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Quantitative Analysis of Energy Efficiency Indices in the Regions of the Russian Federation as Exemplified by Energy Consumption

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ABSTRACT

The Russian government has set the target of reducing energy intensity of the gross domestic product by 40% over the period from 2007 to 2020. To solve the problem, energy conservation and increasing energy efficiency programs are implemented at the national, regional and municipal levels. The reduction in energy intensity can occur not only as a result of special measures to save energy resources, but for other reasons. The effectiveness of energy efficiency policies should be judged by such indicator which would reflect exactly technological efficiency. The current system of accounting energy efficiency in Russia has not yet handled this problem. In this article the energy intensity index of physical volume of the gross regional product was calculated and analyzed based on Rosstat data over 2005-2013 for the 80 regions of the Russian Federation. Additive decomposition of electricity consumption increment in the regions according to such major factors as economic activity, the structural and technological factors was performed.

Keywords: Energy Efficiency Indicators, Aggregated Energy Efficiency Indices, Energy Intensity of the Economy
JEL Classifications: E02, G21, O13, Q43

1. INTRODUCTION

The development of global competition requires more efficient use of energy resources, so one of the most important strategic tasks that the President put in 2008 is to reduce the energy intensity of the Russian economy by 40% by 2020 in relation to the level of 2007 (RF Presidential Decree of June 4, 2008).

In accordance with the basic documents of strategic planning of development of the Russian Federation (The Concept of Long-term Socio-Economic Development, 2008; Long-term Forecast, 2013) the transition of the national economy to an innovative path of development until 2030 is planned. The energy policy, including energy efficiency policy, is aimed at solving this problem.

National energy policy is determined by the Energy Strategy of Russia. The National Energy Strategy up to 2030 is currently functioning (Energy Strategy of Russia, 2009) (hereinafter – the ES-2030). In addition to that, the Ministry of Energy has prepared a draft of the updated Energy Strategy of Russia for the period until 2035 (Energy Strategy of Russia, 2014) (hereinafter – the ES-2035).

It is expected that ES-2030 will be implemented in three stages (Table 1). By 2030, the conditions for faster growth of sectors of the economy with low power consumption and the implementation of technological energy-saving potential will have been created. It should consist in that by 2030 specific energy intensity of gross domestic product (GDP) will have fallen by more than two-fold, and specific electricity intensity of GDP – not less than by 1.6 times as opposed to 2005 (Table 1).

At present the first stage of ES-2030 is near completion. The federal "Energy Efficiency and Energy Development" program ("Energy Efficiency and Energy Development", 2014) has been developed and is now performed, as well as regional and municipal programs in constituent entities of the Russian Federation. There has been some reduction in the energy intensity of the economy,

Table 1: Indicators of energy efficiency of the Russian economy at the three stages of the energy strategy-2030 (percentage of 2005)

Indicator/stage	2015	2022	2030
Specific energy intensity of GDP	≤78	≤57	≤44
Specific electricity intensity of GDP	≤84*	≤73*	≤60

Source: (Energy strategy of Russia, 2009), *Drawn up by linear interpolation according to the source. GDP: Gross domestic product

which is estimated at 2.2% for the period from 2008 to 2012 (Energy Strategy of Russia, 2014). However, as it is noted in the EC-2035 Draft, to gain the objectives of ES-2030 is very problematic, since the main contribution to the achieved reduction in energy intensity of GDP was made by structural changes in the economy and recovery growth in the industry (The Ministry of Energy of the Russian Federation, 2011) while the influence of the most important technological factor was neutralizes by the fall of efficiency of the old worn-out equipment (Energy Strategy of Russia, 2014). In the long-term a key role in reducing energy consumption and improving energy efficiency of the Russian economy is given to technological energy saving. In this regard, the role of research to estimate the contributions of various factors to dynamics of power consumption and the study of the degree of influence of technological factor has increased.

In world practice, special statistical systems of indicators of consumption and energy savings are used to monitor the effectiveness of inter-state and national energy policies. They have much in common, but at the same time they take into account the specifics of different countries. Various methods for determining energy efficiency indices and decomposition of contributions of the individual factors in the dynamics of power are used (Bashmakov and Myshak, 2012).

