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Assessment and analysis of energy infrastructural potential of Russian regions

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Abstract. The paper is devoted to the questions of assessment and analysis of the energy-infrastructural potential of Russian regions. The characteristics of energy infrastructure in a region play an important role in the evaluation of investment attractiveness of potential places for industrial investment. This paper describes the author's methodical approach to the assessment and analysis of the energy-infrastructural potential of the regions by plotting energy-infrastructural maps and by building a matrix of the regions. It allows distinguishing similar territorial entities based on the indicators of energy infrastructure with the aim of increasing the efficiency of the selection procedure for potential places for industrial investment. The developed method was tested on the example of assessment and analysis of characteristics of Russian region's energy infrastructure. That resulted in the construction of rating of the regions by the level of energy-infrastructural potential and generating of energy-infrastructural maps. The obtained results have theoretical and practical importance and can be used in the development of activities in the field of energy efficiency in the regional context and in the analysis of the energy-infrastructural capacity of potential locations for industrial investments.

Keywords: energy-infrastructural potential, investment attractiveness, the ratio of regions, the coefficient of energy tariffs, the coefficient of technological connection, industrial investment, the region's economy, energy infrastructure, energy tariffs, technological connection.

1 Introduction

A key feature in the evaluation of potential places for industrial investment has the analysis of investment potential of the territories. It determines not only the level of future investment costs but probability and volume of risks of project realization. There are many approaches to the definition of investment potential and its components [1-7].

From our point of view, infrastructure component plays a significant role in the assessment of investment potential of the regions. It includes characteristics of the geographical location, transport and energy infrastructure, the availability and quality of means of communication, etc. Considering the investment attractiveness of investing in the industrial sector it is worth mentioning one crucial characteristic of the energy infrastructure namely the topographic availability of generating capacities, the cost of technological connection to electric networks, the level of electricity tariffs in the region [8-12].

2 Research methodology

Let us define the "energy-infrastructural potential of the region" as an integral feature which reflects the conditions of transportation and selling of energy resources to consumers and influence on the investment appeal of the territory.

Accession conditions to the energy infrastructure determine the investment costs. The existing tariffs for energy resources in the region influence the level of current expenditures of the investment project during its implementation.

Since electrical energy is the main energy resource consumed by humanity, it is reasonable to use two components: the cost of electric energy in the region [13, 14] and the availability of technological connection to electric networks.

The cost of electric energy in the region reflects the level of tariffs for electricity, tariffs for power and transmission services of electricity. The availability of technological connection reflects the tariffs for technological connection operating in the region and

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availability of generating the capacity to the regional electric power system.
For evaluation of components and an integral value of energy-infrastructural potential, we propose to use a number of indicators.

3 The ratio of energy tariff

This indicator is developed for the analysis of the cost of electric energy in a regional section. It is calculated as the ratio of electricity tariff in a given region to average value on the set of territorial units (formula 1)

$$K_{T,i} = T_{P,i} / \overline{T}_P, \qquad (1)$$

where $K_{T,i}$ – the coefficient of energy tariffs for the considered territorial unit i;

$T_{P,i}$ – electricity tariff in the considered territorial unit;

$\overline{T}_{P,i}$ – average tariffs in the researched population of territorial units.

The tariffs for electricity $T_{P,i}$ for a territorial e ntity i defined by the formula (2) are the arithmetic sum of the rates directly on electricity, electric power, services in the transfer of electric energy and sales rate of extra charges of retail companies.

$$T_{P,i} = T_{E,i} + T_{M,i} + T_{CH,i} + T_{\pi,i}, \qquad (2)$$

where $T_{E,i}$ – the tariff for electric energy in the considered territorial unit;

$T_{M,i}$ – the tariff for electric power in the considered territorial unit;

$T_{\pi,i}$ – the tariff for service of electricity transmission in the considered territorial unit;

$T_{CH,i}$ – the rate of sales extra charges of retail companies in the considered territorial unit.

