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**Article**

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# Globalization of the Power Sector as Factor for Sustainable Development and Energy Security

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**ABSTRACT**

The problem of ensuring that the entire world population has access to energy sources is well known. One of the approaches to solving this problem is the formation of interstate power connections. This article focuses on how to measure the effectiveness of interstate power connection projects in terms of ensuring the sustainable development of countries and regions of the world. In the article, we develop a mathematical model of synergy effects driven by creating interstate power connection. The applicability of the model is demonstrated by the example of a prospective energy association of the Eurasian Economic Union.

**Keywords:** Globalization, Sustainability, Energy, Eurasian Economic Union, Sustainable Energy, Energy Security
**JEL Classifications:** O13, P18, Q1

## 1. INTRODUCTION

The energy problem is one of the key global problems of the modern age. A sustainable energy sector is necessary for a stable national economy, job security, science and technology development, and eradicating poverty. "Energy is the golden thread that connects economic growth, increased social equity, and an environment that allows the world to thrive. Development is not possible without energy, and sustainable development is not possible without sustainable energy." – UN Secretary-General Ban Ki-moon (UNDP, 2016).

In this regard, ensuring universal access to energy services is one of the fundamental global challenges. This was noted in the UN General Assembly Resolution No. 70/1 of 25 September 2015, according to which ensuring access to affordable, reliable, sustainable and modern energy for all is one of the sustainable development goals for humanity (United Nations, 2015).

Despite the ongoing efforts under the UN auspices to ensure the availability of energy supply, over 1 billion people around the world do not have access to electricity, about 3 billion people from Asia and sub-Saharan Africa prepare food without access to environmentally friendly and efficient technologies (The World Bank, 2018).

In 2017, expert groups, working under the auspices of the World Bank and the International Energy Agency (IEA), concluded that the measures taken to achieve the sustainable development goals set out in Resolution No. 70/1 were insufficient. It is predicted that by 2030, about 8% of the global population will still have no access to electricity and over 25% will not have clean fuels (UNECE, 2018).

This underscores the relevance and urgent need to create electric power infrastructure that ensures universal access to energy sources. Development of electricity interconnection could be one

way to solve this problem. In the context of the global economy, the formation of interstate power connections is part of a global integration process that began in various regions of the world more than a hundred years ago, and has now entered an active phase of its development due to the growth of energy consumption in the world.

Creation of a common electricity market allows for mutually beneficial electricity trading between countries, expanding electricity markets, increasing the reliability and continuity of electricity supply, using the most efficient equipment and renewable energy sources. The result of this will be equality of energy supply in different world regions and the reduced cost of electricity.

## 2. ANALYSIS OF THE SYNERGISTIC EFFECTS OF ELECTRICITY INTERCONNECTION

The integration of electricity markets provides such strategic benefits as technological improvements of the electric power system; increasing investment prospects; long-term development of related production and technological industries; widespread introduction and testing of digital and cyber-physical technologies in a large-scale, geographically distributed industry; implementation of energy-efficient technologies, reducing both the volume of losses of electric energy, and the cost of equipment maintenance.

The long-term strategy for forming a common electricity market involves not just the design of the technological and organizational-economic infrastructure of the common electric power industry, but the deep and systematic development of the energy potential of the participating countries and the formation of long-term "points of growth" for integrated national economies. This allows, as a result, to create a unified electricity environment with unified standards of industrial, technological and environmental security, to establish long-term technical and economic cooperation and develop long-term infrastructure initiatives.

For these purposes, it is necessary to harmonize the rules of cooperation and the functioning of the common electricity market. Institutionally, this initiative is implemented through the formation of a transnationalized electricity market and the creation of a supranational system operator, which ensures the coordination of power purchase agreements (Arshinov, 2013).

Regarding system theory and system analysis, integration in the global power industry and creating common electricity markets represent the construction of a complex organizational, technical and political-economic system that includes national electric power systems. The issues of evaluating the increase in the cumulative efficiency of individual elements when combined into an economic system are one of the most important areas of modern economics and are reflected in numerous publications.

