ELECTRICAL SUPPLY QUALITY INCENTIVE AND THE SMART GRID IMPLEMENTATION AS FACTORS OF ENERGY EFFICIENCY IMPROVEMENT AND ECONOMIC GROWTH IN SOUTHERN RUSSIA

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Abstract

In the present paper the characteristics of the relationship between indexes of economic development and energy efficiency in throughout the country and separate regions is described. The key role in increasing the energy efficiency and economic growth is given to the modernization of electrical grid infrastructure in the southern Russian. The priority guide lines of strategic development of the electrical grid infrastructure in the southern of Russia are argued in favor of introduction of SMART GRID technologies and improvement of the electricity transportation management on the basis of RAB rate policy and energy supply quality incentive.

Keywords: *energy intensity of the economy, RF regions, economic growth, regions at comparisons, loss of resource on the grid, SMART GRID, electrical supply quality incentive*

1. THE QUANTITATIVE ASSESSMENT OF THE LOWERING EFFECT OF THE GRP ELECTRICITY INTENSITY DUE TO THE GROWTH OF GROSS PRODUCT IN RUSSIA

In current environment of severe economic downturn and foreign-policy crisis, decline in output of goods and services, inflation, drop in the actual income of the population in our country, the problem of energy efficiency improvement at the national and regional levels continues to be relevant (Bogachkova, LY, Khurshudian, SG 2014). To phase out imports, stabilize prices and provide the economic security and social stability, these are primary tasks set by the RF government, it is necessary to reduce energy costs in all spheres of economical activity.

Energy efficiency is currently a necessary condition of the countries at competitiveness in the world economy. The implementation of the condition is provided with the introduction of the modern technologies, modernization of all spheres of economical activity, ecology, lifestyle and way of thinking. Energy efficiency and sustainable economic growth are interrelated and interdependent processes.

In countries with developed market economy, governmental energy efficiency programs have been implemented for over thirty years, providing energy-efficient economic growth: 1% growth in gross domestic product accounts for only 0.4% increase in energy consumption (Voronin, AY 2008).

In Russia in accordance with the international practice, improvement of energy consumption is viewed as a priority of governmental economical policy since the 1950s. The quantitative measure, showing that an adequate level of energy efficiency in Russian economy has been achieved, should be the reduction of the GDP energy intensity by 40% between 2007 and 2020 (State program of the Russian Federation 2010).

The analysis of the GDP dynamics and energy efficiency of Russian economy strongly suggests that the level of energy consumption influences the economic growth, moreover the index of economic growth itself has a favourable or adverse effect on the energy efficiency (Bogachkova, LY, Khurshudian, SG 2013). Thus, large manufacturing outfits did not operate full out due to the transformational recession of Russian economy in the 1990s, however, consuming large base quantities of electricity to maintain equipment in working condition, that was not directly related to the volume of production output causing the growth of the GDP energy intensity. During the 2000s there was a recovery growth period of the economy (the average annual rate of the GDP growth amounted to 4.78%) so a completely different situation was observed – there was a monotonic decrease in

electric intensity of the GDP (at the mean of 3.1% per year) (fig.1). However, this growth was caused by the due not so much to increase the increase of capacity utilization rather than the value improvement of energy resources consumption and the decrease of the relevant semi-fixed costing of electricity (Bogachkova, LY, Khurshudian, SG 2013).

