov, 2018).

Next, we introduce a linguistic variable for the evaluation. Let the linguistic variable be "The level of readiness of the country's electric power industry for digitalization", which is described by a set of indicators in the following way (formula 1):

$$Y = [x;\ T;\ D], \tag{1}$$

where x is the designation of the variable "Readiness of the country's electric power industry for digitalization". T is a set of values of readiness of the country's electric power industry for digitalization: "Extremely low level of readiness of the country's electric power industry for digitalization", "Low level of readiness of the country's electric power industry for digitalization", "Average level of readiness of the country's electric power industry for digitalization", "High level of readiness of the country's electric power industry for digitalization" and "Extremely high level of readiness of the country's electric power industry for digitalization". D is the definition area on the segment [0;1].

Table 1 Evaluation indicators of the countries' readiness for digitalization in the electric power industry

Group of indicators	Indicator, dimension	Data source
Regulation and provision of the electric power industry		
Political resolve and transparency	Regulatory indicator for sustainable development in the field of RES	WorldBank
	Corruption Perception Index	Transparency International
	Rule of law index	World Justice Project
Availability of electric energy	The ratio of the average salary in the country (net) to EE price for the population, $/kW*h	State Statistics Services of Enerdata countries
	EE price for industry (net), $/kW*h	IEA
	The level of the country electrification, %	WorldBank
Safety and sustainability of the electric power industry		
Environmental sustainability	CO_2 emissions per capita, t/person	WorldBank State Statistics Services of countries
	CO_2 emissions for total electricity consumption, t/MW*h	World Bank BP Statistical Review
Reliability and quality of power supply	SAIFI (System Average Interruption Frequency Index)	WorldBank Countries' specialized departments
	SAIDI (System Average Interruption Duration Index)	
Electricity generation		
Structure of the electric power system	The share of EE generated at the DG facilities (including RES without hydropower) of the total EE volume, %	WorldBank Industry associations
	The share of EE produced by coal-fired generation of the total EE volume, %	WorldBank
	The share of EE produced by gas generation and HPP of the total EE volume, %	
Science and innovation		
Human capital	The total number of educational institutions, according to the source, pcs.	QS (World university rating by subject Engineering Electrical & Electronic)
	The share of jobs in the DG segment (including RES with hydropower) of the total workforce, %	IRENA Industry Associations
Operational and investment efficiency	The ratio of GDP to the amount of electricity consumed, PPP (Purchasing Power Parity) $/MW*h	BP Statistical Review IMF
	Investment Freedom Index	The Global Economy
	Access to loans	WorldBank
	The share of DG investments (including RES without hydropower) from the total investment in electricity generation, %	IRENA Industry associations Countries' specialized departments

Each of the factors has its own area of definition. In accordance with the basic provisions of the fuzzy-set theory, if each factor is assigned the degree of its belonging to an odd set A, then this membership is expressed by the number $\mu A(x)$ – the membership function on the interval [0;1]. Next, each value of the linguistic variable (which, by its construction, is a fuzzy subset of the values of the interval (0, 1)) is compared with the function of belonging of the integral indicator to one or another fuzzy subset (Gutman et al., 2021). It is possible to represent a similar function in the form of a triangular membership function μ(x), described by triangular numbers of the form: $\beta(a_1, a_2, a_3)$, where a_1 and a_3 are the abscissas of the lower base, a_2 is the abscissa of the upper point of the triangle, specifying μ(x) in the domain with non-zero membership carrier x to the corresponding fuzzy subset. Thus, the Y function value will characterize the level of readiness of the country's electric power industry for digitalization, depending on selected factors. This function will be called the parameter evaluating this element. To evaluate the level of readiness of the country's electric power industry for digitalization, a scale of fuzzy values of the variable Y has been developed. Table 2 below shows a scale for evaluation of the level of readiness of the country's electric power industry for digitalization. This scale was developed on the basis of the reviewed scientific literature on the topic under consideration (Verma et al., 2020; Singh, 2019; Grabchak, 2018; Abramov et al., 2017).