The concept of synergism cuts across subjects and is found in the scientific works on tectology by Bogdanov (2003), Wiener's

cybernetics (1961), the theory of self-organization of dynamical systems of Ashby (1957), the theory of dissipative structures of Prigozhin (Prigozhin and Nikolis, 1979), the general theory of systems of von Bertalanffy (1968), Beer's models of a viable system (1981), the synergetics of Haken (1983) and other scientists who studied the processes of the evolution of complex systems of different natures. In economics and management, the concept of synergy is displayed in the classical works by Ansoff (2007) on corporate strategy, and Porter (1985) on the processes of value creation. The most famous field of application of the concept of synergy in the economy is the evaluation of the effectiveness of mergers and acquisitions. Here, synergy is understood as an increase in the efficiency of activity as a result of a merger of companies compared to their activities prior to merging (Evans and Bishop, 2001).

An analysis of publications by Russian and foreign authors on the synergy concept and its application in various areas of science allows us to draw conclusions on the universality of the approaches used and the prospects for their application to the study of integration processes in the global electric power industry. In particular, methods for evaluating synergy effects that have been tested to substantiate management decisions at the microeconomic level can be applied to substantiate projects for the formation and development of power interconnections at the macroeconomic level.

Indeed, the processes of forming a power interconnection and creation of a common electricity market are characterized by synergy effects for the participating countries. On the infrastructural and technological side, this process includes the entire complex of electric power facilities, both the direct electricity generating facilities, and the entire pool of transport and connecting connections, as well as other auxiliary equipment.

The specific nature of the production process in the power industry entails the need to maintain a constant balance between production and consumption. For this purpose, various administrative, organizational and economic mechanisms are used to stimulate the interest of subjects in maintaining established standards of electric power system operation.

Given the technological characteristics of the power industry (Ashby, 1957), the process of providing electricity can be expressed by the components of the electricity balance by the following Equation (1):

$$G+I-E = C+L \qquad (1)$$

where $G$ is the net energy production (domestic capacity); $E$ and $I$ denote export and import (transboundary capacity); $C$ is the consumption by all types of customers; and $L$ represents losses.

To denote the difference between export $E$ and import $I$ as net exports $NE$:

$$NE = E-I \qquad (2)$$

Then, taking into account Equation (2), Equation (1) is converted to the form:

$$G - C - L = NE \qquad (3)$$

The logistic features of electricity, primarily due to the fact that it is impossible to efficiently store and transmit over long distances, give rise to serious potential losses due to the inability to realize unclaimed power. Thus, the validity of the electricity interconnection project can be based on the indicators of "electric power profitability" by minimizing losses. Based on this hypothesis, it seems appropriate to group the countries of the world according to the indicators entered in Equation (3), in accordance with Table 1.

Typical examples of countries in the world that fall into these selected groups are listed in Table 2.

To identify the sources of economic synergy arising from national power systems integration, we will use the classification of the effects of economic synergy according to functional and structural features.

Functionally, we will distinguish:
- The effect of operational synergy in the interconnection, due to the influence of the regional coordinator (dispatcher), which allows to consolidate and optimize energy consumption regimes throughout the territory of the interconnection, to predict and smooth load fluctuations on the elements of the electric power infrastructure; improve the reliability of the interconnection by guaranteeing supplies in a single system; to ensure and maintain consistency in the regulatory indicators of the quality of electricity and electrical power equipment due

to the large-scale effect; and guarantee the mutual assistance of participants in critical and abnormal situations;
- The effect of managerial synergy in the interconnection lies in the stimulating function of the regional coordinator, that predicts demand, and in accordance with this demand manages the activities of local generators. This allows to generate pre-regulated volumes of electricity, to reduce local and global operational reserves for critical and emergency situations; centralized planning and regulation of consumption allows local sellers to optimize and rationalize maintenance and repair work, to choose the best schedule for carrying out these works; optimize the load of a particular seller, thereby reducing its production costs, in particular for fuel resources; and significantly reduce environmental harm through a supply and load management plan;
- The effect of financial synergy in the interconnection lies in the cost reduction of the local participant to operate and maintain the technological infrastructure and equipment, the availability of larger electric power integration and development projects. Also, the effective structure of the electricity interconnection allows the local participant to build long-term investment and infrastructure plans in accordance with the general development projects of the region.