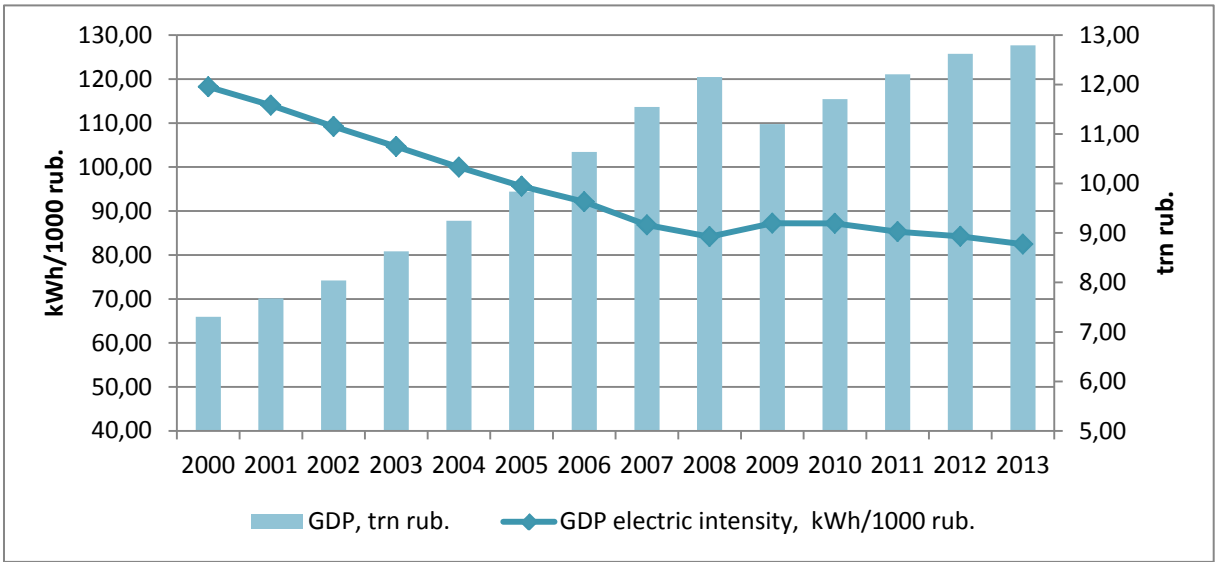


Fig.1. Dynamics of the GDP and electricity intensity of the GDP in Russia in 2000-2013 (at 2000 values). Source: Compiled based on the Rosstat data. Federal State Statistics Service (Rosstat) 2013.

To research and assay the statistical correlation between GDP (GRP) power intensity and the volume of the gross product for the Russian Federation and a number of regions (Bogachkova, LY, Khurshudian, SG 2013, 2014)], a power regression model of the form (1) has been developed:

$$X = A \cdot Y^{B}, \qquad (1)$$

where X is the electric intensity of the gross domestic product in kWh/1000 rub., Y – the volume of the gross domestic product in billion rubles (the X and Y are expressed at 2000 values); A and B are the regression parameters; B is the exponent characterizing the elasticity of X electric intensity in terms of gross product Y volume.

In the power model (1) the parameter B is the elasticity coefficient. The elasticity modulus B shows the average change of the dependent variable (electric intensity) in percentage terms, if the GDP (GRP) factor changes by 1%. The negative sign of the elasticity B shows the inverse negative relationship. The growth in the gross product decreases its electricity intensity decreases while the reduction increases. The higher the elasticity coefficient of electric intensity by the volume of the GDP in absolute value, the higher the utilization of production capacities is. For example, for the Russian Federation, Southern Federal District, the Volgograd and Rostov regions, the values of parameter B are in the interval from -0,84 to -0,65. Thus, 1% growth in the GDP decreases the electric intensity of the GRP of these regions by an average of $|B|$=0,75%. For the NCFD (North Caucasian Federal District), Dagestan, Kalmykia, Adygea, Stavropol and Krasnodar Kraies, the parameter B takes on the values from -0,65 to -0,45. The elasticity in these regions is lower than national average: 1 % growth in the GDP leads to the reduction of electric intensity by approximately 0,55%. The minimum elasticity of electric intensity of the gross domestic product ranging from -0,45 to -0,26 is observed in the republics of Chechnya and Ingushetia (Bogachkova, LY, Khurshudian, SG 2013).

Two indexes - electric intensity of the gross regional product and GDP per capita are compared for the Russian Federation, Federal districts of the RF and southern regions of Russia, id est the regions of the

North Caucasus and South Federal districts (Fig. 2). In many regions of the North Caucasus (Ingushetia, Karachay-Cherkessia, North Ossetia, Adygea) and the South Federal District (Kalmykia, the Volgograd region), which have higher than the average for the RF electric intensity levels, the values of GDP per capita are much lower than the average for the RF.