4 The coefficient of technological connection

To evaluate the accessibility of technological connection the indicator "coefficient of connection" is calculated for every investigated region according to the formula (3).

$$K_{T\pi,i} = K_{W,i} \times KT_i, \qquad (3)$$

where $K_{T\pi} i$ – coefficient of accessibility of technological connection in the reporting territorial unit;

$K_{W,i}$ – the coefficient of dynamics of demand for electricity consumption territorial entities i (defined by the formula 4);

KT_i – the ratio of the cost of technological connection to the territorial entity i (defined by the formula 5);

$$K_{W,i} = W_i^{\ X} / W_i^{\ Y}, \qquad (4)$$

where $W_i^{\ X}$, $W_i^{\ Y}$ – the volume of demand for electricity consumption of territorial entity in the periods X and Y. X is accepted as later of the studied periods and Y is accepted as earlier of them.

$$KT\,i = T_{T\pi}\,i / \overline{T}_{T\pi}, \qquad (5)$$

where $T_{T\pi}\,i$ - the tariff for technological connection to power grids in the considered territorial unit;

If $K_{TП}\,i > 1$, it means that the availability of technological connection for the territorial entity is less than average availability for the set of territorial entities and vice versa.

5 Integral coefficient energy-infrastructural potential

Private indicators of energy-infrastructural potentials, such as the level of energy tariffs and the availability of the technological connection coefficient give the resulting index, called "integral coefficient of energy-infrastructural potential" $K_{I,i}$:

$$K_{I,i} = (K_{T,i} \times 0,7) + (S_{P,i} \times 0,3) \qquad (6)$$

The values of integral coefficients of energy-infrastructural potential can be used for comparative assessments in the regions and any other territorial entities with the aim of making more reasonable investment decisions.

For a more detailed analysis and comparison of components of the energy-infrastructural potential of several regions it is advisable to use "the map of the energy-infrastructural potential of the regions", built in the coordinates "coefficient of energy tariffs and the coefficient of technological connection". This representation allows identifying regions with similar characteristics of energy-infrastructural potential and reducing the number of regions for analysis of potential locations for industrial investments.

6 Practical application

The testing of the proposed methodological approach to the assessment and analysis of the energy-infrastructural potential of territorial entities have conducted on the example of the energy characteristics of Russia's regions. Information base of a research was made by the actual values of energy characteristics of regions, acting in 2016: free non-regulated prices for electric energy and for electric power in retail electricity markets [15-17];

uniform regional boiler tariffs for electric power transmission for voltage class HV (110 kV) in one rate [18]; rate of sales extra charges of the basic regional guaranteeing suppliers for consumers with the maximum capacity of power receivers >10 MVA [19]; regional values of rates per unit of maximum capacity for technological connection to electric networks [20, 21], and magnitude of the demand for electricity consumption in the Russian regions for the periods of 1990 and 2014 [22].

"Coefficient of energy tariff" was calculated for each region of Russia (an example of calculation of the coefficient for the regions of Central Federal district is presented in table 1), the "coefficient of technological connection" and "integral coefficient of energy-infrastructural potential " (example of calculation for regions of the Central Federal district is presented in table 2). The rating of regions of Russia by the value of energy-infrastructural potential is shown in Fig. 1.

Table 1. Calculation of the coefficient of energy tariff for regions of the Central Federal district