Table 2 A scale for evaluation of the readiness of the country's electric power industry for digitalization

Set of values	Linguistic evaluation	The general explanation of the evaluation	Detailed explanation of factors
0–0.333	Extremely low level of readiness of the country's electric power industry for digitalization	Electric power infrastructure is close to nonexistent or is at very low level, electric energy is not generated or generated in very small volumes, projects for the electric power industry digitalization are not implemented, there are no conditions for the development of science and innovation in the electric power industry, and the environmental situation is at a very low level	Extremely low level of electricity availability, absolutely unreliable and substandard electricity supply, there are no investments and R&D costs in the industry, electricity is generated from non-renewable sources, RES are not used as fuel, extremely high level of carbon emissions into the atmosphere
0.167–0.5	Low level of readiness of the country's electric power industry for digitalization	The level of the electric power infrastructure development is low, electricity is generated in insufficient volume, the level of electrification is low, education in the electric power industry and electrical engineering is at a low level, and the environmental situation is not significant for the state	Electricity is available, but not everywhere. Electricity is supplied with frequent and long tripping, R&D costs in this area are at an initial stage, the RES use as fuel is under study, and there is a sufficiently high level of carbon emissions into the atmosphere
0.333–0.667	The average level of readiness of the country's electric power industry for digitalization	There is a sufficient level of electricity supply, the electric power infrastructure is developing at a moderate pace, projects are being developed to digitalize the electric power industry, science and ecology are developing, and education in the electric power industry is at a basic level	Electricity is available in the country, the average level of reliability and quality of electricity supply. RES has a small share in the structure of electricity generation, mainly combustible energy sources are used, paying attention to the education of specialists in the electric power industry, and investment activity is available
0.5–0.833	High level of readiness of the country's electric power industry for digitalization	The high level is characterized by the implementation of digital projects in electric power industry, electric power infrastructure is developing at a rapid pace, a sufficiently high level of the country electrification, and ecology and education in the electric power industry are the priorities in the country's economy	Sufficiently reliable and high-quality electricity supply (very low risk of tripping), the RES use is quite high in the structure of electricity generation, investment activity in the country is at a high level, R&D costs are significant for the industry development, and environmental development is making progress (reduction of carbon emissions into the atmosphere)

Set of values	Linguistic evaluation	The general explanation of the evaluation	Detailed explanation of factors
0.667–1	Extremely high level of readiness of the country's electric power industry for digitalization	Attention is paid to the RES use. Digital technologies are used in household and industrial areas of the electric power industry, developed electric power infrastructure, electrification of the country is at the highest level, digital projects are being developed and implemented at a rapid pace, the country is environmentally friendly, and the population is educated in the electric power industry	The emphasis on the RES use in the structure of electricity generation, most of the state budget consists of R&D costs, a large number of training centers and universities with technical specialties, carbon emissions are as low as possible, and very reliable and high-quality power supply (the tripping risk is almost impossible)

The factors used for modeling as input and their values are presented below in Tables 3, 4. Using these factors, it is possible to evaluate the level of readiness of the country's electric power industry for digitalization.

Table 3 Indicators offered to evaluate the readiness of the country's electric power industry for digitalization

Area of activity	Designation	Indicator
Regulation and provision of the electric power industry	X_1	Regulatory indicator for sustainable development in the field of RES
	X_2	The level of the country's electrification, %
Safety and sustainability of the electric power industry	X_3	CO_2 emissions per capita, t/person
	X_4	SAIFI (System Average Interruption Frequency Index)
	X_5	SAIDI (System Average Interruption Duration Index)
Electricity generation	X_6	The share of EE produced by gas generation and HPP of the total EE volume, %
Science and innovation	X_7	The total number of educational institutions, according to the source, pcs.
	X_8	Investment Freedom Index

Table 4 The values of the input indicators of the model proposed to evaluate the readiness of the country's electric power industry for digitalization in 2019

	Japan	Estonia	Iceland	Finland	Denmark	Russia	Tanzania	Belarus	UAE	Sweden	Min value	Max value
X_1	77.43	69.91	76.58	70.57	79.29	59.86	41.86	56.73	72.29	80.43	13.86	96.57
X_2	100	100	100	100	100	100	32.8	100	100	100	7.76	100
X_3	8.7	9.3	11	7.7	5.4	12	0.2	6.5	16	4.1	0	41
X_4	0.01	0.18	0.41	0.16	0.5	0.05	46.77	0.48	0.24	0.66	0.01	500
X_5	0.02	0.3	0.63	0.2	0.5	0.17	20.9	0.51	0.25	0.61	0.02	940
X_6	44.27	0.79	69.06	23.79	7.18	64.48	57.72	98.43	97.25	38.98	0	100
X_7	16	1	2	4	3	11	1	8	3	5	0	84
X_8	70	90	85	85	90	30	55	30	40	85	0	95