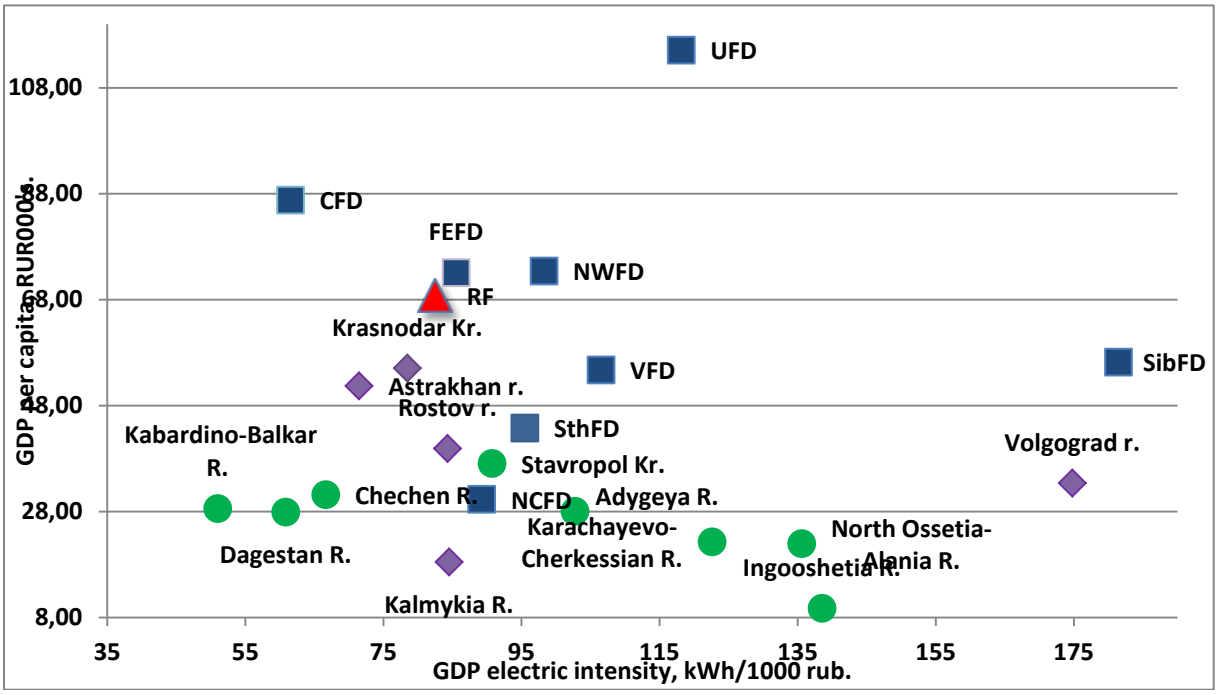


Fig.2. The GDP per capita (at 2000 values) and electric intensity of the GRP of southern Russian regions in 2013 (at 2000 values). Source: the author's calculations.

In Fig.2 we shall accept the notations: Federal districts (blue squares): CFD – Central Federal District, NWFD – Northwestern Federal District, SthFD – South Federal District, NCFD – North Caucasian Federal District, VFD – Volga Federal District, UFD – Ural Federal district, SibFD - Siberian Federal District, FEFD – Far Eastern Federal District. The regions of the southern Federal district are marked by purple diamonds; the regions of the North Caucasus Federal district are marked by green circles.

2. THE URGENT PROBLEMS OF THE ELECTRICITY SUPPLY NETWORK DEVELOPMENT IN RUSSIA

Electric intensity is directly related to the level of economic development. Fig. 2. clearly demonstrates that the lower levels of economic development are viewed in regions with relatively high electric intensity of the GDP. The increasing level of the GDP (GRP) per capita is the main indicator of economic development; the energy intensity of the economy decreases with the growth of the GDP and otherwise when the level of the GDP falls the energy intensity rises.

One of the main reasons of inefficient electricity consumption in southern Russia is considerable energy transmission losses, as illustrated in fig. 3.