Structurally we will distinguish:
- Subadditive synergy, which has a short- and medium-term nature and is expressed in reducing overall costs by eliminating unnecessary production processes, reducing specific energy costs, increasing sales, etc.;
- Superadditive synergy, which is based on the long-term benefits of the integration project: access to new customers, mutual aid, development of corporate and competitive potential, diversification of production, portfolio of partners and the business as a whole.

The above classification is common in the literature on the concept of economic synergy and is also used in the related areas of the economy of the fuel and energy complex. Subadditivity is reflected in a decrease in the aggregate costs of the participants in the power interconnection, while superadditivity consists in increasing their cumulative effect. In the context of the process under study, the subadditive component corresponds to the effects of operational and financial synergy in the interconnection, and the superadditive component corresponds to the effects of managerial and financial synergy effects.

The quantitative assessment of the synergy effect in the interconnection is based on its presentation in the form of subadditive and superadditive flows of additional economic benefits of the participants of the association:

**Table 1: Criteria for grouping countries of the world by the possibilities for cross-border implementation of excess capacity**

| Criteria | Description |
|---|---|
| $G \leq C$ | Own sources of power generation are not sufficient for domestic consumption. |
| $(G > C) \wedge (L \leq NE)$ | Own sources of power generation provide domestic consumption, and efficient cross-border implementation of excess capacity is achieved. |
| $(G > C) \wedge (L > NE)$ | Own sources of power generation provide domestic consumption, but the cross-border realization of excess capacity is limited (inefficient) due to significant losses. |
| $(G > C) \wedge (L \gg NE)$ | Own sources of power generation provide domestic consumption, but the cross-border realization of excess capacity is not practically achievable due to high losses. Net exports<5% of losses. |

**Table 2: Typical examples of countries' perspectives for cross-border electricity trade (absolute figures, GW/h)**

| Group | Country | Generation | Consumption | Net export | Losses |
|---|---|---|---|---|---|
| | | $G$ | $C$ | $NE$ | $L$ |
| $G \leq C$ | Greece | 46,702 | 51,372 | 8,819 | 4,149 |
| $(G > C) \wedge (L \leq NE)$ | France | 539,416 | 439,561 | 67,190 | 32,665 |
| $(G > C) \wedge (L > NE)$ | Russia | 994,657 | 880,042 | − 8,048 | 106,567 |
| $(G > C) \wedge (L \gg NE)$ | India | 1,278,907 | 955,927 | 4,998 | 327,978 |

$$F_t^{\text{sub}} = G_t w_1 - N_t E w_2 \qquad (4)$$

$$F_t^{\text{sup}} = G'_t w_3 + L'_t w_4 \qquad (5)$$

where $w_1$, $w_2$, $w_3$, $w_4$ are weights that reflect integration and disintegration factors of interconnection; $G'_t$ is the estimated increase in national electricity production in the period $t$, $L'_t$ is the assessment of the reduction of non-technological losses in the period $t$.

In the "as it is" situation, when potential participants of the interconnection are considered separately, the weighting factors $w_1$, $w_2$, $w_3$, $w_4$ are equal to one, and the subadditive flow (Eq. 4) means the current state of the national electricity balance in economic terms. At the same time, the long-term effects $G'$ and $L'$ are equal to zero, and therefore the superadditive synergy (Eq. 5) is absent.

When considering the merged situation in the "as will be" format, the weights $w_1$, $w_2$, $w_3$, $w_4$ additionally contribute an expert corrective assessment of the components of the integration process. To evaluate the long-term effects of $G'$ and $L'$, we propose to use methods of games theory.

To calculate the value of subadditive and superadditive long-term synergy effects, we use the capitalization model of economic benefits flows:

$$S^{\text{sub}} = \sum_{t=0}^{T} \left( \frac{1}{1+r} \right)^t F_t^{\text{sub}}; S^{\text{sup}} = \sum_{t=0}^{T} \left( \frac{1}{1+r} \right)^t F_t^{\text{sup}} \qquad (6)$$

where $F_t^{sub}$ sub is the subadditive flow of economic benefits; $F_t^{sub}$ sup is the superadditive flow of economic benefits; $r$ is the discount rate; and $T$ denotes the forecast horizon.

