Modular digitalization of the energy sector

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Yurij Gribanov [1*], Aleksandr Shatrov [2]

[1] Academy of Digital Economics, Turgenevskaya Sq., 2, Moscow, 101000, Russia
[2] Academy of Digital Economics, Komsomolskij Av., 41, Perm, 614039, Russia

[*] E-mail: nas.company@bk.ru

Abstract. Relevant issue is tendency for the formation of innovative strategies of transition towards high-tech economic development giving the growth of cyber-physical security, emergence of new challenges to national and international security at the global level in the process of networking peer-to-peer production P2P (Peer-to-peer) which is reflecting the basic contours of egalitarian society lies in collective solution of planetary problem of climate change based on voluntary participation of all parties in a decentralized network system of production, decentralization and self-organization and formation of their own regional strategies.
On the basis of technological singularity and exponential technologies there is a steady tendency to increase the level of integration and multiple connections of smart devices.
Country connecting to cyberphysical systems requires integration of economy through creation of network cost and modular digitalization of integrated production systems in a number of industries of the economic complex, in the normalization of the level of network segmentation based on establishment and application of global open standards of interoperability and power quality parameters.
The research task is to confine an examination of methodological foundations of modular digitalization of the energy sector of Russian economy.

1. Introduction

Countries connecting to cyber-physical systems demands integration of economies through creation of network cost and modular digitalization of joint systems of production in many branches of economic medium, in rationing of level of network segmentation on the basis of introduction and application of global open standards of functional compatibility and parameters of quality of the electric power worldwide [1].

Analysis of threats of a homeland security of the state upon transition to high-tech economic development allows to allocate a number of problematic issues at the present stage of formation of regional strategy of modular digitalization.

Author in his publications, performances at conferences and also in business interviews already made attempts to comprehend and describe specifics of “digital economy” and emerging “digitalization processes” in Russia [2].

2. Methodology

Scientific, theoretical and methodological basis of research was formed by the works of domestic and foreign authors on economy and the theory of organization, practices of the IT infrastructure analysis at the enterprises of various branches of economy, materials of scientific and practical conferences and seminars on the research subject.

Methodological basis of research was made by general scientific methods of economic and comparative analysis, analytical and statistical methods.

The empirical basis of a research is presented by scientific publications and periodicals on the studied problem, normative legal acts regulating issues of enterprises functioning, official statistics data, Internet resources, published statistical materials and researches regarding activity of organizations belonging to energy sector of RF economy [3].

3. Findings and discussion

The world is living today in condition of third industrial (or digital) revolution which is being gradually transformed into fourth industrial revolution, or "Industry 4.0" and is characterized by merge of technologies and blurring of borders between physical, digital and biological spheres on the basis of "cyberphysical systems" establishment in production process. It is supposed that these systems will unite in one network so as to communicate with each other in real time and will be able to build production without participation of a man [4].

Thus, if the automation of the production which began in the middle of the 20th century was characterized by narrow specialization in which control systems were developed for each sphere and enterprise separately, and were not scaled, then in a basis of the new technological revolution there is a development of global industrial networks, the key drivers of which are cloud technologies, development of the ways of collecting and analysis of big data, crowdsourcing, economy and biotechnologies.

At the same time, it should be noted that society, in global sense, entered an absolutely new stage of the development – "modular digitalization" as the new economic event created on the economy of knowledge which cardinally differs from the economy of goods manufacturing. "Modular digitalization" acts as a universal accelerator of economy and society development [3].

However, expansion of forms of cooperation, innovations in data management, databases of the Internet of things - IoT (Internet of Things), redesign of industry, openness of innovative programs and services for all systems are most noticeable in this context of tendency digital infrastructure formation and new opportunities of connection to it by means of electronic means of communication [5].

On the basis of technological singularity and exponential technologies, steady tendency of increase in the level of integration and multiple connections of intellectual devices is observed. In the market one technological wave replaces another one. Global changes are also reflected in the fact that the world becomes more and more connected and practically everything begins to connect to everything everywhere. The concept of IoT acts as the technological center.

Introduction of the "cyberphysical systems" in productions is caused by the increase in number of high-tech innovative processes with the use of "digital business" and "net energy". These systems unite into one network, communicate with each other in real time and are capable to build production without participation of a man. Now in the market one technological wave replaces another one and the steady tendency to increase in the level of integration and multiple connection of intelligent devices is observed.

In view of all existing theories and forecasts, it is necessary to consider the following: the course of history is not predetermined, there are no relentless regularities of its turns and rare events of "black swans" which cannot be predicted. Changes happen so promptly that nobody with sufficient thoroughness can claim how the world economy will develop in future because according to the researches of

N. Gilberta and P. Lopez, a considerable part of technological memory (94% in 2016) is already in a digital format [6].

In this context, progressive infrastructure of accounting, the so-called AMI (Advanced Metering Infrastructure), acts as a fundamental requirement for modernization of networks and provides a basis for motivation and connection of consumers to “clever” networks (Smart Grid) on the basis of integration of modern technologies forming intellectual interaction between the consumers and system operators. [7] AMI will be used as Smart Grid basis for the integration of multidisciplinary energy, requirements satisfaction of consumers and protection of income. Systems will “reasonably” operate the energy in complicated autonomous modes in order to ensure considerable levels of distributed generation, storage, maintenance of flexibility of networks, trade of energy on the basis of intelligent counters which will be capable to measure except voltage and electricity, such parameters as the general harmonious distortions, parameters of quality of the electric power, power and so forth.

It is necessary to emphasize that in new business models of the future industrial network intellectual networks and the decentralized registers of digital data on the basis of digital power assets will dominate.

By conservative estimates, on a global scale only potential economic benefit from "modular digitalization" on the basis of global availability of comprehensive Internet of IoE (Internet of Everything) in the next decade can make 19 trillion US dollars. 14.4 trillion dollars from them will fall on a private business, and 4.6 trillion dollars - on a public sector. This economic benefit will be created by millions of various ways on the basis of network connections of people, processes, data and objects. Key role in these processes is played by decisions of infrastructural systems and innovative technologies [5].

Distribution of IoT opens possibilities of circular innovations creation and creation of new digital architecture of the network imposed on existing physical architecture and fulfilled in the form of universal wireless network which will become the base for digital infrastructure. However, global community notes that digital division between the countries grows quicker if compared to economic one.

According to the report published by the Global Center for Digital Business Transformation, rapid disappearance of many companies and conversion of the markets can become the result of digital revolution. Need of fight for markets of production at preservation of such tendencies in the future will disappear, but economic interventions on the basis of technological domination will be carried out in a preventive order [8].

Developed countries of the world, such as the USA, China, Korea, have already completed creation of intercontinental digital networks today. For example, China signed cooperation agreement on implementation of initiative called “One belt - one way” with more than 30 countries on cooperation in creating demonstration infrastructure of industrial and financial sectors integration [9].

Features of modern evolutionary process come down, in essence to the formation of a new civilization, new financial model, protection of economy against excessive external influence of multinational corporations and transition from the processes of globalization to the policy of isolationism which can completely turn the course of history.

Latest events demonstrate prevalence of such tendencies as USA leaving the Pacific partnership, Great Britain leaving the EU, appeal of Chinese President Xi Jinping to unite for the implementation of Chinese nation revival. That is why in the nearest future development of digital economy in the majority of countries will be recognized as strategic priority with the main components: digital transformation of society; development of a digital ecosystem; digital education; digital resistance and trust to digital content [6].

New calls during an era of global economy of knowledge and technological revolution mostly come down to the fact that in the nearest future two technologies will change digital economy and new net energy. Such postulates for the first time were key subjects of the summit of G20 (Hanzhou, China) which concerned an internal economic situation of each country on the creation of innovative economy, access to

new technologies, fair trade and a new financial system on the basis of exchange of information at digital informational support, scientific and civilized cooperation.

The power industry, in the context of formation of the new digital architectural model, acts as a base of future civilization which is capable to resist to global social, environmental and technological challenges.

Energy is accepted as the major tool within the agenda in the field of sustainable development all over the world for the purpose of integration of steady power systems and acts as that sector of the market where it is possible to reach largest economic efficiency at the state level as the energetic efficiency acts as a peculiar criterion of quality of functioning of the economic model of the state, harmonious interaction between subjects of managing, population and authorities, and is the priority direction of public policy practically in all countries worldwide. This feature is noted in the final document of UN summit on adoption of the agenda in the sphere of development for the period after 2015 “Transformation of our world” [10].

As life experience shows, development and distribution of digital technologies led to the situation when communication in Internet became an attribute of network interaction of everyday life of the most part of the population of the country, and innovative technologies brought communication in Internet to absolutely new level where by definition of American futurologist Elvin Toffler, the consumer performs function of the producer (producer + consumer), thereby forming the intellectual market environment as a basis of synthesis of technical and commercial contours of interaction: new technologies create new opportunities and form new quality of market relations, and decisions of the power policy made by one state inevitably influence other states in a global power system and enter the phase of the fast transition with potentially far-reaching consequences [7].

Thus, there is a transformation of the traditional power, the power of future on the basis of intellectually distributed power, including account for alternative types of fuel (control device for pre-launching and launching) and the renewables (R), informational systems of management, intelligent switching equipment, consumer services which allow to operate accumulation and electricity consumption is formed.

As a result of it, the paradigm of existing system of electric energy in the world will undergo cardinal changes owing to transition from classical centralized transition of energy production to more decentralized system in which participants dynamically change roles and interact as power cooperatives, however the problem of ensuring reliable and stable power supply remains prime [8].

Key role in such interaction is played by two models. On the one hand, it is a common information model, and on the other - power communicational networks and systems of substations for optimum control and ensuring functional compatibility at the level of information models whose names differ depending on networks characteristics (Smart Grid, IntelliGrid, Power Grid and so on).

Cornerstone of Smart Grid is the possibility of repeated connection of intelligent devices, software, processes, control centers and their interaction by means of communication infrastructure. In this regard, strategic requirement in support of this process consists in developing the reliable communication infrastructure of transportation of data in real time through global networks - WAN, and one of ways of decrease in risks when planning a profile of infrastructure of communication networks - AMI is ensuring their functional compatibility. WAN cover huge territories and the states and based on hybrid communication technologies, including technologies of fiber-optical communication systems, communications on power lines - PLC (Power Line Communication) and also data transmission in cellular networks [4].

In a new paradigm of power development, top priority issue consists in ensuring energy, safe, steady, competitive, available at the price, for each consumer on a basis: energy security, solidarity and trust; integrated domestic energy market and all-European power system; energy efficiency, as independent power source; transition to low carbon economy, climate-friendly and competitive economy [6].

Within financial aid, according to European mechanism of interaction - CEF (Connecting European Facility), the long-term program of financing of development European transport, power and telecommunication infrastructures for 2014-2020 is allocated for financing of PCIs to €5.35 billion [11].

Integration of markets according to the guidelines for trans-European power network (TEN-E) which are adopted in 2016 in Tirana (Albania), and the priority strategic PCIs infrastructure projects providing realization of nine priority strategic infrastructural power corridors in the sphere of the electric power, gas and oil and also three infrastructural priority branches for intellectual networks, highways and transport networks. PCIs of priority Smarts Grid are considered as autonomous, and as a part of clusters from several grouped PCIs.

According to the report of EUR Lex, by year 2020 expansion of Smart Grid is anticipated positively (80%) in 27 EU countries. Now there is a set of innovative technologies which provide the basis for requirements satisfaction of management in Smart Grid to the environment on realization of the functions necessary for work main (with high voltage) and distributive (with an average and low voltage) networks [5].

Measures concerning continental connection of power networks, establishing cross-border interrelations of each country are the basis for connection to intercontinental power network and have to be based on the system approach focused on standardized global decisions [7].

In order not to remain on a roadside of these processes, there is an urgent demand in Russia for the formation of general internal model of energy transmission and mutual connection of national intellectual network that represents crossing of the developed power ecosystem and energy of IoT and ensuring functional compatibility based on global open standards [12].

Interaction in the context of implementation of the concept of flexibility between roles in the energy market (supply, trade, production, storage, consumption and so forth) and roles which are regulated by laws (system operations, operations in network) is complicated and demands the mechanism of control to ensure quality and reliability of electrical power supplies.

Reliability of power supply depends on electromagnetic impact of the environment (electromagnetic, electric and magnetic fields, current and voltage) exerted by technical facilities. Electromagnetic hindrances, which arise in a power system, are characterized by two components: electromagnetic and technological and can cause substantial economic losses.

Research conducted by European experts shows that global damage caused by power supply reliability violation is reaching 500 billion Euro per annum, which constitutes 50% of turn in electricity sector, and tends to increase. Growth of losses connected with reliable operation failures in the power system is confirmed also by researches performed by Agency on cooperation of power regulators - ACER (Agency for the Cooperation of Energy Regulators) [4] and dedicated to retrieving of causes of electric power failure damages - Voll (Value of lost load).

By estimates of ACER, for EU member states the Voll value fluctuates from 11000 Euro/MW/h to 26000 Euro/MW/h. However, actual size of damage caused to consumers from one kWh of the electric power lost loadings many times over exceeds rated value. In 2017, by results of monitoring of efficiency of all power system in 28 EU countries of loss made 34.1% of energy by delivery to ultimate consumers [7].

Thus, annual losses from decline in quality of the electric power and reliability of power supply are measured by hundreds of billions of dollars and tend to increase. Analysis of results of researches conducted in various countries allows to draw a conclusion that across the nation economic losses from violation of electromagnetic compatibility are estimated in billions of dollars and tend to increase.

Experts consider that use of the modern technologies of management based on Smart Grid with wide use of up-to-date information and communication technologies will give the chance to maintain dynamic balance of supply and demand, to improve use of digital assets, to increase quality of the electric power

and stability of power supply systems in condition of adverse external effects and elemental disasters and, finally, will give a chance to considerably reduce losses [4].

Complexity of system decisions in power industry upon transition to Smart Grid, according to the researches of experts, allows to avoid considerable losses (from 30 to 50 percent) due to intensive use of assets and decrease of the maximum loading, final energy consumption, losses in networks, reserves of power of the system generation and also increase of the capacity of intersystem communications.

The key to success in transformation of market approaches consists in ability of the state initiatives to react in time on the dynamics of the market, requirements and conditions according to a certain strategy of generation of "net energy" with domination of the leading scientific directions of introduction of physical processes in the near future. For example, design of systems on the development of ultraclean, inexpensive power sources on the basis of cold nuclear fusion or low-energy nuclear reactions - LENR (Low Energy Nuclear Reactions) from the industrial point of view can cause real "power revolution" for production of heat and the electric power that is not followed by intensive radiation, residual radioactivity and greenhouse gases and influence a homeland security in general [13].

As scientists note, energy production with the use of E-CAT generators (Energy Catalyzer) by LENR on the basis of cold synthesis in kW range is much cheaper (approximately by 2.6 times), than for fossil types of fuel and atomic energy [5].

According to the Agency of the advanced defensive research projects - the DARPA (Defense Advanced Research Projects Agency) of the U.S. Department of Defense of LENR will be "breakthrough technology" for which today such countries as China, India, Japan actually created their own investment fund for assistance of development of this technology, and Russia allocates considerable resources for their development [14].

Each country, considering the real situation, independently establishes its own model of conducting digital business and gradual integration of innovative processes for achievement of long-term results of development of clean power branches and considerable reduction of greenhouse gases in the energy sector of the state. At the same time, observance of general conceptual model of high level which describes interaction of main Smart Grid participants and general framework of reference architecture of functional compatibility of aggregation of several architecture is considered to be mandatory (business, functions, information, communication, safety).

Forming of Smart Grid concept and architecture in Russia is not an easy task as now there are various concepts and architecture representing the viewpoints of particular interested parties, and the power supply system functions on the basis of a large number of diverse participants who are hierarchically connected with each other and have to work together while each participant of the power supply system builds-up and operates the part of network in his own way [6].

Power branch of Russia as one of important branches of RF economy which are important in the system of a national security, is one of the most technically backward and economically inefficient [4].

Besides, lack of coordination on the part of administration and destruction of the state approach in technical regulation in the backbone sphere in the state, insolvency of the executive authorities since 1991 to create summary power balance, existence of special account of a power supply system at the prevailing most of private owners of the energy companies on transportation and electrical supply to consumers requires the political solution in the choice of a model [15, 16].

4. Conclusion

Thus, considering the need for reduction of a part of imported fossil organic types of energy resources and need for replacement by alternative types of energy resources, including secondary, Russia needs to take a pro-active position in formation of a national technological initiative and fulfilling structural reform has been proclaimed one of top-priority issues forwarded by G20.

Besides, integration of new technologies, services and objects into the existing difficult domestic infrastructure of power industry makes essential changes, and the two-way communication and intelligent devices become more and more important and necessary in the increase of energy sector efficiency and possibility of implementation of bilateral information transfer, control of the equipment and distributions of energy.

The digital economy is an evolutionary development of the traditional economy, as evidenced by technological singularity. Russia at this stage of economic development has to take a proactive position in formation of national technological initiative and structural reform implementation.

5. Prospects of the research

The aim of the further research is to identify, within the framework of the existing model, in the structure of main economic activity of enterprises within a certain industry of invariant processes that can be "digitized" (or automated) by the system of IT-outsourcing, implemented as unified modules which are cumulatively included in the universal network platform.

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