Economic Efficiency of Using the Electric Grid Complex: Problems of Reserves of Network Power and Development of Intelligent Technologies

Maria A. Aleksandrova (0000-0002-6045-4624)[1], Konstantin N. Belyaev (0000-0003-2111-2709)[1], and Sergey S. Ivanov (0000-0003-3968-9071)[2(*)]

[1] Lomonosov Moscow State University, Moscow, Russia
marina@sail.msk.ru, buryakovaos@yandex.ru

[2] Institute of World Economy and International Relations of the Russian Academy of Sciences, Moscow, Russia
ivs2510@mail.ru

Abstract. The key problems in the functioning of the Russian electric power industry are reliability, safety, quality and availability of electricity, environmental impact. Here we aim to: (1) to discuss the results of the reformation and prospects of the electric power industry development and (2) analyze the results of the simplified approach of technological connection of consumers to the network infrastructure. As a tool for increasing the responsibility for the reservation of extra capacity it is proposed to introduce a fee for services in transfer of electric energy on the basis of the amount of maximum power of the appliance. Payment by users is not fully used reserves of capacity will optimize existing network infrastructure to eliminate the construction of networks, rational load of the substation. The solution of the problem is proposed to be carried out on the basis of a differentiated approach and the formation of a mechanism for payment of unused capacity reserve taking into account the operational redistribution of electricity between consumers. The electric power industry needs a full-scale modernization, replacement of economically inefficient obsolete equipment with innovative, supporting the principle of Smart Grid intelligent energy systems. Transition of power engineering to digital technologies is the only possible way of improvement of quality and reliability of power supply and the solution of financial and economic problems of a network complex without growth of tariffs and additional load on consumers.

Keywords: Electricity reform · Tariff setting in the electricity sector · Economic system · Smart grids

1 Introduction

The aim of the energy policy pursued in Russia is to create an innovative and efficient energy sector of the national economy, ensuring energy security and sustainable industrial growth, increase the quality of life of the population, and strengthen the country's foreign economic position. The growth of industrial

production, which began in Russia in 2017 and continues in 2018, significantly increased the requirements for energy information security, flexibility and reliability of the entire electric grid complex
(Belayeva, 2014).

The development and regulation of the electric grid economy of the country is carried out in accordance with a set of measures defined in 1992 to reform the power industry and the formation of a competitive market for electricity (capacity). Over the years of reformation, more than a hundred and fifty legislative acts have been adopted on restructuring, privatization and streamlining the rules of operation of energy companies in the market environment, considerable experience has been accumulated with consumers of energy resources and services of energy companies (Aleshina, 2016). In 2009, The Energy strategy of Russia for the period up to 2030 was adopted, approved by the order of The Government of the Russian Federation No. 1715-R of 13.11.2009, The General scheme of placement of electric power facilities until 2035, The State program "Energy Efficiency and Energy Development". However, the unresolved task of reforming-the liberalization of the electricity market and increased competition, which should result in lower electricity tariffs for consumers, leads the industry to the opposite effects. The mechanism of competition between producers for contracts with consumers announced by the reformers does not work, and a significant increase in the network component in the final price of electricity is the reason for the steady growth of tariffs, a factor hindering the development of the entire national economy.

2 Materials and Method

2.1 Descriptive Analysis

A serious problem in reforming the Russian electric power industry since 2005 has been the availability of technological connection of consumers to electric networks in the regions. In order to solve the problem in 2015 at the legislative level, a number of significant changes aimed at simplifying the procedures of technological connection were introduced: the number of administrative approval procedures and the connection time (up to 90 days) decreased, the cost of accession for preferential categories of consumers decreased, 50% of the investment component was excluded from the fee for technical connection. According to the Federal Law on modification of Article 23.2 of the Federal Law "On the Electric Power Industry" the payment for construction of objects of the power grid economy performed within technical accession of the power accepting devices with the maximum power to 150 kW is not levied. Construction of distribution networks from existing power grid facilities to the applicant's site for connection is made entirely at the expense of the network company. As a result, according to the Ministry of energy of Russia, if 5 years ago, according to the criterion of accessibility of the electric grid infrastructure in the world Bank's DoingBusiness rating, Russia took almost the last 184 place, in 2017 Russia entered the top ten countries in this indicator (Lyubimova, 2015).

Along with the positive result of simplification of the order of technical

connection, the problem of optimization of network capacity reserves has sharply escalated. Every year the power company receives more than 500 thousand applications for new connection to electric networks. In accordance with the acts of technological connection in 2009–2016, the increase in the maximum capacity was 65 GW. Power generation by power plants of the Unified energy system of Russia in 2016 amounted to 59,576.3 million kWh, including thermal power plants – 59,324.0 million kWh., nuclear power plants – 252.3 million kWh. The structure of power generation by types of power plants of the Unified power system of Russia in 2016 is shown in Fig. 1.

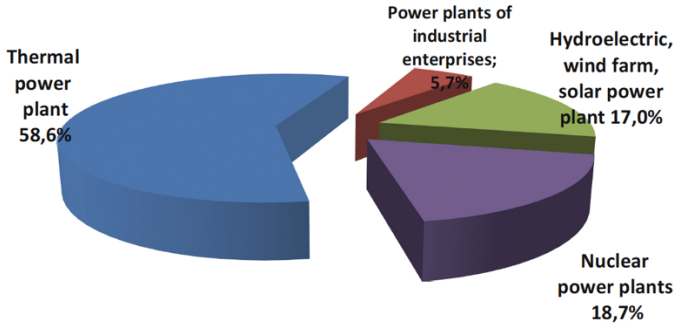

Fig. 1. Structure of power generation by types of power plants EES of Russia.

However, in practice, the connection of new consumers was not accompanied by a proportional increase in power consumption. Over the years of reforms in the electricity sector in the whole country, the useful power consumption has not increased by 1 kW-h. at the same time, the installed capacity of power plants has increased so much that more than 30 million kW of generation have been unclaimed (there are over the necessary reserves).

Table 1 presents data on reserve capacities in the regions of the Russian Federation (the sample includes only entities with more than fifty largest consumers of electricity).

The dynamics of real energy consumption was twice lower than the increase in capacity and the average for the Russian Federation is 58%, which indicates a low utilization of network capacity introduced during this period.

Table 1. Reserves of network capacity in consumers with Pmax over 3 MW, for 2016.

	Subject Russian Federation	Number of consumers	Electricities thousand kWh	P Fact. mW	Pmax. mW	Share of provision, %
1	Tyumen region	80	36,226,163	4,389.3	6,406.7	31
2	Belgorod region	61	7,627,078	990.5	1,485.6	33
3	Kaluga region	62	982,772	229.9	440.7	48
4	Vladimir region	70	1,940,008	297.0	571.7	48
5	Omsk region	68	3,238,991	616.9	1,256.9	51
6	Moscow region	396	3,143,956	2,035.4	4,228.4	52
7	Perm region	61	8,003,835	1,635.5	3,489.1	53
8	Moscow	258	3,819,295	848.9	1,834.8	54

9	Samara region	80	6,424,396	876.3	1,942.9	55
10	Sverdlovsk region	181	12,282,534	2,026.0	4,550.3	55

consumption, which indicates that the newly joined consumers do not use the requested value of the maximum power of 100%. For example, according to PJSC "Interregional distribution grid company of the North – West" and "Vologdaenergo," in 2012–2016 in this region the average load of newly introduced power centers with voltage of 35 kV and above did not exceed 45%. This problem is typical for almost all regions of Russia.

3 Results

According to SAP expert estimates, the potential for GDP growth associated with the development of digital electricity will amount to 200 billion rubles, of which 100 billion rubles – in the electricity networks. As a result of the digital transformation of the network business, the profit growth of energy companies will be 4.3% of the current indicators.

The main risks associated with the introduction of an intellectual power grid are connected, firstly, with a high cyber danger, which is due to the complex architecture of information and communication networks. Therefore, in the conceptual development of Smart Grid, considerable attention should be paid to ensuring cybersecurity, including the confidentiality, integrity and completeness of all information systems. Secondly, the security risks are related to the prevention of cascading failures. World and Russian practice shows that the main problems associated with the spread of Smart Grid technology are: a significant number of consumers who have different requirements for the quality of electrical energy; the lack of reliable energy storage; significant financial resources necessary for the implementation and operation of the system, the lack of standards and regulations; the lack of motivation by the management of the generating 248 O. Danilova and I. Belayeva companies because the purpose of the implementation of the system – the energy savings and the earnings depend on the volume of sold electric energy (Chebanov et al., 2015).

Despite these problems, the "smart grids" allow you to increase the capacity of overhead power lines and power supply reliability by 30%; to distribute the load curve due to power grid energy storage more power by 25–30%; to reduce the area that is covered by the grid facility due to the innovative materials and construction technologies; to reduce losses of electricity during its transmission by 25%, which will lead to savings 34–35 billion kWh per year and reduce the amount of fuel burned and emissions of carbon dioxide into the atmosphere.

4 Discussion

One of the problems of strategic development of Russia's regions is high level of their differentiation according to economic, social, and institutional parameters

(Treshchevsky et al., 2017; Risin et al., 2017); (Sazonov et al., 2013; Popkova et al., 2018a, 2018b; Treshchevsky et al., 2018). Low predictability of the level of influence of new financial and other limitations on economy and social sphere of regions requires formation of tough basis of socio-economic policy, based on the strategy of region's socio-economic development. In the conditions of financial and economic limitations to formation of strategies of regions, it is necessary to set additional requirements.

Based on theoretical studies and practice of development of strategies of the regional level, we offer the main provisions of the theoretical and methodological approach to substantiating the goals of region's socio-economic development:

- region's mission should reflect its functional specifics;
- general goal of the new strategy should ensure succession and update of goals of the implemented strategy of socio-economic development of the region until 2020;
- goals of subjects of management of various levels should take into account diversity of preferences of various institutional groups of the region (Endovitsky et al., 2017);
- number of priorities in the economic, social, and spatial aspects should be limited (in our opinion – down to one priority in economy, social sphere, and organization of space);
- goals should be determined quantitatively (in the usual conditions, goals could be reflected not only by quantitative indicators but also qualitative characteristics);
- narrow list of goals is necessary – those that are critical for preserving stability of region's socio-economic system;
- it is important to ensure orientation at invariant (common for Russian regions) goals, defined in the program documents of the public authorities of the RF: the Strategy of national security of the RF; Message of the President to the Federal Assembly of the RF dated March 1, 2018; the Project of the Concept of spatial development of the RF.
- social goals are oriented at support for poorly protected social groups of population, development of education and healthcare.

5 Conclusion

As a result of the provision of benefits to certain categories of electricity consumers in the regions of Russia, the demand for connection to electric networks has significantly increased. However, the increase in the number of new consumers did not result in a comparable increase in power consumption. The increase in the demand for electricity connections was not due to the activation of market mechanisms, but only to the measures of state support for the creation of new electrical facilities. Network organizations spend money not only on the creation of the necessary network infrastructure to consumers, but also on the maintenance of already built electrical networks, to maintain their readiness to issue to consumers

the full amount of the declared maximum capacity, defined in the documents on technological connection. The source of funding for excess capacity is investment and operating funds that network organizations divert from the modernization and renovation of electrical networks. The solution to this problem may be the introduction of economic responsibility of consumers for reserving maximum capacity.

A promising direction for solving the accumulated problems may be the introduction of an intelligent electricity metering system. Intelligent accounting will completely change the stereotypes of technological connection, as without digital authorization and binding to the metering device, the consumer will not be able to use the services of the network. Installation of electricity meters will allow consumers to access hourly consumption schedules, optimize the cost of electricity through the use of different tariffs. State bodies, in turn, will have the opportunity to monitor the reliability and quality of services, reliability of electricity balances for tariff regulation.

Acknowledgment

The reported study was funded by RFBR according to the research project No. 18-314-00009.

References

Government of the Russian Federation. (2015). *State Program "Energy Efficiency and Energy Development"* (May 5, 2015, No. 3384p-P9). Moscow, Russia. Retrieved from http://i.cons-systems.ru/u/8c/0a55a8bcc311e4aca5fbaefc9347ae.

Aleshina, E. V. (2014). Problems and prospects of development of electric grid business Russian Railways holding. *Bulletin of Samara state University of Economics*, *3*(113), 36-40

Belayeva, I. (2014). *Socially responsible activities of the state and business*. In Proceeding from SGEM 2014: *International Multidisciplinary Scientific Conferences on Social Sciences and Arts.* Albena, Bulgaria.

Lyubimova, N. G. (2015) Long-term supply of reliable and affordable power supply to consumers. *Bulletin of the University*, *10*, 76–79.

Risin, I. E., Treshchevsky, Y. I., Tabachnikova, M. B., & Franovskaya, G. N. (2017). *Public Authorities and Business on the Possibilities of Region's Development.* In Popkova, E. G. (Ed.) *Overcoming Uncertainty of Institutional Environment as a Tool of Global Crisis Management* (pp. 55-62) (Ser. Contributions to Economics). Cham, Switzerland: Springer International Publishing AG.

Sazonov, S. P., Lukyanova, A. V., & Popkova, E. G. (2013). The financial budgeting governance in transitive economies. *World Appl. Sci. J.*, *23*(11), 1538–1547.

Endovitsky, D. A., Tabachnikova, M. B., & Treshchevsky, Y. I. (2017). Analysis of the economic optimism of the institutional groups and socio-economic systems. *ASERS J. Adv. Res. Law Econ. VII*(6, 28), 1745-1752.

Vertakova, Y., Risin, I., & Treshchevsky, Yu. (2016). *The methodical approach to the evaluation and development of clustering conditions of socio-economic space*. In Proceeding from IBIMA 2016*: Innovation Management and Education Excellence*

Vision 2020: from Regional Development Sustainability to Global Economic Growth. Milan, Italy

Popkova, E. G., Bogoviz, A. V., Ragulina, Y. V., & Alekseev, A. N. Perspective model of activation of economic growth in modern Russia. *Stud. Syst. Decis. Control*, *135*, 171–177 (2018b)

Parakhina, V. N., Ustaev, R. M., Boris, O. A., Maximenko, L. S., & Belousov, I. N. (2017). *Study of tendencies of formation and evaluation of hr innovational potential of the regions of the Russian Federation*. In Popkova, E. G. (Ed.) *Overcoming Uncertainty of Institutional Environment as a Tool of Global Crisis Management* (pp. 295–301) (Ser. Contributions to Economics). Cham, Switzerland: Springer International Publishing AG.

Maslov, P. (1926). *The agrarian question in Russia* (2nd ed.). Moscow, USSR: State Publishing House.

Serkov, A. F., Maslova, V. V., & Chekalin, V. S. (2018). *Sustainable development and increasing the competitiveness of Russian agriculture in the context of deepening integration in the EAEU*. Moscow, Russia: Scientific Adviser.

Belyanin, V. A. (Ed.). (2017). *Perm region in figures 2017: Brief statistical digest.* Perm, Russia: Permstat.

Gordeev, V., & Rustam, A. (2018). *The World Bank lowered its forecast for economic growth in Russia and in the world*. Retrieved from https://www.rbc.ru/economics/ 09/01/2019/5c353d059a7947dfebf839cd/.