When forming a model, it should also be taken into account that the projects of cross-border electricity integration also contain charge components reflecting the costs of organizational and economic measures, resource, technological and infrastructure support of the participants; measures for unification and standardization of production and operation mechanisms, and others. Therefore, in order to assess the economic synergy effect in the interconnection, taking into account Equations (4-6) we obtain the following Equation:

$$S(C) = \sum_{i \in C} \left( S_i^{sub} + S_i^{sup} \right) - R(C) \qquad (7)$$

where $C$ represents the participants of the interconnection, $S_i^{sub}$ and $S_i^{sup}$ – the effects of subadditive and superadditive synergy for the local participant, and $R(C)$ the cost of measures to form the interconnection $C$.

It should also be noted that despite the technical and economic advantages of the integration process, it is significantly impeded by political and socio-economic factors. The difference in the scientific, technical and production-technological potential of neighbouring countries, the serious influence of interstate tensions

and conflicts, as well as other foreign policy factors markedly reduce efficiency and interest in electric power cooperation at the trans-regional level. Therefore, when developing cooperation projects in the energy sphere, political and country risks require detailed and long-term analysis.

The proposed model is promising for assessing the validity of the interconnection projects, since it is based on the technological features of the process of electricity supply and consumption, and also takes into account the regional physiographic and infrastructural potential of the states participating in electric power integration.

# 3. SCENARIO ANALYSIS OF SYNERGETIC EFFECTS OF THE EURASIAN ECONOMIC UNION INTERCONNECTION

On the basis of above mentioned model for the assessment of synergetic effects, we will analyze the example of the Eurasian Economic Union power interconnection.

The concept of forming a common electric power market for the EAEU, approved by the Eurasian Economic Council in 2015 (The Supreme Eurasian Economic Council, 2015), identified the main directions, principles and structural elements of the future interconnection. However, the main work on its formation is to be implemented in 2019, when a specific plan of activities will be developed and implemented. Thus, the work on determining the final model of the electricity interconnection of the EAEU is still ongoing, which predetermines the need to substantiate the mechanisms for its creation and functioning, including taking into account the potential synergistic effects for the participating countries.

To calculate the integral effect of economic synergy, we use Equation (7), adopting $R = 0$ for practical estimates, since the main purpose of the study is a comparative analysis of the participants' benefits for various scenarios, their costs for the implementation of integration measures, can be taken as the constant value.

The indicators of the electric power profiles of the countries participating in the interconnection of the EAEU and the corresponding coefficients for assessing the potential for the cross-border implementation of the excess electrical power are given in Table 3.

The cost characteristics of the flows of economic benefits of the participating countries are estimated on the basis of the cost contribution of the participating countries, calculated on the basis of the volume of losses and national tariffs. For each country, weights are calculated using the Equation:

$$w_i = (L_i) \bigg/ \sum_{i=1}^{m} (L_i) \qquad (8)$$

where $L'_i$ is the estimate of the electric energy losses of the i-th participant.

Based on these estimates, the cost of selling electricity for end-users in the EAEU can be determined in the form of a generalized dispersion of extreme values of national prices for electricity $p_i^*$ (Table 4):

$$p^0 \triangleq p^* = \begin{cases} \sum_{i=1}^{m} w_i p_i^{\min} \\ \dfrac{1}{2} \sum_{i=1}^{m} w_i (p_i^{\max} + p_i^{\min}) \\ \sum_{i=1}^{m} w_i p_i^{\max} \end{cases} \quad (9)$$

Thus, on the basis of Equation (9), we obtain the interval estimate of the cost of energy $p^0 = \{2.01, 3.73, 5.46\}$ rub/kWh, which allows us to analyze the effects of economic synergy in the EAEU interconnection for the following scenarios:
- Pessimistic ($p^0 = 2.01$);
- Realistic ($p^0 = 3.73$);
- Optimistic ($p^0 = 5.46$).

When analyzing, it is also necessary to take into account the influence of the military-political and technical-economic aspects of integration in the EAEU interconnection. For this purpose, expert assessments of the priorities and risks of the participating countries were used.

The proposed approach allows to take into account the specifics of the problem being solved, which comprises the significant influence of the military-political and technical-economic aspects of the integration process, which leads to the need to modify the synergy model that is based on purely rational goals of increasing sales and maximizing financial gain. For these purposes, the calculation is made taking into account the possibility of a negative situation involving the cumulative deterioration of the military-political or technical-economic condition of the participants using different coefficients of significance of the criteria. When performing additive convolution according to three options, coefficients of significance of the criteria of the military-political and socio-economic status of the participants of the interconnection are introduced. These coefficients perform the functions of enhancing the materiality of expert assessments for a specific course of events.