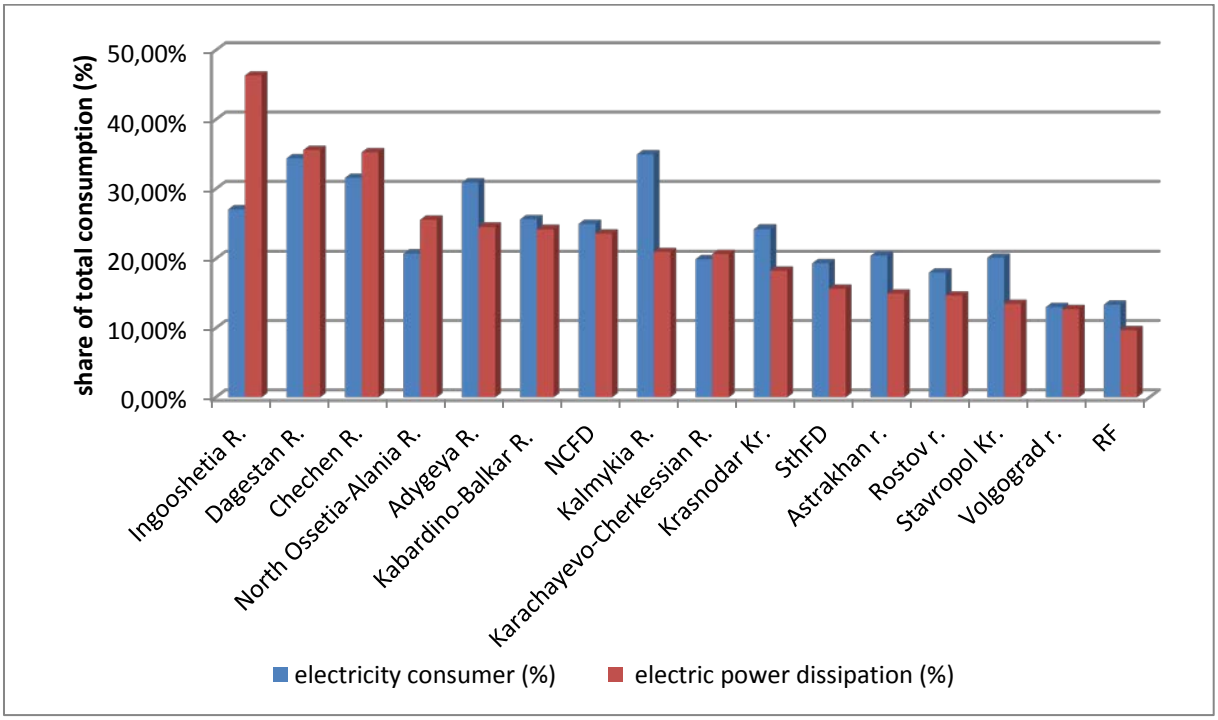


Fig.3. The power use in the household sector and energy transmission losses, which are expressed as a fraction of the total consumption in corresponding regions of southern Russia (2013, %). The data of the Russian Federal State Statistics Service (Rosstat) were utilized Source: Compiled based on the Rosstat data.

Energy transmission losses in southern Russia are comparable with the power use in the household sector the given problem is the most acute in the territories of North Caucasus. According to fig.3 Energy transmission losses in Ingushetia, Dagestan, Chechnya, North Ossetia and Karachay-Cherkessia exceed the residential energy consumption. In 2013, actual losses in North Caucasus went beyond the limit by 8,68 %. It should be noted that the approved normative losses in these areas are several times higher than national average (Jangurazov, KB 2015). Furthermore, regional network organizations absorb losses due to the significant volume of lost business, which is not taken to tariffs, affecting the financial condition and investment potential of the regions.

Generally, in Russia there are also large amounts loss of resource on the grid (13,36%), while in the advanced economies this indicator are in the range of 4 to 8% away from electricity generation (Vorotnickii ,VE 2011).

This fact is able to become a deterrent of the country's economic growth. Excessive losses of power in the electrical grid can lead to the electricity price increase for end users and deterioration of the competitivity (competitiveness) of domestic services and goods.

Alongside with substantial volume of energy loss in the RF power grid, that is the basis of Russian energy infrastructure a lot of time-critical severe issues have turned up recently (Jangurazov, KB 2015).

Amid power market liberalization, insulation of energy transportation from other kinds of activity and use of regulations traditionally applied to natural monopolies, stimulating the reduction of service cost when revenue is limited has led to the increased deficit of funds available for investment, enhanced wear-out rate of Plant and Equipment and consequently deterioration in quality and security of power supply. Low quality of power supply, interruption of electrical supply to different consumers can cause financial and physical damage (operational incidents, temperature abuse of food, thermal abuse of raw materials and supplies, security alarm outage, etc.). Deterioration in quality and security of consumer supply has become a global challenge due to the power market liberalization.

The problem of energy transportation through the distribution networks in the RF regions are interlinked and interdependent. Electric losses are directly dependent on the high level of wear of Plant and Equipment, conditioned upon investment deficit. Attracting investments is attended with difficulties because it is necessary to keep the prices on electrical energy transportation down. The tariffs have already surpass the world counterparts, that could be in particular explained by the necessity to offset the costs of network organizations to compensate large energy losses and by the problem of electric reliability assurance (Bogachkova LY, Gribova, AP 2015).