The Russian energy efficiency statistics is less developed. The official system of energy efficiency target indicators and methodology of their evaluation (Methods, 2010) are insufficiently developed, there is no corresponding statistical system of energy efficiency (Bashmakov, 2010). Data on total consumption of fuel and energy resources in all the regions of the Russian Federation became available on the Rosstat web-site only recently and they are only for 2012, 2013.

It is necessary to improve the information and analytical support of energy efficiency state policy. Independent researches on the analysis of the dynamics of energy consumption in regions are in demand. Therefore, the topic of this work is currently important.

2. LITERATURE REVIEW

Despite the fact that the Russian system of accounting and statistical basis of energy efficiency indicators are in a formative stage, Russia has been actively working on the quantitative analysis of energy consumption in various economic processes. Energy conservation is studied at national, industry-specific, corporate and territorial scales. As can be seen from the literature review, in the works of various authors up to ten levels of power management are considered (Bashmakov, 2000; Mingaleev, 1998). Gachot et al. (2012) argue an important role in energy planning at the federal and regional levels for the implementation of not only energy policy, but also socio-economic policy in general. However, as underlined by Bashmakov (Bashmakov, 2010; Bashmakov and Myshak, 2012), the effectiveness of this tool requires monitoring the implementation of plans and programs, development and implementation of an integrated permanently operating complex system of energy efficiency accounting.

Russia's leading consulting and analytical organization in the field of energy efficiency of the economy is the Center for Energy Efficiency (CENEf). Since 1992 CENEf employees have regularly conducted and published research results on a wide range of energy issues. CENEf is the main developer of the state program of energy saving and energy efficiency of Russia for the period up to 2020, adviser of the Russian executive authorities, international organizations and foreign agencies, financial institutions, business communities. CENEf employees (Bashmakov and Myshak, 2012) laid the methodological foundations for the formation of such statistical system of advancing energy efficiency in Russia, which would correspond to contemporary international practice.

Another well-known and recognized organization is the Interfax-ERA, Ecological and Energy Agency. The Interfax-ERA was created in 2010 and now it specializes in the analysis of the energy efficiency of the national and regional economies, municipalities, companies and enterprises. The agency staff have developed and used their own method (Artyukhov and Martynov, 2010), including the evaluation of the technological modernization effect by taking into account the reduction of environmental pollution. The method allows for a comparative analysis of ecological and energy efficiency in Russian regions (Artyukhov et al., 2011). But, this method does not include and does not solve the problem of decomposition of contributions of different factors (economic growth, structural changes and technological renewal) to the dynamics of power consumption in the regional economy.

The lack of statistics, which would correspond to the official methods for calculating energy efficiency target indicators (Methods, 2010), led to the fact that many different ways to analyze the energy efficiency in regional economy have been developed and they are currently used (Bogachkova et al., 2012; Danilov et al., 2012; Golovanova, 2009; Lebedev et al., 2012; Popov et al., 2012). However, the study of the contribution of different factors to the dynamics of power consumption in the regional economy is not dealt with in these studies.

As can be seen from the review of current literature (Bashmakov and Myshak, 2012; Su and Ang, 2012) method of decomposition analysis is widely used in the world research practice when investigating energy intensity of various production processes and associated with them effects of environmental pollution. This method allows taking into account the impact of a large number of various relevant factors (Sorrella et al., 2008).

In their research Bashmakov and Myshak (2012) describe a mathematical tool that is used in the decomposition analysis enabling to estimate the impact of individual factors on the dynamics of energy efficiency and energy intensity of GDP and calculate indicators that reflect progress in reducing energy intensity of the economy through the technological factor and the implementation of national policy measures. However, trans-regional comparison of the aggregated energy efficiency indices of the constituent entities of the Russian Federation was not carried out in this study.