The region	Amount of the tariff, RUB/kWh					Energy tariff coefficient
	For electricity	For electricity	For transfer	Sales extra charges	Total	
Belgorodskaya oblast	1.18	0.60	1.45	0.16	3.38	1.05
Bryanskaya oblast	1.17	0.55	1.62	0.07	3.41	1.06
Vladimirskaya oblast	1.21	0.55	1.55	0.03	3.33	1.03
Voronezhskaya oblast	1.23	0.55	1.21	0.15	3.14	0.97
Ivanovskaya oblast	1.10	0.55	1.05	0.10	2.80	0.87
Kaluzhskaya oblast	1.23	0.56	1.58	0.04	3.41	1.05
Kostromskaya oblast	1.17	0.55	1.53	0.10	3.34	1.03
Kurskaya oblast	1.10	0.55	1.09	0.10	2.84	0.88
Lipetskaya oblast	1.20	0.57	1.33	0.05	3.16	0.98
Moskovskaya oblast	1.22	0.55	1.14	0.04	2.95	0.91
Orlovskaya oblast	1.24	0.54	1.69	0.07	3.53	1.09
Ryazanskaya oblast	1.23	0.56	1.08	0.07	2.94	0.91
Smolenskaya oblast	1.15	0.57	1.58	0.08	3.37	1.04
Tambovskaya oblast	1.22	0.54	2.13	0.08	3.97	1.23
Tverskaya oblast	1.15	0.55	1.84	0.09	3.62	1.12
Tulskaya oblast	1.28	0.57	1.52	0.15	3.51	1.09
Yaroslavskaya oblast	1.25	0.56	1.11	0.17	3.09	0.96
Moskva	1.22	0.55	0.98	0.11	2.86	0.89

The analysis has shown that the regional values of the integral coefficient energy-infrastructural potential range from 0.43 to 1.47, indicating significant differentiation of regions. The difference between the high and low energy-infrastructural potential is almost 3.5 times. This fact underlines the relevance and importance of evaluation, analysis, and accounting of energy-infrastructural potential of the regions in the process of making investment decisions in terms of selecting the most appropriate locations for industrial investments.

For detailed component analysis of the parts of energy-infrastructural potential of Russian regions and their groupings, the map of the energy-infrastructural potential of the regions shown in Fig. 2 was built. The location of the regions in the given coordinates (the value of the coefficient of energy tariff and the value of the coefficient of technological connection) allows making a separation into groups with similar characteristics of energy-infrastructural potential. This separation will help to improve the validity of management decisions on the choice of locations for the most efficient allocation of industrial investment (table 3).

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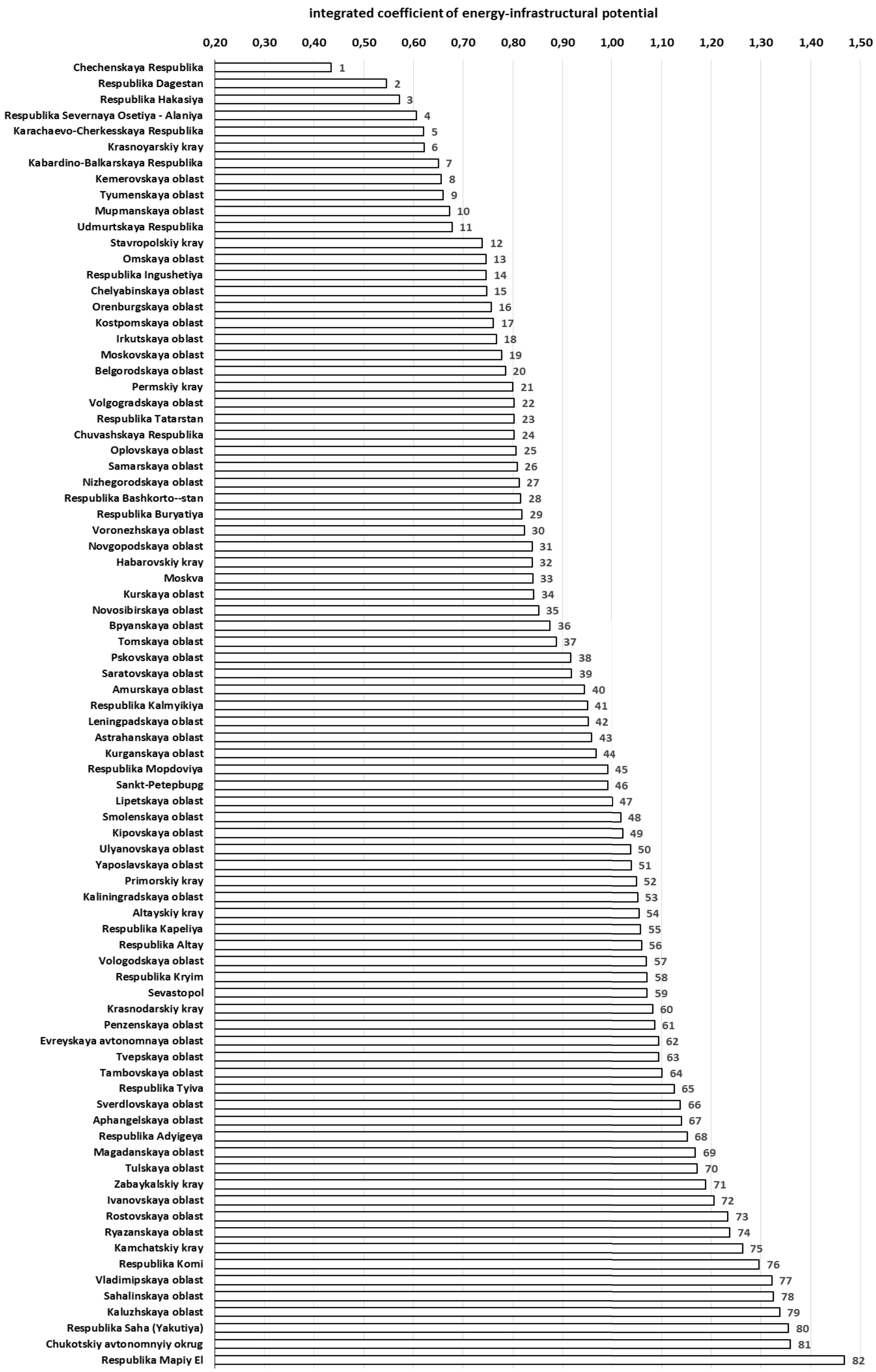