Values of the selected factors were set according to the following formula (2):

$$x = \frac{x_i - \bar{x}}{\bar{x}} \quad (2)$$

In this model, all factors are assumed to be equivalent. For the analysis, the authors selected eight factors; hence it follows that the significance of the r_i factors is calculated as r_1=1/8. That is, the significance level of each factor with their number equal to 8 will be 0.125.

According to Nedosekin's methodology (Nordekin, 2003), if there is a set of i=1..N individual factors with their current values x_i, and each factor has its own M-level classifier, then it is possible to determine the quantitative value of the aggregated factor by the double convolution formula (formula 3):

$$A\_N = \sum_{j=1}^{M} \alpha_j \sum_{i=1}^{N} d_i \, \mu_{ij}(x_i) \tag{3}$$

where α_j – nodal points, d_i – the weight of the i-th factor in the convolution, $\mu_{ij}(x_i)$ is the value of the membership function of the j-th qualitative level relative to the current value of the i-th factor, M – the number of levels of the classifier.

The final formula for the five-level classifier will have the following form (formula 4):

$$y = \sum_{j=1}^{5} y_j \sum_{i=1}^{N} r_i \lambda_{ij} \tag{4}$$

where y_i – nodal points of triangular numbers, λ_{ij} is determined by the matrix table.

The nodal points are calculated by the formula (5):

$$Y = 0.833 - 0.167 * (j - 1) \tag{5}$$

3. Results and Discussion

According to the data obtained, calculations were carried out. Figure 1 shows the value of the integral indicator for evaluating the readiness of the electric power industry of the studied countries for digitalization. Thus, Japan had the highest value of the final indicator among the countries under study. This suggests that this country is the best prepared for the digitalization of the electric power industry, according to 2019 data. The value of the final index, equal to 0.692, is interpreted according to the membership function as follows: the readiness level of the Japanese electric power industry is 84.63% relating to the high level, and 15.37% relating to the extremely high level. This high value of the final indicator was achieved due to the high value of the regulatory index for sustainable development in the field of RES and the largest number of educational institutions in the electric power industry among the countries under study. Japan is also the leader in SAIFI (System Average Interruption Frequency Index) and SAIDI (System Average Interruption Duration Index) indices. Their values are the lowest in the world.

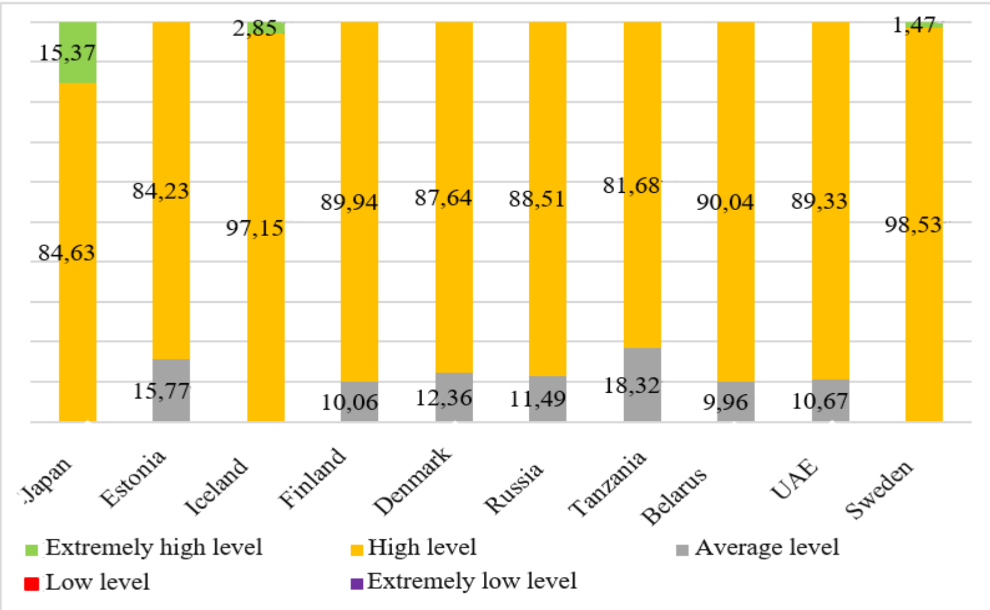

Figure 1 Results of evaluation of the readiness level of the electric power industry for digitalization