The present work contributes to the study of energy intensity of the Russian economy. Based on the Rosstat database on the regions in 2005-2013 it presents statistical analysis of the dynamics of electricity intensity of physical volume of GRP as an aggregated index of energy intensity of the regional economy, decomposition of the dynamics of electricity consumption growth according to the main factors and evaluation of the regional aggregated indices of technological electricity efficiency.

3. METHODS

3.1. Method of Calculation and Analysis of Electrical Intensity Index of Physical Volume of the GRP as an Aggregated Index of the Efficiency of Energy Consumption in Regions of the Russian Federation in 2005-2013

One of two aggregated energy efficiency indices of the national and regional economies specified by Russian Energy Strategy is a specific electricity intensity of GDP/GRP:

$$X = {}^{\mathrm{E}}\!/_{\mathrm{A}} \qquad (1)$$

Where, X is the specific electricity intensity; E refers to the total volume of electricity consumption in the country (or region); A is gross product (the GDP if the country is considered as a whole and the GRP if it concerns the region). To characterize the dynamics of the index (1) for a certain period of time it is advisable to use electricity intensity index of physical volume of the gross product, which can be calculated using the following formula (Inshakov et al., 2013):

$$Y = \frac{X^{t}}{X^{0}} = \frac{E^{t} \cdot A^{0}}{A^{t} \cdot E^{0}} \qquad (2)$$

Where the values of variables in the reference period are provided by the 0 index and the t index corresponds to the current period; gross product is considered in constant prices.

The Rosstat database was used for the analysis: (1) GDP and GRP expressed in current prices for 2005-2013 (Gross Regional Product, 2015), which were transferred to the price of the framework period - 2005; (2) the quantity of electricity consumption in the National and Regional Economies, (The Electrical Balance of the Russian Federation, 2015). 80 constituent entities of the Russian Federation (including members of their autonomous territorial entities) with the exception of the Crimea and Sevastopol, details of which are not available for the specified period of time were examined.

3.2. The Decomposition Method of Growth of Electricity Consumption in Regions of the Russian Federation in 2005-2013 in Terms of the Main Factors, Estimation Method and Analysis of Aggregated Regional Efficiency Indices of Energy Consumption

Due to the great economic importance of ensuring energy saving technologies (as opposed to reducing the energy intensity of the economy as a result of the GRP structural changes and because of the growth of scale of production) the problem of decomposition of growth of energy consumption in the regions in terms of the main factors and quantitative evaluation of the technological impact factor is kept up to date. A method based on the theory of indices (Bashmakov and Myshak, 2012. p. 18-22) is used to solve this problem in the present study. With regard to the power consumption in regions of the Russian Federation it is possible to specify this method as follows:

The total electricity consumption in the region can be represented as the sum of energy consumption in various sectors of the regional economy:

$$E = \sum_{\mathrm{i}} E_{\mathrm{i}} = \sum_{\mathrm{i}} A_{\mathrm{i}} \cdot I_{\mathrm{i}} = A \sum_{\mathrm{i}} S_{\mathrm{i}} \cdot I_{\mathrm{i}} \qquad (3)$$

Where, E and E_i are total electricity consumption in the economy of the region in whole and the i^{th} industry branch (or sector) in particular; A and A_i refer to gross product (GRP) as an indicator of economic activity for the region's economy in general and for the i^{th} industry branch in particular; I and I_i are specific electricity consumption (per unit of gross product) in the regional economy on the whole and in the i^{th} industry branch in particular; S_i is the share of sector i in GRP.

Based on the expression (3), we use an additive method of decomposition of growth of electricity consumption:

$$\Delta E = E^{t} - E^{0} = \Delta F_{\mathrm{A}}^{t} + \Delta F_{\mathrm{S}}^{t} + \Delta F_{\mathrm{I}}^{t} + R \qquad (4)$$

Unexplained excess R is reduced to zero, if you take the following assumptions:

$$\Delta F_{\mathrm{A}}^{t} = (A^{t} - A^{0}) \cdot \sum S_{\mathrm{i}}^{0} I_{\mathrm{i}}^{0} \qquad (5)$$

Where $\Delta F_{\mathrm{A}}^{t}$ is the contribution of GRP growth at constant structure and specific consumptions at the level of the framework year;

$$\Delta F_{\mathrm{S}}^{t} = A^{t} \cdot (\sum S_{\mathrm{i}}^{t} \cdot I_{\mathrm{i}}^{t} - \sum S_{\mathrm{i}}^{0} \cdot I_{\mathrm{i}}^{t}) \qquad (6)$$

Where $\Delta F_{\mathrm{S}}^{t}$ is the contribution of changes in the structure of the regional economy, provided that the GRP and the specific electricity consumption are at the level of the year t;

$$\Delta F_{\mathrm{I}}^{t} = A^{t} \cdot (\sum S_{\mathrm{i}}^{0} \cdot I_{\mathrm{i}}^{t} - \sum S_{\mathrm{i}}^{0} \cdot I_{\mathrm{i}}^{0}) \qquad (7)$$

Where, ΔF_{I}^{t} is the contribution of changes in specific energy consumption under the condition of equality of GRP to the level of year t while maintaining the structure of activities at the level of the framework year; it is this additive component that describes the energy saving technology in the region, which is carried out through the introduction of new advanced production technologies and/or as a result of the implementation of measures for energy saving and growth of energy efficiency.

Assumptions (5-7) are taken to simplify the calculations. Despite the fact that when they are executed the residual R in formula (4) is set to zero, the contributions to the growth of electricity consumption of the three considered factors derived according to these formulas turn out to be approximate (Bashmakov and Myshak, 2012. p. 18-22).

Next, we consider the growth in electricity consumption and indices of contributions of a variety of factors in it as a percentage of total electricity consumption in the framework period:

$$\delta E = \frac{E^{t} - E^{0}}{E_{0}} \cdot 100\% \tag{8}$$

$$I_{A} = \frac{\Delta F_{A}^{t}}{E_{0}} \cdot 100\% = \frac{\left(A^{t} - A^{0}\right) \cdot \sum S_{i}^{0} I_{i}^{0}}{E_{0}} \cdot 100\% \tag{9}$$

$$I_{S} = \frac{\Delta F_{S}^{t}}{E_{0}} \cdot 100\% = \frac{A^{t} \cdot (\sum S_{i}^{t} \cdot I_{i}^{t} - \sum S_{i}^{0} \cdot I_{i}^{t})}{E_{0}} \cdot 100\% \tag{10}$$

$$I_{T} = \frac{\Delta F_{I}^{t}}{E_{0}} \cdot 100\% = \frac{A^{t} \cdot (\sum S_{i}^{0} \cdot I_{i}^{t} - \sum S_{i}^{0} \cdot I_{i}^{0})}{E_{0}} \cdot 100\% \tag{11}$$

The Rosstat database was used for the analysis: (1) Data on GDP, GRP and their structure (by industries) expressed in current prices for 2005-2013 (Gross Regional Product, 2015), which were transferred to the price of the framework period – 2005; (2) data on the electricity consumption in the National and Regional Economies (The Electrical Balance of the Russian Federation, 2015). Eighty constituent entities of the Russian Federation (including members of their autonomous territorial entities) with the exception of the Crimea and Sevastopol, details of which are not available for the specified period of time were examined.

The sector structure of GRP and the structure of energy consumption in the region, as reflected in the electrical balance, do not coincide. In this paper, they are brought to mutual correspondence by consideration of the two enlarged sectors of the regional economy and the formation of the corresponding enlarged sections of the GRP structure, as shown in Table 2. The first enlarged sector of the regional economy brings together electricity intensive industries of the production sphere, and the second enlarged sector – of non-production sphere (mainly) (Raizberg et al., 1999). In our view it is advisable to take into account the losses of electricity in networks as part of electricity consumption in production sector, as they arise in the course of economic activity of the "production and distribution of electricity, gas and water" type.

4. RESULTS

4.1. Descriptive Statistics of Electricity Intensity Index of Physical Volume of GRP for 2005-2013 and the Distribution of the Regions of the Russian Federation by its Value

Table 3 presents the distribution of regions of the Russian Federation according to electricity intensity index of physical volume of GRP over the 2005-2013 period. On average, electricity intensity index of physical volume of GRP was 0.83 across all regions of the Russian Federation over the 2005-2013 time span. This means that the electricity intensity*of* regional economies declined by 17% on average. The standard deviation of the index was 11%. The maximum value of the index ($Y = 1.10$) is observed in the Tyumen region, indicating the increase in electricity intensity of physical volume of GRP by 10%. The minimum value ($Y = 0.59$) is in the Tambov region (electricity intensity of physical volume of GRP decreased by 41% in this area). A quarter of the regions demonstrated the value of the Y index in the range of $0.59 \leq Y \leq 0.76$ (reduction of electricity intensity *of* GRP is from 23% to 41%); the Y index of half the regions do not exceed 0.82 (GRP reduction is not less than of 18%); more than three-quarters of the total number of constituent entities of the Russian Federation are characterized by the Y index values ≤0.89 (GRP reduction of 11% or more). Electricity intensity *r*eduction less than by 11% was observed in 10 regions. Finally, the electricity intensity increase in GRP from 2% to 10% was observed in 8 regions.

4.2. The Results of the Decomposition According to the Main Factors of Growth in Electricity Consumption in Regions of the Russian Federation in 2005-2013 and Ranking of Constituent Entities of the Russian Federation in Terms of the Aggregated Regional Index of Technological Energy Efficiency

The calculation results for the entire set of regions of the Russian Federation over 2005-2013 are shown in Table 4, which illustrates the following: The growth of electricity consumption amounted to an average of 16%; the growth factor, ceteris paribus provided an average increase in electricity consumption by 37%; the factor of change in the structure of the economy, provided that the GRP and specific electric energy consumption are at the level of *t* year, has caused a reduction in power consumption by 5% in average; the technological factor (the change of specific electric energy consumption in various sectors of the economy happening due to the introduction of new technologies and/or as a result of the implementation of energy saving measures and energy efficiency improvement under the condition of equality of GRP to the level of *t* year, while maintaining the same structure of GRP) provided a reduction in energy consumption by 16% in average.

Thus, the generalized regional technological energy efficiency index (I_T) suggests a significant contribution of measures to improve energy efficiency in the dynamics of power consumption in regions. In the majority of constituent entities of the Russian Federation it takes negative values (in out 64 of 80 regions), representing a decrease of power consumption under the influence of technological factor.

Table 2: Formation of enlarged sections of the GRP structure in accordance with the structure of the regional energy balance for calculation of the aggregated index of regional electricity efficiency technology

Enlarged sectors	Region energy balance categories*	GRP sectors**
Sector 1 (manufacturing industries)	Mineral production, manufacturing activity, production and distribution of electricity, gas and water. Electricity losses in networks	C. Mineral production D. Manufacturing activity E. Production and distribution of electricity, gas and water
	Agriculture, hunting and forestry	A. Agriculture, hunting and forestry
	Construction	F. Construction
	Transport and communications	I. Transport and communications
Sector 2 (primary non-production sectors)	Wholesale and retail trade	B. Fishing, fish farming
	Other activities	G. Wholesale and retail trade; repair of motor vehicles, motorcycles, household goods and personal items
	Urban and rural population	J. Financial activities
		K. Real estate operations, rent and services
		O. Other community, social and personal services
		H. Hotels and restaurants
		L. Government control and military security; social insurance
		M. Education
		N. Health care and social services
		P. Households activities

Compiled on the basis of statistics service (ROSSTAT) database. *The Electrical Balance of the Russian Federation, 2015: http://www.gks.ru/wps/wcm/connect/rosstat_main/rosstat/ru/statistics/enterprise/industrial/#. **Gross Regional Product, 2015: http://www.gks.ru/wps/wcm/connect/rosstat_main/rosstat/ru/statistics/accounts/#. GRP: Gross regional product

AQ2

Table 3: Quartiles of the distribution of the regions of the russian federation in terms of the electricity intensity index of physical volume of GRP over 2005-2013 period

Quartile 1		Quartile 2		Quartile 3		Quartile 4	
Region	***Y***	**Region**	***Y***	**Region**	***Y***	**Region**	***Y***
Tambov region	0.59	Chukotka Autonomous Okrug	0.76	Omsk region	0.82	Nizhny Novgorod region	0.89
The Republic of Dagestan	0.60	Saint Petersburg	0.76	The Republic of Kalmykia	0.82	Tomsk region	0.89
Astrakhan region	0.64	The Chuvash Republic	0.77	Ryazan region	0.82	The Tyva Republic	0.90
Belgorod region	0.65	Krasnoyarsk Krai	0.77	The Republic of Mordovia	0.83	Lipetsk region	0.91
The Mari El Republic	0.66	Sverdlovsk region	0.77	Kamchatka Krai	0.83	Novgorod region	0.92
Penza region	0.66	Perm Krai	0.77	The Sakha (Yakutia) Republic	0.83	Yaroslavl region	0.92
Tula region	0.67	The Republic of North Ossetia-Alania	0.77	The Jewish Autonomous Region	0.84	The Republic of Ingushetia	0.93
Irkutsk region	0.68	Oryol region	0.78	Altai Krai	0.84	Udmurtia	0.93
Kaliningrad region	0.69	Orenburg region	0.78	Volgograd region	0.84	The Komi Republic	0.95
Moscow region	0.70	Kurgan region	0.79	Magadan region	0.85	Moscow	0.95
Smolensk region	0.70	Leningrad region	0.79	Pskov region	0.85	Tver region	0.97
Bryansk region	0.71	Kostroma region	0.79	Republic of Karelia	0.85	Samara region	0.98
Bashkortostan	0.71	Kaluga region	0.80	Chelyabinsk region	0.85	Murmansk region	1.02
Saratov region	0.72	Vladimir region	0.80	Krasnodar Krai	0.85	The Chechen Republic	1.02
Kursk region	0.73	Stavropol Krai	0.81	Sakhalin region	0.87	Vologda region	1.03
Ivanovo region	0.73	The Republic of Buryatia	0.81	Khabarovsk Krai	0.88	Kemerovo region	1.03
Voronezh region	0.73	Novosibirsk region	0.81	Arkhangelsk region	0.88	Amur region	1.06
Ulyanovsk region	0.75	Rostov region	0.82	Primorsky Krai	0.88	The Republic of Khakassia	1.06
The Kabardino-Balkar Republic	0.76	The Karachay-Cherkess Republic	0.82	The Republic of Adygea	0.89	Altai Republic	1.07
The Republic of Tatarstan	0.76	Zabaykalsky Krai	0.82	Kirov region	0.89	Tyumen region	1.10

As shown in Table 4, the maximum value of the index ($I_T = 376\%$) was found in the Amur region, it demonstrates not the decrease, but the abrupt increase in the specific electricity consumption in the sectors of the economy of this region, despite the need for energy saving. The minimum value ($I_T = -112\%$) is observed in the Kamchatka region, where, according to the index, the specific electricity consumption in sectors of the economy under the influence of technological factor declined by more than 2 times. A quarter of the most successful regions showed the I_T index value in the range of ($-112\% \leq Y \leq -33\%$); in half the regions the I_T index does not exceed (20%); power consumption of three-quarters of the constituent entities of the Russian Federation is characterized by the I_T index values $\leq -5\%$. The reduction of power consumption due to technological factor less than by 5%, is observed in the two regions. Finally, in 16 regions specific electricity consumption of sectors of the economy did not decline, but grew.

5. DISCUSSION

The analysis of the electricity intensity index of physical volume of GRP over 2005-2013 showed that in 2013 electricity intensity of

Table 4: The ranking of regions of the Russian Federation on the regional aggregated index of I_T technological electricity efficiency and decomposition of growth of energy consumption upon the main factors

Rating	Regions	I_T (%)	I_A (%)	I_S (%)	δ E (%)
1	Kamchatka Krai	−112	28	0	−84
2	The Republic of Dagestan	−74	106	−4	28
3	Tambov region	−66	62	0	−4
4	Belgorod region	−62	90	−5	23
5	Astrakhan region	−57	61	−2	2
6	The Mari El Republic	−52	59	−1	6
7	Penza region	−51	58	−2	5
8	Kaliningrad region	−47	58	−1	10
	Irkutsk region	−47	58	−3	8
9	Tula region	−42	43	−5	−4
10	Saratov region	−38	48	−4	6
	Voronezh region	−38	59	−4	17
11	The Republic of Bashkortostan	−36	54	−8	10
12	The Kabardino-Balkar Republic	−35	42	0	7
	Saint Petersburg	−35	53	−1	17
	Kaluga region	−35	72	0	37
	Smolensk region	−35	45	−8	2
13	Bryansk region	−34	43	−8	1
	Moscow region	−34	47	−10	3
14	Kursk region	−33	40	−5	2
15	Ulyanovsk region	−32	34	−1	1
16	Chukotka Autonomous Okrug	−31	27	0	−4
17	Leningrad region	−30	46	−1	15
	The Republic of Tatarstan	−30	49	−6	13
	Perm Krai	−30	34	−1	3
	Orenburg region	−28	34	−1	5
18	Karachay-Cherkessia	−27	43	0	16
	Rostov region	−27	49	−1	21
19	Krasnodar Krai	−24	61	0	37
	Krasnoyarsk Krai	−24	39	−9	6
	Kurgan region	−24	22	−2	−4
	Oryol region	−24	24	−3	−3
20	The Sakha (Yakutia) Republic	−23	28	2	7
	The Chuvash Republic	−23	22	−5	−6
21	Zabaykalsky Krai	−22	46	−5	19
	Vladimir region	−22	33	−4	7
22	Sverdlovsk region	−21	46	−12	13
23	Altai Krai	−20	35	−2	13
	Ryazan region	−20	34	−4	10
	Kalmykia	−20	12	0	−8
24	Ivanovo region	−19	16	−12	−15
	Novosibirsk region	−19	38	−6	13
25	Omsk region	−18	24	−4	2
26	The Republic of Mordovia	−17	45	−8	20
	Sakhalin region	−17	67	−5	45
	The Republic of North Ossetia-Alania	−17	41	−15	9
	The Republic of Adygea	−17	80	−3	60
27	Kostroma region	−16	25	−10	−1
	Pskov region	−16	21	−2	3
28	Nizhny Novgorod region	−14	29	0	15
	Arkhangelsk region	−14	28	−1	13
	Stavropol Krai	−14	37	−8	15
29	Volgograd region	−13	12	−3	−4
30	The Republic of Buryatia	−12	21	−11	−2
31	Moscow	−9	22	4	17
	Chelyabinsk region	−9	27	−10	8
	Tomsk region	−9	21	−4	8
32	Novgorod region	−5	38	−7	26
	Magadan region	−5	20	−14	1
	Udmurtia	−5	22	−4	13
	Komi Republic	−5	17	−1	11
	Jewish autonomous region	−5	24	−15	4
33	Yaroslavl region	−2	29	−8	19
	Samara region	−2	21	−1	18

Cond...

Table 4: *(Continued...)*

Rating	Regions	I_T (%)	I_A (%)	I_S (%)	δ E (%)
34	The Tyva Republic	0	19	−12	7
35	Lipetsk region	1	30	−13	18
	Kirov region	1	17	−13	5
36	Tver region	3	29	−6	26
37	Republic of Karelia	6	4	−22	−12
38	The Republic of Ingushetia	7	60	−19	48
39	Altai Republic	10	18	−1	27
	Tyumen region	10	19	3	32
40	Kemerovo region	13	5	−10	8
41	Murmansk region	14	−4	−12	−2
42	Vologda region	15	5	−12	8
43	The Chechen Republic	19	56	−16	59
44	Khabarovsk Krai	25	22	−8	39
45	Primorsky Krai	28	32	−2	58
46	The Republic of Khakassia	29	28	−21	36
47	Amur region	376	16	−20	372

Compiled according to the results of calculations. Paint bucket denotes the second and fourth quartiles.

regional economies declined by 17% in average for the constituent entities of the Russian Federation. This result allows us to hope that it will be possible to reduce the electricity intensity of the Russian economy (in general) by 16% by 2015, as outlined in the Energy Strategy of Russia for the period up to 2030 (Table 1). However, the standard deviation of the given index was 11%, indicating a significant diversification of regions of the Russian Federation on the dynamics of electricity efficiency. Based on the estimates obtained, the best result was achieved in the Tambov region, which revealed the decrease in electricity intensity *of* GRP by 41%, while the worst result was in the Tyumen region, where there was an increase in electricity intensity of the economy by 10%.

On the basis of the index method the additive decomposition of growth in electricity consumption in regions of the Russian Federation in 2005-2013 in terms of the main factors was performed. These factors include the growth of GRP, change in the structure of GRP and dynamics of specific electricity intensity in sectors of the regional economy. As a result, it was found that the greatest effect to the dynamics of electricity consumption was made by GRP growth (ceteris paribus, it provided an increase in electricity consumption by an average of 37%). The second in absolute value but opposite in direction was the effect of the technological factor (ceteris paribus, this factor reduced power consumption by an average of 16%). The effect of the structural factor is rated as relatively small: Ceteris paribus, it provided a reduction of power consumption by an average of 5%.

It should be emphasized that the impact of the technological factor was taken into account in the assumption of the constancy of other factors (for fixed value and unchanged structure of GRP). The impact of this factor on the dynamics of power consumption in the region is characterized by a regional index of technological electricity efficiency of the process. This index describes the dynamics (typically downward) of specific electricity consumption for the production of goods and services in various sectors of the regional economy. It characterizes the effectiveness of regional policies in the field of energy saving and efficiency, including the technological renovation of production processes.

The resulting estimate of the effect of the technological factor in the growth of electricity consumption in the region was an unexpected result. The effect of this factor turned out to be second only to the effect of the growth of GRP and more than the effect of the structural factor in terms of the absolute value (size). This contradicts the Draft of Energy Strategy of Russia for the period up to 2035, which indicated that the main role in reducing the energy intensity of Russia's GDP (as a whole) played a structural change in the economy and recovery growth in the industry. The discrepancy between the results obtained with the official data may be due to the following circumstances. First, the estimate of the structural factor obtained is undercharged, as in the present work only two sectors of the economy were examined, while it is known that the greater the number of sectors is used, the higher the estimated effect of the structural factor appears (Bashmakov and Myshak, 2012). Second, the power consumption is considered in this paper, but not all fuel and energy resources referred to in the Draft of Energy Strategy-2035 are taken into account. Third, hypotheses (5-7) introduce errors into the calculations. And finally, fourthly, the structures of GRP and power balance, available on the Rosstat website, differ from each other (Table 2).

However, the debatability of the results obtained is a confirmation of the scientific and practical relevance of the research topic and the need for its further, more detailed study.

6. CONCLUDING REMARKS

Our study can be developed in the following areas:

1. In the process of development of the available official statistical database of energy efficiency analysis the dynamics of consumption of not only electricity, but also all energy resources in regions of the Russian Federation in general can be considered in the framework of such studies
2. It is advisable to consider not only the two sectors of the regional economy (production sphere and non-production sphere) but more of them, which will improve the accuracy of estimates

of the contribution of the structural factor in the dynamics of power consumption in regions of the Russian Federation

3. It is of interest to extend the list of factors affecting the dynamics of energy consumption in the region (to consider not only economic growth, structural shifts and technological innovation in the future, but also other relevant factors)
4. Not only the specific energy consumption of certain sectors of the economy can be used as an indicator of technological renewal. Justification of the choice of other indicators may be the subject of the further study
5. In addition to the index method for analyzing the impact of various factors on the dynamics of energy consumption in regions mathematical and econometric modeling can be used as well.

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