Fig. 1. Rating of Russian regions based on the value of integrated coefficient of energy-infrastructural potential.

Table 2. Calculation of the coefficient of technological connection and integral coefficient of energy-infrastructural potential for regions of the Central Federal district

Region	Demand for a power consumption, million kWh		Coefficient of dynamics of demand for a power consumption	Tariff on technological connection, rub/kW	Coefficient of a tariff for technological connection	Coefficient of technological connection	Integrated coefficient of power infrastructure potential
	1990	2014					
Belgorodskaya oblast	11 987.5	14 932.0	1.25	131.7	0.14	0.18	0.79
Bryanskaya oblast	5 670.0	4 010.0	0.71	601.4	0.64	0.46	0.88
Vladimirskaya oblast	9 042.5	7 276.0	0.80	2 351.6	2.52	2.02	1.33
Voronezhskaya oblast	12 218.1	10 791.0	0.88	509.1	0.54	0.48	0.82
Ivanovskaya oblast	6 696.9	3 431.0	0.51	4 345.9	4.65	2.38	1.32
Kaluzhskaya oblast	4 784.7	6 905.0	1.44	1 686.1	1.80	2.60	1.52
Kostromskaya oblast	4 462.7	3 617.0	0.81	144.7	0.15	0.13	0.76
Kurskaya oblast	9 774.9	8 451.0	0.86	818.5	0.88	0.76	0.84
Lipetskaya oblast	12 553.5	12 251.0	0.98	1 014.9	1.09	1.06	1.00
Moskovskaya oblast	36 692.0	42 424.0	1.16	371.1	0.40	0.46	0.78
Orlovskaya oblast	4 273.3	2 686.0	0.63	207.1	0.22	0.14	0.81
Ryazanskaya oblast	7 900.2	6 522.0	0.83	3 518.7	3.76	3.11	1.57
Smolenskaya oblast	8 501.9	6 095.0	0.72	1 249.6	1.34	0.96	1.02
Tambovskaya oblast	5 950.3	3 420.0	0.57	1 316.6	1.41	0.81	1.10
Tverskaya oblast	9 250.6	8 097.0	0.88	1 108.3	1.19	1.04	1.10
Tulskaya oblast	15 820.1	10 008.0	0.63	2 026.7	2.17	1.37	1.17
Yaroslavskaya oblast	9 034.2	7 579.0	0.84	1 375.0	1.47	1.23	1.04
Moskva	37 433.2	55 114.0	1.47	466.7	0.50	0.74	0.84

