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Modeling of Energy Sustainability at The Regional Level (SDG 7 Achievement in The Russian Federation)

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Abstract*: *The aim of the article is to develop proposals for modeling of energy sustainability at the regional level. Analysis of the approaches used in the theoretical studies and practice of quantitative determination of energy sustainability at the regional level shows that it is most advisable to form a comprehensive methodology for energy assessment, which includes a comparison (analogy) method, as well as regulatory, balance, and design methods. The normative method is used to determine the sum of element-by-element energy potentials calculated for technological processes in all sectors of the region's economy. The comparison method is based on the determination of regional energy sustainability by its value in the base region and the ratio of energy consumption in a region under consideration and the source region. In the consequence of the study, it was revealed that there is no shared opinion regarding the energy sustainability modeling at the regional level. Estimates of planned commissioning of generating capacities are characterized by considerable inconsistency. There is a lack of coordination between energy development programs as an infrastructure sector and the regional economy. It is proved that the coordination of interests is possible if considering energy sustainability as an independent system. In this case, the excess capacities will act as competitors, which are focused on generating income. It is determined that the development degree of network infrastructure in the region determines the possibility of using excess capacity in power systems.

Index Terms*: *energy sustainability, infrastructure, modeling, region, market, mechanism, state, economic activity, space.

I. INTRODUCTION

Sectoral and territorial interdependence of economic space requires an integrated approach to modeling of energy sustainability. Currently, the energy-saving policy of the state is focused on solving mainly sectoral goals and objectives, while the territorial aspect of the energy saving problem is practically not considered. At the same time, the region, as a set of territorial-industrial formations, is characterized by the configuration and planning structure, transport and municipal infrastructure schemes, the nature of the construction and energy efficiency of its facilities, the territorial binding of types of economic activity, and the spatial distribution of energy facilities. Consequently, the level of territorial energy sustainability, as well as the size and structure of the regional energy saving potential are significantly influenced by the urban situation and measures to change its energy efficiency. In terms of urban planning, two key areas of energy sustainability are of special interest: first, modeling of the territory from the energy saving perspective, energy-efficient territorial modeling of regions and municipal entities; and, second, creation of industrial, public, and residential buildings with efficient use of energy during operation, their reconstruction and modernization in order to bring the energy standard to up-to-date requirements.

II. LITERATURE REVIEW

The study of issues related to the analysis of energy sustainability at the regional level was reflected in the works of A. Grunwald [1], G.I. Kalimullina [2], A.I. Karpovich [3], M.V. Perkova [4], L.K. Prokopenko [5], S.B. Rostovtsev [6], and others. The literature analysis on the research topic allows identifying contradictions that prove the need for modeling energy sustainability at the regional level.

Scientists [7-9], when studying the energy consumption level and the efficiency of energy use in the territorial-industrial formations, have determined that it depends on the energy interrelationships existing in the region. This involves interrelationships between natural energy and social energy, related to the demographic situation and the population's quality of life. Therefore, to obtain a balanced result of energy saving, it was proposed to take into account the whole complex of factors affecting these relationships. Therefore, the regional policy in the field of energy saving should be formed in accordance with the following provisions: one should consider the territorial-industrial formation as a single energy system, the interrelationships of which form a closed circuit functioning in a single natural, economic, social and physical space; to take into account changes in the composition of energy saving measures and their different effectiveness to the extent of territorial growth and socio-economic development of the region;

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to carry out energy zoning according to the structure and level of energy consumption and energy saving, which allows for energy saving measures by rational placement in the areas of energy consumers.

III. METHODS

A. General description

Analysis of the approaches used in the theoretical studies and practice of quantitative determination of energy sustainability at the regional level shows that it is most advisable to form a comprehensive methodology for its assessment, which includes a comparison (analogy) method, as well as regulatory, balance, and design methods. The normative method is used to determine the sum of element-by-element energy potentials calculated for technological processes in all sectors of the region's economy. The comparison method is based on the determination of regional energy sustainability by its value in the base region and the ratio of energy consumption in a region under consideration and the source region.

In the balance method, energy sustainability is estimated based on the value and structure of the regional fuel and energy balance and energy survey data. The information base of the present article includes the statistical data of state bodies, legislative and regulatory documents regulating the modeling of energy sustainability at the regional level, as well as the results of conducted research [10-12].

B. Algorithm

In the course of research it is planned to improve the approach to energy sustainability modeling at the regional level, to develop activity coordinating measures among the main energy market entities ensuring the formation of energy sustainability, to justify the statement on the rational design of energy saving in the context of economic reforms at the regional level.