Iceland ranks second in terms of the readiness of the electric power industry for digitalization, with a final indicator of 0.671. This means that the level of readiness of the

Icelandic electric power industry for digitalization is 97.15% at a high level and 2.85% at an extremely high level. It is worth noting that Iceland is one of the countries with an extremely high share of electricity produced by gas generation and hydroelectric power plants, and such an indicator as a regulatory indicator for sustainable development in the field of RES is also of high importance. However, the number of educational institutions in electric power and electrical engineering in Iceland is extremely small.

Sweden ranks third in terms of the readiness of the electric power industry for digitalization. Its final indicator reaches a value of 0.668, which indicates that the level of readiness of the electric power industry for digitalization is 98.53% at a high level and 1.47% – at an extremely high level. In addition, Sweden has the largest regulatory index for sustainable development in the field of RES, an extremely high index of investment freedom and a fairly large number of educational institutions among the countries under study. Carbon emissions per capita are the lowest not only among the countries represented, but also around the world.

Finland and Belarus have approximately the same level of readiness of the electric power industry for digitalization by the value of the final indicator: 0.6502 and 0.6504, respectively. Classifying the values of these indices, it can be concluded that the level of readiness of the electric power industry of Finland and Belarus for digitalization is 89.94% and 90.04% at a high level and 10.06% and 9.96% at an average level, respectively. This value of the final indicator of Finland was facilitated by the extremely high value of the regulatory indicator for sustainable development in the field of RES and the extremely low share of electricity produced by gas generation and HPP. In Belarus, on the contrary: the regulatory indicator for sustainable development in the field of RES is at an average level and is one of the lowest among the countries studied, and the share of electricity produced by gas generation and HPP reaches almost the maximum possible value worldwide. In addition, Finland has an extremely high index of investment freedom, which cannot be said about Belarus – the index of investment freedom is at an extremely low level. The total number of educational institutions in electric power and electrical engineering in all the countries under study is at an extremely low level. However, among the countries represented, Belarus has this indicator value above the average level, while Finland has the opposite.

In sixth place by the readiness of the electric power industry are the UAE, which final indicator is 0.6492. It is interpreted as follows: the readiness level of the UAE electric power industry is 89.33% at a high level and 10.67% at an average level. It is worth saying that carbon emissions per capita in the country have the maximum value among the countries under study. The share of electric energy produced by gas generation and HPP reaches almost the maximum possible value worldwide, as well as in Belarus, and the index of investment freedom is at a low level.

The final indicator of Russia has a value of 0.6478. This indicates that the level of readiness of the country's electric power industry is 88.51% at a high level and 11.49% at a low level. This level is achieved by the average value of the regulatory index for sustainable development in the field of RES, sufficiently large carbon emissions per capita among the countries studied, an extremely low value of the index of investment freedom and a sufficiently large share of electricity produced by gas generation and HPP. The SAIFI and SAIDI indicators in Russia have rather low values. In addition, Russia ranks second in the number of educational institutions in the electric power industry among the countries studied in this work.

Denmark, with a final indicator of 0.6464, ranks 8th in the ranking of the countries represented. Interpreting the values of the final indicator, we can say that the level of readiness of the Danish electric power industry for digitalization is 87.46% at a high level and 12.36% at an average level. It is worth noting that the regulatory index for sustainable development in the field of RES has an extremely high value (after Sweden), and Denmark also has one of the highest indices of investment freedom. Carbon emissions per capita reach rather low values. However, the share of electricity produced by gas generation and HPP is the smallest among the countries represented. The number of educational institutions in electric energy is small as well.

Estonia's final indicator is 0.6407. This indicator value is interpreted as follows: the level of readiness of the Estonian electric power industry for digitalization is 84.23% at a high level and 15.77% at an average level. The value of the investment freedom index has an extremely high level (as in Denmark). However, the share of electricity produced by gas generation and HPP is extremely small (almost reaches the minimum value worldwide), as well as the number of educational institutions in the electric power industry. The regulatory indicator for sustainable development in the field of RES has an average value relative to other countries.