Table 3. The matrix of energy-infrastructural potential of Russian regions

Group	Parameter	Region
Group A	High capacity factor electricity tariffs and the coefficient of technological connection	Voronezhskaya oblast. Kurskaya oblast. Moskovskaya oblast. g. Moskva. Leningradskaya oblast. Murmanskaya oblast. Novgorodskaya oblast. Pskovskaya oblast. Volgogradskaya oblast. Respublika Dagestan. Respublika Ingushetiya. Kabardino-Balkarskaya Respublika. Karachaevo-Cherkesskaya Respublika. Respublika Severnaya Osetiya – Alaniya. Chechenskaya Respublika. Respublika Bashkortostan. Respublika Tatarstan. Udmurtskaya Respublika. Chuvashskaya Respublika. Permskiy kray. Orenburgskaya oblast. Samarskaya oblast. Saratovskaya oblast. Tyumenskaya oblast. Chelyabinskaya oblast. Respublika Hakasiya. Krasnoyarskiy kray. Kemerovskaya oblast. Novosibirskaya oblast. Omskaya oblast. Tomskaya oblast. Habarovskiy kray. Amurskaya oblast
Group B1	High capacity factor electricity tariffs and low coefficient of technological connection	Ivanovskaya oblast. Lipetskaya oblast. Ryazanskaya oblast. Yaroslavskaya oblast. Respublika Kapeliya. Vologodskaya oblast. Kaliningradskaya oblast. g. Sankt-Petepbupg. Astrahanskaya oblast. Kipovskaya oblast. Sverdlovskaya oblast. Respublika Altay. Altayskiy kray. Zabaykalskiy kray. Irkutskaya oblast. Evreyskaya avtonomnaya oblast
B2 Group	A low capacity factor electricity tariffs and the high rate of technological connection	Belgorodskaya oblast. Bpyanskaya oblast. Kostpomskaya oblast. Oplovskaya oblast. Smolenskaya oblast. Tambovskaya oblast. Aphangelskaya oblast. Respublika Kalmyikiya. Krasnodarskiy kray. Rostovskaya oblast. Stavropolskiy kray. Respublika Mopdoviya. Nizhegorodskaya oblast. Penzenskaya oblast. Ulyanovskaya oblast. Kurganskaya oblast. Respublika Buryatiya. Kamchatskiy kray. Respublika Kryim. g. Sevastopol. Magadanskaya oblast
Group C	A low capacity factor electricity tariffs and the coefficient of technological connection	Vladimipskaya oblast. Kaluzhskaya oblast. Tvepskaya oblast. Tulskaya oblast. Respublika Komi. Respublika Adyigeya. Respublika Mapiy El. Respublika Tyiva. Respublika Saha (Yakutiya). Primorskiy kray. Sahalinskaya oblast. Chukotskiy avtonomnyiy okrug