C. Process flow diagram

The study is planned to be carried out according to the following diagram, in which the modeling of energy sustainability is considered as a dynamic process that provides the formation of parameters for the regional energy development (Fig. 1).

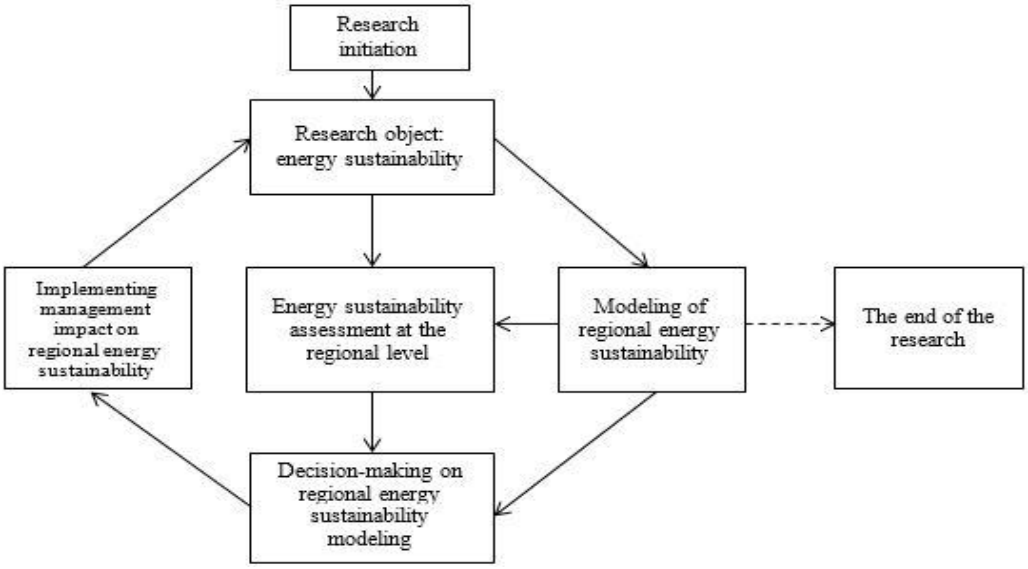

Fig. 1: Flow diagram of regional energy sustainability modeling

IV. RESULTS

In the course of the research, the possibilities of implementing the "third mission" of the Moscow State Institute of International Relations (MGIMO) were considered. One of the functions of the MGIMO University and the United Nations Association of Russia (UNA-Russia) consists in delivering the global agenda and UN programs to the Russian regions in a reliable and timely manner and facilitating implementation as quickly as possible of best topics and practices worthy of being implemented in the Russian regions.

At the same time, the agenda of sustainable development is actively developed MGIMO University. One of its types is the creation of Youth Models. In this particular case, one can consider the direction of "Sustainable Development Goals 7" (SDG 7) in the public agenda in the context of achieving energy sustainability of the federal districts of the Russian Federation. In this aspect, the Laboratory of Geoecology and Sustainable Environmental Management of MGIMO University has developed a methodology to assess the region's ability to achieve sustainability. At that, the modeling is based on clusters traditionally distinguished when working with the sustainable development agenda. These are an assessment of economic, environmental, and social sustainability of the region. At the same time, this methodology can be applied

thematically to the energy sustainability agenda.

Within the framework of using this technique, students of six Russian universities were grouped into teams (up to 15 people in each team) depending on their actual residence in a particular federal district. Working groups of 3-4 people were created within each team, who carried out cluster based assessment.

To evaluate the results of the teams, an expert jury was formed, which attracted experts from different regions, namely, civil servants, scientists, industry and business representatives. In this aspect, input and final testing of experts and team members were conducted separately. In the course of testing, the results of modeling, as well as the results of testing all participants in the process, were discussed.

The obtained results were presented to the Federal Agency for Youth Affairs (Rosmolodezh), the Ministry of Energy (Department of Strategic Planning) and the BRICS International Energy Agency, which initiated the modeling. In consequence of the model, participants received invitations and certificates for internships in various organizations, which was for them a good start in terms of professional training.

Implementation of measures to improve energy sustainability requires significant investment and time. However, exactly these decisions have significant impact on the level of territorial energy consumption. Therefore, the development of the territorial potential of energy saving is largely determined by the level of energy consumption. At the modeling stage, consumer and energy characteristics of construction technologies can be set that forms the costs of construction production and its energy intensity, on the one hand, and the level of energy consumption and project energy efficiency, on the other hand.

The defining role in energy sustainability modeling belongs to the state energy efficiency standards, which are set by departmental norms and rules. The Russian Federation uses state energy standards, which are mandatory for all organizations in the country, regardless of ownership.

The problem of energy sustainability modeling at the regional level is reduced to the definition of structural and engineering solutions that provide the minimum possible energy consumption. An economic evaluation of energy-saving solutions allows adjusting costs. At that, the specific energy consumption is the main indicator of the effectiveness of energy saving design solutions. Since this indicator underlies the whole system of technical indicators of modeling, it allows performing the multivariate design of energy saving based on the principle of interchangeability of engineering solutions.

The increased consumption of energy resources to maintain an acceptable quality of life of the population and the functioning of the regional economic complex is objectively determined by climatic conditions and a large area of territory. At the same time, regional authorities, when considering energy sustainability issues should adhere to the state principles, which define the key areas of energy saving activities within the framework of a unified strategy for the development of the fuel and energy complex and the regional economy.

However, there are a number of constraints in the implementation of the energy sustainability policy of the regions. They include the following aspects: the declarative nature of the regulatory framework in the field of energy consumption; the disunity of energy saving management bodies, either of which forms own goals and objectives, and uses its own resources and tools; lack of the regional program of energy sustainability; irrationally spent funds and resources; and insufficient statistical information on the final consumption of energy resources.

Studies have shown that when modeling energy sustainability, each ruble invested should yield 3-4 rubles of profit. Therefore, the Russian Federation has taken the right course to improve competitiveness through energy sustainability. But the budget sector, as well as housing and communal services, is still experiencing difficulties in this challenging process. All this indicates the backwardness of Russian energy system compared to the developed countries.

At the same time, the specific energy consumption of housing and communal services is greater than that of machine-building and nonferrous metallurgy. However, these economy sectors have a rather modest budget not allowing employment of qualified specialists and implementing modern energy-efficient technologies. The main reasons for the lack of energy sustainability in the electric power and thermal economy at the regional level are the poor metering of energy consumption, significant physical deterioration of the equipment of thermal power plants, boiler-houses, and diesel power plants, as well as distribution and in-house thermal and electrical networks.

In particular, the level of depreciation of fixed assets of the electric power industry increased from 44.7% in 1999 to 57.2% in 2016, while the coefficient of plant equipment renewal, on the contrary, decreased from 4.0 to 2.2%. At the beginning of 2017, the wear-out rate of fixed assets for production, transmission, and distribution of electrical energy, gas, steam, and water amounted to 57%. However, in 2018, the capacity of the waste equipment reached 25% of the installed electric capacity of power plants.

The increase in the volume of energy consumption in the main sectors of the economy projected in accordance with the scenarios of socio-economic development of the region will certainly affect the aggravation of noted problems and will require the expansion of the energy base of the region to support the growing energy needs. However, the demand for electricity is derived from the demand for goods and services in the economy, while the supply of electricity is limited by the range of electric networks. As a result, the spatial power supply structure, defined by the distribution of the final demand for electricity, pattern upon the nature and characteristics of the location of economic activity and the population. At the same time, the demand and supply of electricity coincide in time, that is, the change in the amount of consumption leads to appropriate regulation of energy generation that affects the technical and economic

performance of power plants.

Therefore, a relatively higher level of losses in the networks, which is determined by the considerable distance of transmission of electricity and high wear of networks, contributes to the production growth (Fig. 2).

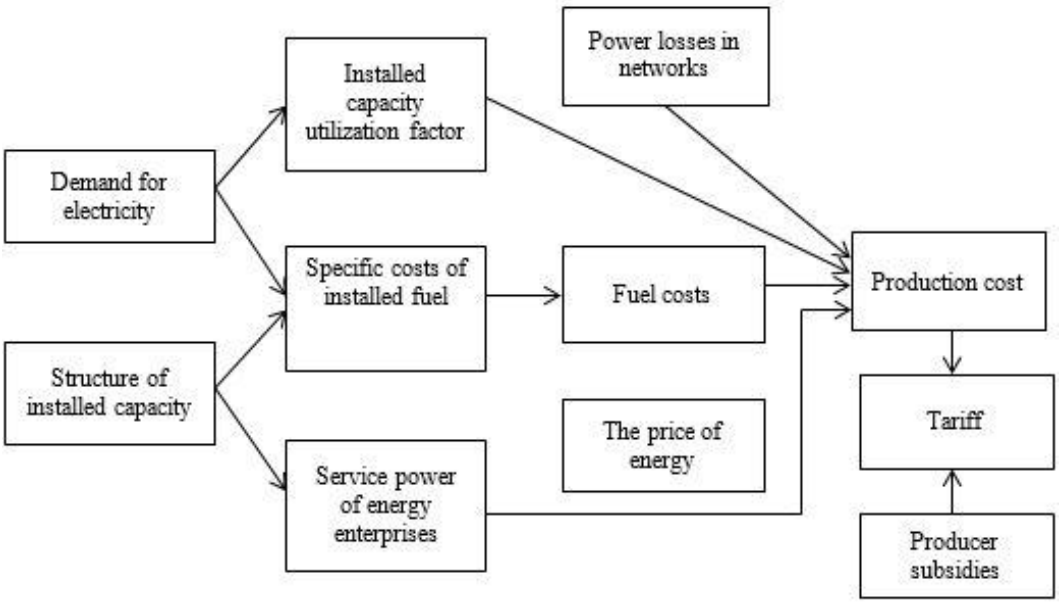

Fig. 2: Modeling of interrelations of production indicators, cost, and tariff for energy resources.

Therefore, there is a whole range of factors determining the increase in the price of electricity production in the region, namely, an increase in the rate of power reserve; high specific fuel consumption per unit of energy production; high cost of fuel used at power plants; and a high proportion of losses. Multidirectional effect of various factors results in a reduction in the gap in cost level when producing 1 kWh of electricity.

In continuation of the decrease in the differentiation of production costs, there is a convergence of average electricity tariffs with the national average. At the same time, the differentiation of production costs between regions is increasing due to the different growth rates in demand for electricity. As a result, the gap in average tariffs is increasing

The reliability of the presented approaches is confirmed by the fact that the features of energy sustainability modeling determine the need to coordinate energy development plans in accordance with the development of the economy of the respective territories, which are usually discussed in the framework of searching for a balance between energy consumption and supply. Retrospective analysis reveals that the regional power industry is currently functioning in conditions of the nonconformance of energy production and consumption.

In the period up to 2025, the strategic development of the economy and power industry at the regional level can be carried out mainly within the framework of integrated projects for the development of territories as well as large investment projects. The implementation of large projects will lead to a significant increase in energy consumption by enterprises and industrial associations. Given that one of the features of the regional energy system is the focus on large consumers, the implementation of energy-intensive projects will increase the proportion of the latter in the energy demand generation.

All this requires an independent account of potential energy consumers because, in the context of the existing structure of energy consumption, the behavior of one or more large consumers violates the compiled inertial trends of energy consumption. Given this feature, domestic energy demand in the region will consist of two components: inertial demand and project demand. The first one is created by energy consumption, which is due to the dynamics of existing consumers in the production of goods and services, seasonal climatic fluctuations, as well as maintenance and growth of living standards. The second one is due to the implementation of large projects in the area under consideration, which, due to the small existing energy demand in the region can significantly affect energy sustainability.

Therefore, for the modeling of energy sustainability from a regional perspective, one should use a two-stage algorithm to forecast energy consumption. At the first stage, the general dependences of energy consumption on the main macroeconomic indicators (assessment of the energy demand function based on the econometric method) are determined to employ the methods of mathematical statistics. In the second stage, expert assessments and the direct counting method are used to determine the demand of new large consumers.

V. CONCLUSION

To sum up, one can note that there is no shared opinion regarding the modeling of energy sustainability at the regional level. Estimates of planned commissioning of generating capacities are characterized by considerable inconsistency.

There is a lack of coordination between energy development programs as an infrastructure sector and the regional economy. Therefore, the harmonization of interests is possible if we consider energy sustainability as an independent system.

In this case, the excess capacities will act as competitors, which are focused on generating income.

At the same time, the development degree of network infrastructure in the region determines the possibility of using excess capacity in power systems. Therefore, three options for the use of excess generating capacities can be considered. In the first case, part of the commissioned generating capacity is not used but is maintained as a reserve to ensure the growth of energy consumption. The second option of using excess generated capacity is associated with the power systems interconnection processes. And a third alternative to the use of excess generated capacity is energy exports.

The main reasons for the lack of energy sustainability at the regional level are as follows: unclear economic ideology of the government on energy policy and innovative processes in industry; lack of awareness of the need to reform the management in general, and implementing strategic management of energy; bureaucratization of economic management and low motivation of staff to achieve energy sustainability; moral and psychological unpreparedness for energy-saving behavior; partial liberalization of the energy market of the Russian Federation with an undistorted mechanism of its functioning, and the overall increase in the cost of energy resources

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