3. THE PRIORITY GUIDE LINES OF STRATEGIC DEVELOPMENT OF THE ELECTRICAL GRID INFRASTRUCTURE IN THE SOUTHERN OF RUSSIA

The main guidelines for solving the problem of energy transportation are: the asset consolidation of regional network organizations to optimize the operation of the regional power supply network; scale up of the return on invested capital method to RAB-based rate policy in order to budget/finance the capital maintenance; the automation of measuring and information system for electric power fiscal accounting; improving of tariff regulation of energy transportation by incentivising the quality and reliability of consumers' electric supply quality.

The implementation of new regulation methods based on RAB (Regulatory Asset Base) started in the RF in 2010 (Sakharova, IV 2013, 'On the accounting of quality of services in tariff regulation of distributive electro-network companies in Russian and foreign practice' *Modern economy: problems and solutions*, no 5 (41) , pp. 43-52.; Saharova IV 2013, 'Overcoming the tendency of the growth shortfall in income from the transportation of electricity through the distribution networks of the region', PhD thesis). In comparison with traditional cost-plus pricing, this method offered opportunities to network companies to mobilize solid investments for technological renovation of the power supply network. A long economic payback period would provide controlled pace of rise in energy transportation tariffs. Although in practice application of this method led to the race of investment programs and unreasonable rise in tariffs.

To provide a background for investment mobilizing in the sector and raising of efficiency of energy companies, certain changes in the sectoral structure of the electricity market have been made: disintegrated post-liberalization energy companies were united in a unified naturally-monopolistic branch network JSC "IDGC Holding" was officially renamed JSC "Rosseti (Russian Grids)" in 2013.

One more guideline that could help to improve the operating of the power supply network in the RF is the modernization of the energy infrastructure on the basis of Smart Grid platform.

Smart Grid is the electrical supply network modernization, that uses informational and communicational technologies to collect information about energy generation and consuming, that allows to raise efficiency, reliability, economic benefit as well as stability of production and power distribution. Besides smart grid allows effectively integrating centralized and microgrids distributed power generation and achieving maximum system economic benefits and technical effect.

The development of microgrids distributed power generation can facilitate reduction of energy transmission losses. This conception provides for a number of various consumers, producing the thermal and electrical energy for their own needs and allot the surpluses in the general heat or electricity networks. Microgrids can provide energy at a more favourable price, reduce the electric intensity of production by means of transmission losses reduction and enhance reliability of the grid (Inshakov, OV, Bogachkova, LJ, Olejnik, OS 2013).

Smart Grid ensures the adaptive management of power use processes and direct involvement of customers in rendering of services of the centralized distributed power generation system itself (Novoselova, O 2012).

However, there exist a range of problems connected with implementation if Smart Grid in the RF (The Strategy of development Russian Government 2013):

- A significant number of consumers, having different requirements for the quality of electrical energy;
- Lack of reliable energy storages;
- Considerable investments during the Smart Grid system integration and its subsequent servicing;
- Absence of corresponding standards and norms;
- Low motivation of power generation companies as their revenue directly depend on the volume of electricity sold; after the implementation of this new technology a part of electric energy is produced by consumers themselves.

In order to solve the problem of additional investments without unjustified energy rate increase the method of promotion of reliability and quality of energy supply. This method has already been implemented in the UK, Italy, Norway and some others (Sakharova, IV 2013, *Modern economy: problems and solutions)*. This method lay in the following: electric distribution companies are encouraged with additional increase to tariffs if they worked properly and fined if not. The quality rating is based on the international indexes of consumer energy supply quality assessment. The size of additional pay for high quality, collected from energy consumers and the size of reimbursement if the quality if energy is poor is fixed on the ground of customers' WTP (willingness to pay) and their WTA –(willingness to accept) the compensation of certain amount.

4. DESCRIPTION OF THE INTERNATIONAL QUALITY AND ENERGY SECURITY INDEXES

To regulate the quality of electrical supply by means of introduction of additional increases to tariffs and tariff preferences for consumers the following conditions shall be fulfilled:

1. Full commissioning of the automated electricity metering system at the entry and exit point of electric power in networks. This measure will allow establishing of the accurate energy accounting the electricity, its losses, and also the time and the quantity of unplanned outage.
2. