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Digitalization of Energy Manufacture: Infrastructure, Supply Chain Strategy and Communication

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Abstract- **The constant development of the electric power industry today leads to a decrease in the sustainability and growth of accidents in the "UES of Russia", necessitates the adoption of operational and supply chain management decisions that are not possible without digitalization. The problems that the industry will face in implementing digitalization projects are identified, namely: increased equipment wear; lack of funding, requirements for technological compatibility of the characteristics and parameters of power equipment and devices, unified switching standards (protocols) and information models, required number of instruments, equipment and software. Despite the obvious problems, digitalization is being actively implemented in the power industry. It is noted that the target model of digitalization in the power industry should include three blocks: digital technologies and databases, information technology infrastructure, including communication channels, information security systems. The spheres of application of existing and future digital technologies and databases at all stages of energy production are considered: generation, power grids, sales activities, in their relationship with the management bodies of the wholesale and retail electricity and capacity markets and regulatory bodies. The possibilities of using own and leased communication channels are criticallyevaluated, the advantages of various communication channels are revealed. It is noted that it is necessary to use channels based on fiber-optic communication lines as the main ones, and satellite communication channels as reserve ones. Special attention is drawn to information security. The components of the effect of digitalization for consumers, energy companies and the state are determined. It is proposed to introduce integrated indicators of the effect of digitalization. The proposed measures are necessary for the implementation of full-scale digitalization of the power industry, including the preservation of savings from digitalization in power companies, government support, and the creation of conditions for the development of active consumers.**

Keywords- *databases, digital technologies, communications, information security, supply chain strategy*

1. Introduction

Currently, a new power management paradigm is being formed, requiring systematic research. It aims to take into account the increase in the number of participants, both suppliers and consumers, to identify mechanisms of interaction between them. It is assumed that among the suppliers of generating facilities with unstable parameters of energy production (renewable energy sources) and microgeneration, the formation of consumers with controlled consumption modes, price-dependent consumers and consumers - producers (prosumers), who generate electricity, are decentralized and have the possibility of selling surplus generation to a common network. Inevitably, the creation of demand-management aggregators, combining consumer abilities to change demand, changing the design principles of distribution systems, the formation of intelligent self-regulating electric power systems, the introduction of smart metering and much more. All of these changes require system solutions; their absence leads to a decrease in the stability of the power system and an increase in the accident rate of equipment and devices, especially automation and remote-control systems in power plants and electrical networks. So, for the period from 2011 to 2017 the accident rate in the work of dispatching-technological control systems (DTCS) at power plants increased 6 times, and in electric networks 3 times. [1] Incorrect actions of the devices of relay protection and automation (RPA) over the same period increased by 1.5 times at power stations, and by 1.4 times in electric networks. According to the classification of causes of accidents with systemic consequences, 41% of accidents occur due to improper operation of RZA devices, which, as a rule, lead to serious

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consequences for consumers. [1] An analysis of the causes of accidents indicates the need for clearer regulation and increasing the efficiency of interaction between the system operator and other market actors and consumers. This can help digitalization of electricity. In our dynamically developing century, it is necessary to make adequate management decisions to optimize the functioning and development of power companies and the power system as a whole, which is impossible without the availability of operational and high-quality information and data processing and transmission technologies that digitization can provide. The goal of digitalization in the power industry, as correctly noted in the Digital Transformation 2030 Concept, developed by PJSC ROSSETI, and which can be extended to all utilities, not only power grids, is to change the logic of processes and the company's transition to risk-based management based on implementation digital technology and analyzing large databases. [2] "Whoever owns the information, he owns the world," said N. Rothschild, founder of the Rothschild dynasty. In addition, as correctly reflected in the concept of PJSC ROSSETI, digitalization contributes to changing the logic of the main, supporting and management business processes, i.e. reengineering of energy companies 'business processes, which can provide increased adaptability and efficiency of energy companies' activities. It is obvious that digitalization in the power industry of Russia will face mass problems:

Firstly, the lack of regulatory and methodological consolidation of requirements for technological compatibility of the characteristics and parameters of power equipment and devices, the use of various switching standards (protocols) and information models;
Secondly, increased wear of power equipment, both physical and moral, which casts doubt on the very fact of the relevance of digitalization;
Thirdly, limited financial resources for the comprehensive modernization of energy production, including digitalization;
Fourthly, the lack of highly qualified personnel with competence in the field of digital technologies;
Fifth, the lack of necessary equipment, measuring instruments and metering devices, as well as software.
As Pavel Livinsky, Director General of Rosseti PJSC, noted: only in the framework of the Hannover Messe exhibition held in April 2019. In Hannover, the companies of the Rosseti group presented a list of more than 200 equipment and software items required in the digital transformation until 2030. Only metering devices accounted for more than 22 million units. The essential condition of the contracts was the localization of production in Russia. [3] It should be noted that the PJSC ROSSETI group of companies is already actively implementing projects with the participation of foreign companies, such as ENEL, Siemens, Tokio Rope and others, in Russia today.

2. Materials and Methods

In accordance with the program “Digital Economy of the Russian Federation” [4], energy companies are developing a target model for the digitalization of the power industry. The target digitalization model of each power company includes three blocks:
-data base and digital technologies necessary for making optimal management decisions, both in relation to the business processes of the energy company, and the external environment, including the market;
- information technology infrastructure, including communications - modern systems for collecting, storing and transmitting information, which allow receiving, processing and transmitting a large amount of information in real time to various users;
-Means and technologies to ensure the security of information technology infrastructure, including cybersecurity.
Cybersecurity is the implementation of measures to protect systems, networks and software applications from digital attacks. [5] Already today, in the electric power industry, digital technologies will be applied in the near future (until 2025):
- for monitoring, processing and storing the results of measurements of the volumes of electricity transmitted and accepted on the wholesale market by metering points - automated information-measuring system for commercial metering of electricity - AIIS KUE and intelligent electricity metering devices. The effect is timely payment, reduction of accounts receivable and unit operating costs. In the future, it is possible to conclude smart contracts and introduce blockchain-automatic calculations without intermediaries [6];
- for diagnostics, calculating the technical condition index, determining the probability of

equipment failures, planning technical impact on equipment for maintaining it in working condition - production asset management systems, including automated monitoring systems and technical diagnostics of equipment - ASMD using predictive risk-oriented analytics - approach based on the similarity method. The essence of the approach consists in comparing the existing condition of the equipment with that adopted as a standard. Effect-optimization of specific operating and capital costs. The use of predictive analytics allowed foreign generating companies:

-significantly reduce the cost of maintenance and repair of equipment (more than 4.5 million dollars);

- to avoid 90% of unplanned equipment shutdowns;

- to reduce the specific consumption of reference fuel by 0.5% due to the optimization of operating modes of the equipment;

-reduce the size of the insurance premium by 40%; [7]

- for forecasting electricity demand, dispatching energy production and automatic maintenance of modes - dispatch control and data collection systems –SCADA within the framework of automated dispatch control systems - automated dispatch control systems and automated process control systems - control systems. The effect is to reduce unit operating costs, optimize fuel consumption, reduce environmental emissions;

- To automate emergency response processes using automatic partition points, controlled disconnectors and short circuit indicators - the network operational mode management system –EMS and the emergency shutdown control system - OMS. The effect is a reduction in unit operating costs and increased reliability. In the future, it is possible to switch to adaptive networks with an optimal topology, calculated using digital network models and intelligent automatic devices;

- for carrying out activities on certain management business processes - management information systems formed on the basis of business process ontology. The effect is a reduction in unit operating costs, optimization of the number of personnel, efficiency of decision-making;

- to perform professional functions in many business process managers of energy companies - automated, highly qualified workplaces using predictive analytics - PMTC. The effect is a reduction in unit operating costs;

- to perform integrated functions in terms of switching, measuring and distribution equipment, protection and automation, creating archives, analysis, forecasting and self-destruction of emergencies, as well as data transmission - digital substations (DSP) of various building architecture. [8] The effect is to reduce specific operating and capital costs by reducing the amount of equipment and space, power losses and improving the reliability and observability of power supply. DSPs can be built faster and it is easier to work out standard DSP projects for replication. Currently there are hundreds of DSPs in the world installed in China, the USA, Canada and other countries. [9]

In the Kaliningrad region since 2014. the project of the whole “Digital District of the Electric Network” is being implemented, within the framework of which the power and network centers are automated. The effect is 5 times reduced the average power recovery time. In Ufa, within the framework of a similar project, it is expected to reduce the electric power losses and the number of accidents by almost 2 times, breaks in the power supply by 3 times, operating costs by 20% [10];

- and so on.

However, this is only the beginning of the path to the digitalization of electric power industry. Promising technologies are presented in Table 1. [2]

Table 1. Digital Technologies Industry 4.0.

Technology	Possible impact	Effects
Ontology activity models (Business Ontology)	Gradual digitalization (optimization) of activities on the company's main business processes.	Reducing the specific operating costs of all business processes of the company.
Digital Doubles (Digital Shadows)	As part of the development of online and offline decision support systems, the creation of mathematical models of the network, objects, processes, etc.	Reducing unit operating costs and developing new types of business for the company.
Industrial Internet of Things (1oT)	A significant reduction in capital (CAPEX) and operating (NEX) costs of collecting data from remote sites and devices on the network, including a qualitative increase in the volume of this data.	Reducing unit operating costs and developing new types of business for the company.

Big Databases (Big Data)	A significant increase in the transparency of activities, high-quality data saturation of online and offline decision support systems.	Optimal decision making in an operational and forward-looking environment.
Machine Learning	Automated processing of data sets in the framework of online and offline decision support systems in the presence of appropriate mathematical algorithms.	Additional effects due to the general processing of technological and corporate data.
Distributed Registries (Blockchain)	Exclusion of intermediaries in the kWh sales chain to the final consumer, transition to automated smart contracts, development of services for active consumers and distributed energy.	Optimal decision making for operational and future activities.

In addition, the target model of digitalization involves the interconnection of all information digital flows among themselves, including those based on cloud technologies, and interaction with the information systems of the executive authorities within a single digital environment. [11] The infrastructure for storing and processing information in the power industry today is based on cloud technologies or rental of data storage system (DSS) capacities. According to Seagate, by 2020, 61% of all information on the world will be stored in the "clouds". [12].

No less important is the component of the target model of digitalization, as the system of information transmission - communication. The organization of communication networks between electric power industry facilities in terms of digitalization involves the use of a wide range of telecommunication technologies that meet the quality criteria required for the transfer of information. A feature of communication networks of the electric power industry is the use of both its own channels and leased from existing services on the market of communication operators (companies). [12] Own communication channels include channels formed using own air lines [13,14]:

- channels of high-frequency communication (HF), transmitting signals via transmission lines of direct and alternating currents of 35 kV and above (via phase wires or ground wire);

PLC channels (Private Leased Circuit) - “clean” dedicated channels designed to build reliable, secure corporate networks with guaranteed bandwidth, transmitting signals over existing transmission networks with voltage up to 220 V;

channels transmitting signals over fiber-optic communication lines (FOCL), including an optical cable placed on overhead lines.

The leased communication channels include channels of third-party operators (companies):

Mobile channels of 3G, 4G and, in the future, 5G, differing mainly in the speed of information transmission;

Internet IoT (Internet of Things) channels formed by embedded technologies of “physical things” (smart meters, sensors, etc., networked) [15];

DMR digital radio channels, with improved protection against eavesdropping;

Channels of satellite communications.

A generalized block diagram of the organization of communication is presented in Fig. 1 [2].

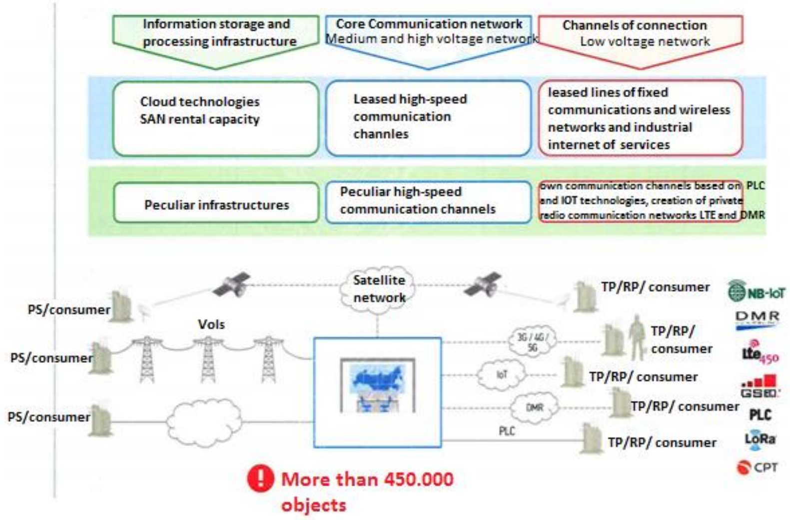

Figure1. Generalized block diagram of communication organization

Until recently, the development of a communication system in the electric power industry was conducted mainly on the basis of using and building its own communication channels, as well as involving mobile channels of 3G and 4G standards. For example, in the Unified Technological Communication Network of the Electric Power Industry, the length of fiber optic links increases over the years and is:
2015 - 66.8 thousand km;
2016 - 70.5 thousand km;
2017 - 73.6 thousand km. [11]
HF communication is also widely spread, so only at the facilities of PJSC FGC UES 11,533 HF semi-sets were installed, including by year:
2015 - 393;
2016 year - 212;
2017 - 264. [11]
Particular attention during the creation and operation of these communication systems was given to the requirements for reliability, reliability and transmission time of information. [16] One of the main ways to achieve the requirements for reliability is the reservation of communication channels in accordance with the standard STO 70238424.17.220.20.005-2011 [17]. As backup channels, channels of the technological network are mainly used, organized along paths independent of the main channel. For example, it is allowed, as an exception, to use as a reserve for dispatch communication channels of other operators that meet the requirements for the exchange of technological information. However, the most rapidly developing technologies for transmitting digital information today are satellite communication technologies. The number of satellite communication operators is constantly growing, among them is the operator - JSC Gazprom Space Systems [7], which has its own Yamal communication satellites and, accordingly, practically unlimited resources for the provision of communication services:
- Backbone satellite channels (up to 300 Mbit / s);
-Channels for remote control systems with redundancy through two or more communication satellites;
-Mobile satellite communications complexes for organizing communications during emergency recovery operations and emergency response (up to 8 Mbit / s);
- Broadband Internet access and cellular communication in remote offices.
In the context of the introduction of digitalization of the electric power industry, it is necessary to take into account that the organizations of the industry belong to the so-called “objects of critical infrastructure” [4]. The life of ordinary citizens and the normal functioning of the country's economy depend on their stable work.
According to the ICS-CERT (The Industrial Control Systems Cyber Emergency Response Team), in 2015, 295 cybersecurity incidents were recorded in the “critical infrastructure” facilities of the United States. [18,19] Moreover, the second place - 46 incidents, occupies the energy sector. It is impossible not to note the attacks on the Ukrainian power grid, which led to the shutdown of seven 110 kV lines and three 35 kV substations, and as a result, the power outages in 5 regions of the country for 6 hours. [5] In April 2016, numerous malicious software, including W32.Ramnit and Conficker, was detected in the “office” network of the German nuclear power plant Gundremmingen. [20,21] (Such aggregated information on incidents at Russia's critical infrastructure facilities is, unfortunately, not publicly available.)
All the above events indicate the presence of serious threats to power facilities in the context of cloud technologies and the need to develop and apply cybersecurity measures.
Particular attention in terms of ensuring cyber security should be paid to dispatching and technological control systems in the power industry. To ensure the cybersecurity of these systems, the following tasks are assumed:
- separation of internetwork traffic of dispatching and technological management systems and office networks;
-protection of operators and servers’ jobs from malicious software, launching unauthorized applications and connecting unaccounted external drives and other devices;
-protection of industrial controllers from unauthorized access to them, changes in the code executed in them and sending incorrect commands to them.
Thus, it is necessary to build a unified system for the protection of information resources, which will minimize the risks of implementing threats to information security.

3. Research Results

The implementation of the model of digitization of power industry should ensure the achievement of the following results:

3.1. For consumers

-increasing the reliability of energy supply, the criteria of which are indicators of the average duration of cessation of electric power supply to consumers (SAIDI) and the average frequency of cessation of electric power transmission to consumers

(SAIFI). According to the companies of the Rosseti group, by 2030. SAIDI should reach a value of 2.4 hours, and SAIFI should reach 0.92; [2]
- ensuring the availability of electricity supply, the criteria of which are the cost of connecting a consumer or manufacturer (applicant) to the electrical network, the number of procedures for technological connection, terms of technological connection of consumers. The connection time for consumers up to 150 kW (the largest group of applicants) should be reduced by 2030. up to 120 days from 192 days in 2017 [2]
For example, the rating of Russia in terms of electricity supply availability in 2017 is given. (Table 2), while it is worth noting that back in 2012. Russia occupied 181 positions (from 190 countries for which the rating was determined). By 2020, Russia plans to enter the top 20 in this rating.

Table2. The World Bank's rating in terms of "Doing Business in 2017" [10]

	Auckland (NZ)	**Singapore**	**London**	**Paris**	**Berlin**	**New York**	**Moscow**	**St. Petersburg**
country position in the ranking	1	2	7	29	17	8	40	40
position in the rating in terms of "connection to the power supply system"	34	10	17	25	5	36	29	29
TP procedures, pcs.	5	4	4	5	3	4	3	3
Term TP, days	58	30	79	71	28	60	150	185
Cost, % of GDP per capita	76	25,8	25,8	40,8	40,8	14,0	37,3	60,1

- reduction of environmental emissions per unit of generated electricity, kg / kWh;
-optimization of electricity tariffs for the end user; reducing the share of the energy component in the costs of production and sale of finished products;
-creation of new services for consumers, increasing the amount of system-wide effects. For example, charging personal and public electric transport, increasing the energy efficiency of street lighting ("smart city"), managing energy efficiency at the consumer ("smart home"), and so on.

3.2. For power companies

-increasing energy efficiency, indicators of which are the reduction of specific fuel consumption, the reduction of electric power losses and the expenses of electric and thermal energy for own needs. For example, according to the data of the companies of the Rosseti group, by 2030. The level of electric power losses in the whole of the power grids of Rosseti should decrease from 9.4% in 2017. up to 7.34%, and with respect to 0.4–20 kV networks from 15.6% to 8.89% [2];
-improving the reliability of information about the technical condition of equipment and components, which allows a more reasonable prediction of the residual life of the equipment;
-increase technical and economic efficiency, indicators of which are the reduction of specific operating and capital costs. Only by the Rosseti group of companies by 2030. a reduction in specific operating costs by 30%, and capital expenditures by 15% compared to the level of 2018 [2];
-increase high-performance workplaces in power companies while optimizing the number of staffs;
-improving information security and optimizing cybersecurity risks;
-increased shareholder value of companies, which is an EV / EBITDA multiplier, which is the ratio of the company's value to its profit before interest and tax on profit and asset depreciation. According to the companies of the Rosseti group, by 2030. This figure should increase from 153 in 2018 to 1000 [2].

3.3. For the state

- maintenance and development of ecosystems;
- forecasting and modeling of energy and information security;
- reduction of supervisory functions;
-development of related industries, such as power engineering, instrument engineering, communications

and others. A prerequisite for achieving digitalization efficiency in the power industry is the availability of a communication system that meets the requirements for speed and reliability;

- development of import substitution;
- reduction of electric intensity by 14-15% [16] and the material intensity of GDP.

Outstanding management theorist P. Drucker said that only things that can be measured can be managed.

Considering the multiparameter effect of digitalization, we propose for each interested party (consumer, energy company and the state) to develop an integral indicator based on a qualitative approach, where all the above components of the effect should be expressed as measurable quantitative indicators, weighted by importance for the interested party, normalized and summarized in the objective functions. Managing the values of the objective functions will guarantee the achievement of the expected efficiency from digitalization on time and in full.

An example of such an objective function might be:

y = A1x1 + A2x2 + A3x3 + ... + AnXn;

where y is the integral indicator of the effect;

A - weight factors of effect indicators;

X-normalized values of effect indicators;

n is the number of indicators of the effect.

4. Discussion

Some skeptics believe that the extreme high physical and moral deterioration of equipment of power plants, and especially electrical distribution networks, will not allow to achieve the expected results. [6,16] However, the following should be kept in mind:

- until 2018, the depreciation of assets was calculated through the service life, given the relatively low utilization rate of installed capacity (ICUF), which in a significant part of the power equipment was below 50%, for example, on steam-powered installations reached 47%, it can be assumed that the existing method of calculation overestimated amount of wear. [1] In accordance with the methodology approved by the Government of the Russian Federation No. 1401 of December 12, 2016, depreciation indicators will be calculated through the integral indicator of the technical condition and the level of depreciation can change drastically, which will make the technical condition of the domestic electric power industry, at least in terms of physical deterioration, comparable to the world one. There are different opinions about the assessment and, accordingly, the choice of communication channels to ensure digitalization. [22, 23 24, 25] Comparative characteristics of communication channels are presented in Table. 3

Table 3. Comparative characteristics of the main communication channels (based on communication lines of fiber optic lines, radio relay lines, satellite lines, telecommunication cable).

Title	Fiber Channels	Telecommunication channels	RRL channels	Satellite channels
Main application	Stationary objects	Stationary objects	Stationary objects	Stationary objects
Additional application area	not	not	not	Mobile objects
The need for intermediate repeaters and amplifiers	Every 100 km	Every 20 km	Every 50 km	not
Cost of	Medium (depends on the number of intermediate amplifiers)	High (depends on the number of intermediate amplifiers and the length of the copper cable)	High (depends on the number of intermediate repeaters)	Low (depends only on the cost of a satellite earth station (DSS)
Terms of construction of the communication channel	About a year, depends on the length of the track	About 2 years, depends on the length of the track	About 3 years, depends on the length of the track	10 to 30 days, depends on station capacity
Channel Transfer Rate	High	Low	Average	Average

From the analysis of data table. 3 it is obvious that the channels based on FOCL and satellite communications are promising. When comparing promising channels, it should be noted that the advantages of fiber-based channels in the speed of information transmission, and satellite communications - in terms of cost and construction time. In addition, when choosing communication channels, it is necessary to take into account the possibility of using satellite communications to organize video surveillance of the construction of digital electric power facilities, including fiber-optic lines. The presence of a portable reporting station at the satellite operator provides the possibility of organizing videoconferencing sessions and video reports both from construction sites and in cases of rescue operations. In the future, if necessary, satellite communications stations can be dismantled and reused to organize communication channels at other power industry facilities.

At the end of the construction of digital electric power facilities with the main information transmission channels, it is recommended to use fiber optic channels, and satellite communication channels, in accordance with STR 70238424.17.220.20.005-2011, as backup channels [26, 27].

They raise questions and sources of funding for the digitalization program in the electric power industry. In our opinion, such sources should be:

- immediate savings achieved as a result of the implementation of the target digitalization model;
- government support, including through direct funding, taking into account the effects that the state will receive from the digitalization program [28,29].

In addition, we agree with the proposal of Dr. Sc. Mishcheryakov about the possibility of using as a source of funding for digitalization in the electric power industry, at least in terms of organizing additional services, from reducing cross-subsidizing electricity tariffs for the public. [1]

5. Conclusion

1. Digitalization in the power industry has long been successfully implemented.

2. In order to achieve the expected efficiency of power industry digitalization, it is necessary in the near future:

- to make adjustments to the regulatory framework in the power industry, in terms of securing the requirements for technological compatibility of the characteristics and parameters of power equipment and devices and used switching standards (protocols) and information models;
-expand the scope of application of satellite communication channels, including as backup;
-create an information security system;
-to ensure the long-term and stability of tariff decisions, including the conclusion of regulatory agreements between territorial grid companies and regional administrations and secure the preservation of cost savings in regulated tariffs for the long-term period, as a guarantee of investment, including digitization;
- to make changes in the regulatory acts stimulating the development of competition in the retail market and forming a consumer desire to find and implement digitalization projects;
-define measures of state support of digitalization projects in the power industry, associated not only with direct funding, but also with training in digital technologies, metrological support, and so on.

3. The solution of the problems posed should ultimately ensure a reliable, high-quality and affordable power supply to consumers and a reduction in the share of the energy component in the costs of producing and selling finished products.

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References

[1] Mischeryakov S.V. *Digital modernization of electric power industry*, 2019. https://www.keu-ees.ru/ (appeal date 15.04.2019)

[2] Of the Concept “Digital Transformation 2030”, approved on December 12, 2017 at a meeting of the Board of Directors of PJSC ROSSETI. http://www.rosseti.ru/investment/Kontseptsiya_Tsifrovaya_transformatsiya_2030.pdf / (Appeal date 5/04/2019)

[3] Rosseti will present at Hannover Messe the concept of digital transformation of electrical networks until 2030, 03/04/2019, https://www.mrsk-cp.ru/press/industry_news/Rosseti-predstavyat-na-Hannover-Messe-kontseptsiyiy- tsifrovoy-transformatsii-elektricheskikh-setey-do /? print = Y / (request date 04/03/2019)

[4] "Digital Economy of the Russian Federation", approved by the decree of the Government of the Russian Federation dated July 28, 1632p, 2017. http://static.government.ru/media/files/9gFM4FHj4PsB79I5v7yLVuPgu4bvR7M0.pdf/(Date 23.04.2019)

[5] Yarushevsky D. Cybersecurity of electric power facilities: about what was, is and will be. https://www.dialognauka.ru/press-center/article/17885/(Date 15/04/2019)

[6] Zimnukhova D.I., Rakova GD, Lyubimova N.G. The introduction of the blockchain technology into the power industry of Russia. Proceedings of the II International Scientific Forum "Step into the Future: Artificial Intelligence and the Digital Economy" Vol. 3 M.: with. 298-303, 2018.

[7] Lipatov M. Russia's first complex of predictive analytics for energy and industrial equipment.https://cyberleninka.ru/article/n/pervyy-v-rossii-kompleks-prediktivnoy-analitiki-dlya-energeticheskogo-i-promyshlennogo-oborudovaniya, 2016 / (Contact date 05/04/2019)

[8] What is digital substation and what makes it digital? 06/27/2018. By Edvard, EEP.Power Substation https://electrical-engineering-portal.com/digital-substation/(Date Date 16/04/2019), Legislative and regulatory documents. Standards

[9] Digital power industry. Publication date: 19-11-2017. ANO Center for Strategic Estimates and Projections. http://csef.ru/ru/ekonomika-i-finansy/direction-topics/czifrovaya-elektroenergetika-6381/(Date date 04/05/2019)

[10] Digital RES is a reality. 12/28/2016 http://www.rosseti.ru/press/news/index.php?ELEMENT_ID=28960/(Date of appeal 04/04/2019)

[11] Success in the cloud: to achieve improved performance, April 21, 2011 https://www.bakertilly.com/insights/success-in-the-cloud-manufacturers-switching-to-cloud-computing-to-achieve/(Date 16/04/2019)

[12] Cloud computing: responding to the need for best practices for storage https://www.seagate.com/ru/ru/point-of-view/cloud-computing-answering-the-need-for-storage-best-practices-master-pov/(Date 19.04.2019)

[13] STO 56947007- 29.130.01.092-2011 Standard of the organization of JSC FGC UES http://www.fsk-ees.ru/upload/docs/56947007-29.130.01.092-2011.pdf/(Date from 16.04.2019)

[14] Livshits A., Organization of technological communication channels in electric networks 6-20 (35) / 0.4 KV http://www.priortelecom.ru/publica/priortelecom_oktses.pdf / (Circulation date 04/18/2019)

[15] Fraunhofer IIS demonstrates direct connectivity via GEO satellite, Thoralf Dietz, Claudia Wutz 7.6.2018 https://www.iis.fraunhofer.de/en/pr/2018/20180607_KS_Geo.html / (Contact date 16.04.2019)

[16] Federal Law "On Communications" of 07.07.2003 N 126-FZ (as amended on December 27, 2018) https://rg.ru/2018/12/29/svyaz-dok.html/ (Revised April 16, 2019)

[17] STO 70238424.17.220.20.005-2011 Standard of organization NP "INVEL" Communication systems for collecting and transmitting information in the electric power industry. Terms of creation. Norms and requirements http://docs.cntd.ru/document/1200097077 / (Date of circulation 19.04.2019)

[18] World Bank Ranking in Doing Business in 2017 http://russian.doingbusiness.org/ru/reports/global-reports/doing-business-2017 / (Contact date 15.04.2019)

[19] Detektion von Büro-Schadsoftware an mehreren Rechnern, 04/25/2016 (http://www.kkwgundremmingen.de/presse.php?id=571)/ (Appeal date 16/04/2019)

[20] The annual report of FGC UES PJSC for 2017 was approved on June 28, 2017 (Minutes No. 20 of July 2, 2017https://www.fskees.ru/upload/docs/2017_GO_FSK_EES_smart_version_pril%201-11.pdf / (Contact date 05.04.2019)

[21] Steitz, S., .Auchard E., (04/26/2016). Technology news: German nuclear plant infected with computer viruses, operator says, REUTERS Retrieved from: http://www.reuters.com/article/us-nuclearpower-cyber-germany-idUSKCN0XN2OSREUTERS, (Revised April 16, 201)

[22] Communication in the electric power industry is an important component of the system for managing particularly critical infrastructure facilities. ABB Ltd. The Department of Communication Systems in Power Engineering. https://library.e.abb.com/public/c9ef05ec4e3142cac12579b1004be1de/ABB_overview_2011.pdf / (Contact date 05/04/2019)

[23] Service center of communication systems in power engineering 2019 ABB. https://new.abb.com/en/servis/servisnye-centry-abb-v-rossii/sistemy-svyazi-v-energetike/(Date Date 05/04/2019).

[24] Comparative evaluation and selection of the optimal communication line https://studbooks.net/2337740/tehnika/sravnitelnaya_otsenka_vybor_optimalnoy_linii_svyazi/ (Contact date 15.04.2019)

[25] E. Chistova. Transmit wisely. Technology number 7 (2018) http://atomicexpert.com/power_industry_digitalization_072018/(Date 05/04/2019)

[26] Sevastyanov D.N. Satellite solutions for the oil and gas sector. Technologies and communications, №5, pp. 58-59, 2016.

[27] Information security in the energy sector: expert opinions.https://securenews.ru/energy_facilities/ (Date 04/15/2019)

[28] Muhammad K. *The Effects of Electronic Human Resource Management on Financial Institutes*. Journal of Humanities Insights. 02(01):01-5, 2018.

[29] Solmaz ,Saadat Emam , Houshang ,Shajari. *Recognition and analysis of effective factors on investors' decision making in stock exchange of Tehran*. UCT Journal of Management and Accounting Studies**,** Issue 4, pp. 14-21, 2013.