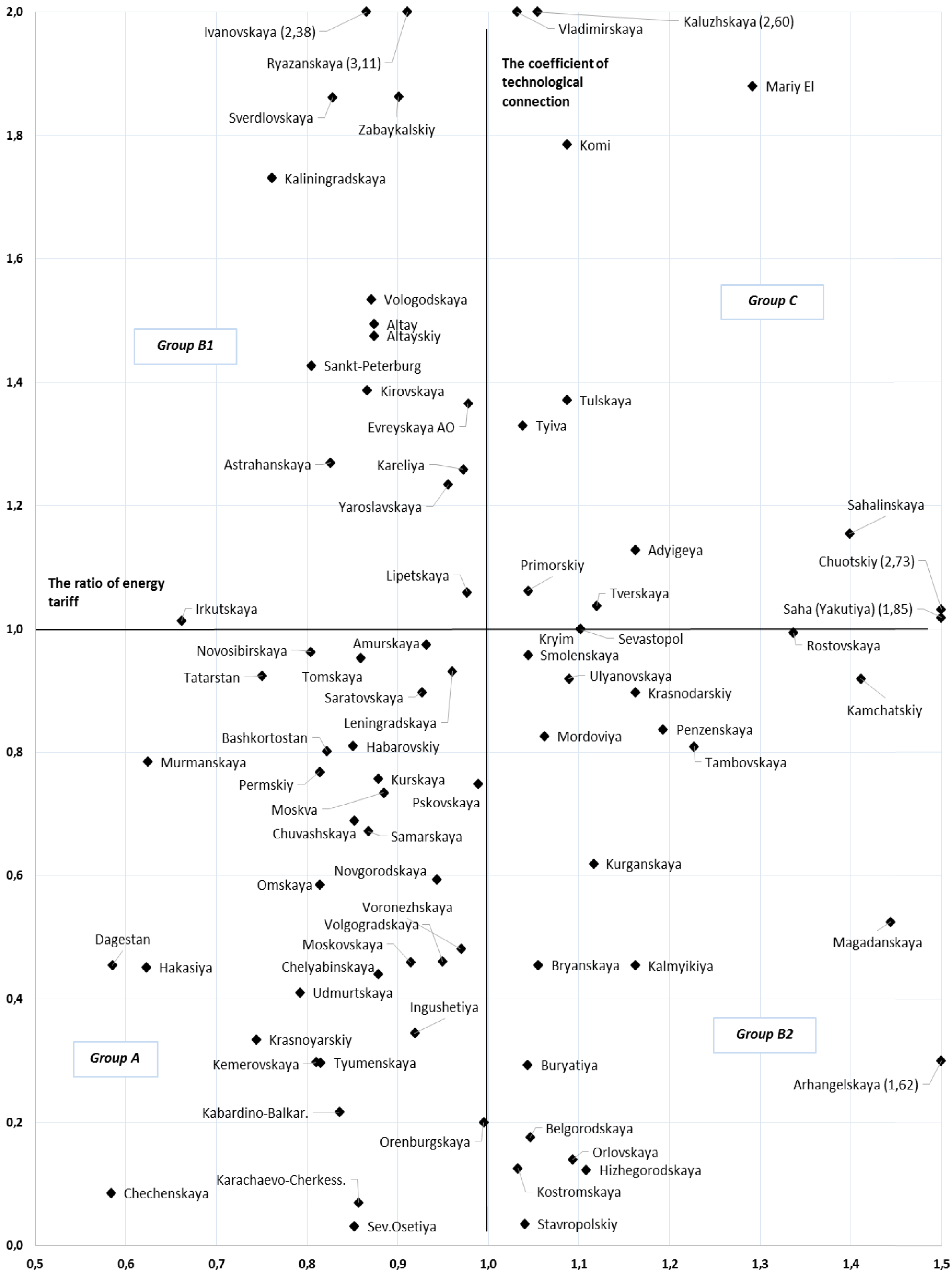

Fig. 2. The map of energy-infrastructural potential of Russian regions.

7 Conclusion

The characteristics of the infrastructure capacity play a significant role in the formation of investment attractiveness of territorial entities. The role of infrastructure potential in case of assessment the allocation of industrial investments is especially high.
The energy-infrastructural potential is defined as an integrated characteristic. which reflects transportation and selling conditions of energy resources to consumers. and influence on an investment appeal of the territory.
The methodical approach developed in the paper to assess the energy-infrastructural potential of any territorial entity. The cost of electricity and the availability of technological connection to electric networks are proposed to use as characteristics of the energy-infrastructural potential of the region.

The proposed methodological approach to the assessment of the energy-infrastructural potential of the regions consists in the calculation the number of coefficients such as the coefficient of energy tariffs. the coefficient of technological connection and integrated coefficient of energy-infrastructural capacity. Next step of this approach is making the rating of regions by the level of energy-infrastructural potential and building maps of energy-infrastructural capacity with the allocation of regional groups with similar energy-infrastructural characteristics.

The practical importance of the assessment method of the energy-infrastructural potential of the regions lies in the possibility of accounting for energy characteristics of the region in the process of making investment decisions in the industrial sector and in development and implementation of management decisions in the field of energy efficiency of territorial entities.

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