The calculation of the convolution functions of the benefits and risks of the countries participating in the interconnection of the EAEU is performed according to the Equation:

$$W_i = \frac{\dfrac{1}{n_P} \sum_{k=1}^{n_P} w_k P_k^i}{\dfrac{1}{n_R} \sum_{k=1}^{n_R} w_k R_k^i} \quad (10)$$

where $P_k^i$ is the evaluation of key benefits; $P_k^i$ the evaluation of key risks; $w_k$ coefficients of significance of key benefits; and $n_P$, $n_R$ the number of criteria for benefits and risks, respectively.

Based on the obtained values of the convolution functions, the parameters of the subadditive and superadditive streams of economic benefits for the local participant can be estimated in accordance with Equations (4) and (5) as follows:
- The subadditive flow is estimated as a benefit from the possibility of the cross-border implementation of the internal

**Table 3: Indicators of electric power profiles of the countries participating in the interconnection of the EAEU**

| Country | Electricity indicators, GW/h | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| | Net generation, G | Consumption, C | Export, E | Import, I | Losses, L | Net export, NE |
| Russia | 994,657 | 880,042 | 14,671 | 6,623 | −106,567 | 8,048 |
| Belarus | 32,518 | 32,649 | 4,488 | 7,806 | −3,187 | −3,318 |
| Kazakhstan | 85,290 | 76,676 | 2,917 | 1,749 | −7,446 | 1,168 |
| Kyrgyzstan | 14,302 | 11,058 | 72 | 0,286 | −3,458 | −0,214 |
| Armenia | 7,389 | 5,353 | 1,314 | 0,206 | −0,928 | 1,108 |
| Moldova | 0,836 | 3,697 | - | 3,342 | −0,481 | −3,342 |
| Tajikistan | 16,448 | 12,333 | 1,326 | 33 | −2,822 | 1,293 |
| Uzbekistan | 52,243 | 47,453 | 13,122 | 13,216 | −4,884 | −94 |

Source: The United Nations Statistics Division, 2016

**Table 4: Windowed estimate of national electricity tariffs**

| Country | Losses, $L_i$ | Weight coefficient, $w_i$ | Estimated national electricity tariff based on weight | | |
| --- | --- | --- | --- | --- | --- |
| | | | Lowest, $w_i p_i^{\min}$ | Highest $w_i p_i^{\max}$ | Average $w_i \dfrac{p_i^{\max} + p_i^{\min}}{2}$ |
| Russia | 106,567 | 0.821 | 1.47 | 4.61 | 3.04 |
| Belarus | 3187 | 0.025 | 0.05 | 0.26 | 0.15 |
| Kazakhstan | 7446 | 0.057 | 0.29 | 0.34 | 0.32 |
| Kyrgyzstan | 3458 | 0.027 | 0.02 | 0.02 | 0.02 |
| Armenia | 928 | 0.007 | 0.03 | 0.04 | 0.04 |
| Moldova | 481 | 0.004 | 0.02 | 0.03 | 0.02 |
| Tajikistan | 2822 | 0.022 | 0.02 | 0.03 | 0.03 |
| Uzbekistan | 4884 | 0.038 | 0.12 | 0.13 | 0.12 |
| Total | 129,773 | 1 | 2.01 | 5.46 | 3.73 |

excess electric power capacity of each participant of the Eurasian Economic Union interconnection:

$$F_i^{sub} = p^0 \left( G_i - NE_i \right) W_i^{sub} \qquad (11)$$

where $p^0$ is the weighted estimate of national electricity tariffs in the interconnection (9); $G$ and $NE$ are the net production and net export of the $i$-th participant; $W_i^{sub}$ is the convolution function (10);

Superadditive flow is estimated as a benefit from the increase in national electricity production and increase in its implementation due to the guarantee of supply and the reduction of losses:

$$F_i^{sup} = p^0 \left( G_i{}' + L_i{}' \right) W_i^{sup} \qquad (12)$$

where $p^0$ is the weighted estimate of national electricity tariffs in the interconnection (9); $G_i{}'$ is the predicted increase in national electricity production, $L_i{}'$ is the assessment of the reduction of losses; is $W_i^{sup}$ the convolution function (10).

Table 5 presents the results of the calculation of the integral flow of economic benefits, estimated in accordance with the Equation:

$$F_i = F_i^{sub} + F_i^{sup} \qquad (13)$$

where $F_i^{sub}$ and $F_i^{sub}$ are subadditive and superadditive flows of economic benefits for the local participant.

The obtained estimates of the flows of economic benefits make it possible to calculate the integral synergy effect for the participants of the interconnection by Equation (7). The results of the calculation are presented in Table 6.

The results show the significant scale of economic synergy that accompanies the formation of the EAEU, which accounts for up to 7–15% of GDP for various participating countries. These quantitative assessments can be used to determine the most efficient distribution of synergies from the point of view of maximizing the welfare of the countries in the energy mix.

The analysis of the economic feasibility of the draft EAEU interconnection should proceed not only from purely financial considerations of efficiency, payback and return on investment. The methodology proposed in this paper allows an assessment of the economic viability of integrating interstate electric power associations that have significant strategic value for the EAEU states. The proposed model for assessing the economic synergy effect of the project of the interconnection of the EAEU is aimed at analyzing not only the increase in return on investment, but also the formation of significant public value for all partner countries. The presented method allows to comprehensively explore and consolidate aspects of the economic feasibility of integration measures along with the national strategy and technical and economic sovereignty.

**Table 5: Assessment of economic benefits from participation in the EAEU interconnection, in trillion rub**

| Countrys | Equivalent additive convolution | | |
| --- | --- | --- | --- |
| | Pessimistic estimates | Optimistic estimates | Realistic estimates |
| Russia | 10.678 | 28.960 | 19.819 |
| Belarus | 0.214 | 0.580 | 0.397 |
| Kazakhstan | 0.225 | 0.609 | 0.417 |
| Kyrgyzstan | 0.030 | 0.081 | 0.055 |
| Armenia | 0.042 | 0.114 | 0.078 |
| Moldova | 0.015 | 0.041 | 0.028 |
| Tajikistan | 0.035 | 0.094 | 0.064 |
| Uzbekistan | 0.131 | 0.356 | 0.244 |

**Table 6: The final results of the evaluation of the economic synergy effect during the formation of the Eurasian Economic Union interconnection, trillion rub**

| Method of convolution | Method of estimates | Synergy effect |
| --- | --- | --- |
| Equivalent additive convolution | Pessimistic estimates | 48,588 |
| | Optimistic estimates | 131,772 |
| | Realistic estimates | 90,180 |
| Additive convolution with military political priority | Pessimistic estimates | 31,581 |
| | Optimistic estimates | 85,649 |
| | Realistic estimates | 58,615 |
| Additive convolution with techno-economic priority | Pessimistic estimates | 34,728 |
| | Optimistic estimates | 94,182 |
| | Realistic estimates | 64,455 |

# 4. IMPROVEMENT OF THE COMMON ELECTRICITY MARKET OF THE EAEU, TAKING INTO ACCOUNT THE EXPERIENCE OF INTEGRATING THE GLOBAL POWER INDUSTRY

The proposal for improving the cross-border electricity trade within the EAEU should be based on existing and successful international experience. However, it should be remembered that the use of certain models of common electricity markets in a "pure" form is unproductive, due to the need to take into account the features inherent in the energy systems participating in the interconnection.

Thus, the European model of integration of energy markets showed a high degree of elaboration and attractiveness of the developed mechanisms of interaction. However, in proposing this model as the basis for the formation of the EAEU electricity common market, participants will need to abandon the existing market model in favour of the bilateral contract market model, which determines the market price.

An interesting example for the EAEU from the point of view of the interconnection of energy systems, including a highly branched network infrastructure, is the example of the integration of the North American PJM and MISO markets. These markets have a capacity market and, in addition to mutual electricity trading,

they also carry out capacity trading. The main idea of their interaction was the joint management of transboundary overloads by establishing procedures for using hardware and software, while simultaneously dispatching cross-border flows in both markets.

The main planned result of the creation of PJM was to obtain all the advantages of the process of market integration, which would increase the economic benefit of the participants of both systems in this common market through the use of both power grid complexes.

At the same time, with the nodal pricing characteristic of these markets, the rules of participation and trading procedures become much more complicated and less transparent. Its use is advisable in the event that the participants of the interconnection form this kind of pricing. For the EAEU member countries, whose energy systems and transmission networks are an order of magnitude smaller than in the Russian Federation, this transition will be accompanied by significant organizational and financial costs, in the absence of adequate compensation due to the advantages of this model.

In 1987, six states of Central America (Nicaragua, Guatemala, Costa Rica, El Salvador, Panama and Honduras) initiated a discussion of the project, designed to unite the participants' energy systems into a single regional market. After 12 years, the governments of these countries signed the "Framework Agreement for the Central American Electricity Market," which became the basis of the common electricity market SIEPAC.

The main goal of SIEPAC is to maximize the benefits for each region (country) by providing free access to each other's regional generating facilities and increasing the reliability of supply through a more powerful energy transmission network. Within the framework of the currently existing regional MER market, wholesale international transactions between the electrical utility companies of the member states are carried out according to the rules of the Framework Agreement.

A feature of the MER market is that it consolidates the energy systems of states with various models and architectures of national energy markets. For example, in Costa Rica and Honduras, there is a model of a single electricity purchaser. At the same time, in Honduras, a significant share of generation belongs to the private sector, and the market is soon planned to switch completely to a competitive basis. In El Salvador, wholesale and retail electricity markets are competitive. In the other three countries, competition is represented only in the wholesale electricity market. At the same time, MER is a separate market with its own rules and nodes, which are located at the ends of cross-border lines between neighbouring states.

In order to adapt the experience of the implementation of the SIEPAC project during the formation of the EAEU common electricity market, in addition to the national electricity markets of the member states, a regional electricity market should also be formed, which will carry out cross-border electricity trade between authorized subjects of national markets. In order to regulate and manage the regional market, regulatory bodies should be formed

in which the EAEU member states will be represented on a parity basis. At the same time, the national electricity markets can continue to function after the creation of a regional market and develop on their own, while retaining their inherent design features, rules and mechanisms of the market.

## 5. CONCLUSION

The problem of providing people with reliable sources of energy supply is complex and multilateral, including the issues of forming the organizational base and technological infrastructure of the future global energy supply system. One of the necessary stages in the development of such an infrastructure is the consolidation of national energy systems and the creation of interstate energy associations.

At the same time, the analysis of existing concepts and programmes for the formation of common electric power markets in various regions of the world, as well as scientific works in this area, showed that in the field of efficiency assessment and justification of the implementation of the interconnection projects, systemic methodological problems persist, caused by the contradiction between the need to justify the integration prospects in the electric power industry and the limitations of the scientific and methodological support used. The main focus of the analysis using existing methods is traditionally considered to be the assessment of economic effects, while the social significance of the electric power industry, including for solving problems of sustainable development, is not sufficiently taken into account.

In order to improve the scientific and methodological support for evaluating the effectiveness of the formation of interconnection, this paper proposes and substantiates the use of concepts and methods for evaluating the synergistic effects of integration, which, in addition to economic indicators, include military-political and technical aspects. The results indicate that the synergistic effects arising in these areas play a decisive role in ensuring the effectiveness of the process of the formation of the interconnection and can constitute a significant proportion of the GDP of the participating countries.

Scenario analysis of the project of the interstate electric power association of the EAEU countries, made on the basis of the developed methodological apparatus, made it possible to obtain quantitative estimates of the effects of subadditive and superadditive synergies for the participants of the energy association and to determine the area of integration perspectives for the integration process.

Based on the obtained scenario assessments and a comparative analysis of the organizational and technical and economic characteristics of the national electricity markets of the EAEU countries, the proposals for the practical implementation of the experience of global electricity integration in the EAEU were substantiated. To substantiate them, quantitative assessments of economic synergies from the integration of electric power systems of both existing and potential participants were used, which allowed to determine the direction of improving the mechanisms

of the common electricity market of the EAEU taking into account the prospects for implementing strategic Eurasian energy infrastructure projects.

The developed scientific and methodological apparatus can be used to analyse the processes of the formation of the interconnections in other regions, including in terms of assessing their impact on the implementation of the sustainable development goals of both the regions under consideration and the future global energy system as a whole.

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