The lowest value of the final indicator was found in Tanzania – 0.6364. This suggests that Tanzania is least ready for the digitalization of the electric power industry. Classifying the value of this indicator, we can conclude that the level of readiness of the country's electric power industry is 81,68% at a high level and 18.32% at an average level. This indicator value was facilitated by a rather low value of the regulatory index for sustainable development in the field of RES (the lowest among the countries under study), a very small number of educational institutions in the electric power industry, as well as very high values of the SAIFI and SAIDI indices (the highest among the countries represented). In addition, it is worth noting that the level of electrification in all countries except Tanzania has the maximum value in the world, while in Tanzania, the country electrification level is extremely low. However, the share of electricity produced by gas generation and HPP is at an average level among other countries, and carbon emissions per capita reach almost the minimum value worldwide. Since the main trends in the digital transformation of energy are decentralization, decarbonization and digitalization, it is necessary to develop these areas for a faster and more successful increase in the level of readiness of Russian energy for digitalization and transition to a new level.

The main recommendations for improving the readiness of the electric power industry of the Russian Federation for digitalization are the following:

1) increase in the efficiency of current assets and cost efficiency (it is necessary to increase labor productivity, remove inefficient capacities, etc.);

2) investing in new assets, such as energy storage units and charging stations for electric vehicles, etc.;

3) increasing digital technological potential through the development and implementation of pilot projects and improving digital competencies;

4) development of new services in the electric power industry (consulting in energy efficiency, etc.).

In addition, in external perspective, it is necessary to investigate the issues and barriers that hinder the development of digitalization in the electric power industry. It is necessary to create and establish foundations and private organizations that will allocate finance and invest in the new digital technologies and solutions in energy development. It is also necessary to work out the issues related to state support for digitalization and digital transformation of the electric power industry by creating special agencies. Organizations and companies that will primarily and purposefully engage in the electric power industry development and allocate funds from their budget for the implementation of investment projects.

In internal perspective, attention should be paid to the development and promotion of digital competencies in companies, as well as the promotion of an innovative culture. A huge prospect will be the exchange of experience in energy industry digitalization between organizations in the country, as well as adopt he best solutions and practices.

It is also worth noting that the process of updating digitalization programs in Russia and digital strategies in companies, taking into account the development and priorities of each fuel and energy sector, the implementation of digital projects, as well as the interaction and exchange of experience between the Russian and international energy markets contribute to a faster and better increase in the level of readiness and the level of digitalization of the energy industry in the country.

4. Conclusions

Within this study, a certain pool of indicators was collected that evaluate the level of readiness of countries' electric power industry for digitalization. The quantitative evaluation of the readiness level of the electric power industry in 10 countries was performed based on a fuzzy-multiple approach. Based on the obtained results, it can be concluded that in 2019, the readiness level of the electric power industry of the Russian Federation was 88.51% at a high level and 11.49% at an average level. In comparison with other countries represented, Russia is on 7th place. The values of some of its indicators are lower, that indicates the need to change the policy of regulating the digitalization of energy industry in the country and use a foreign experience to increase the readiness level of the energy industry of the Russian Federation for digitalization. Based on the collected pool of indicators it can be concluded that in order to increase this level, Russia needs to take the following actions: to increase the use of renewable energy sources; to develop distributed power generation and involve consumers in the use of individual decentralized sources of electricity; to develop and implement their own digital and information technologies that will be able to manage and regulate independently the processes of consumption, distribution, generation and pricing of electricity, as well as monitor the condition of equipment and make timely decisions in the "smart" power system; to develop the mass use of electric transport with the possibility of providing mobile electrified trains with their own energy carriers from the network and their recovery if necessary; to improve the education system in electric power industry, electrical engineering and, in general, energy industry in order to increase the level of digital competencies in this area, as well as to retrain and re-educate personnel for the country's new energy. Thus, the implementation of all the above recommendations and proposals on digitalization of the electric power industry and energy industry until 2025 will allow Russia to maintain the level of competitiveness in this area and will also contribute to a fairly rapid increase in the readiness level and the level of the country's electric power industry for digitalization.

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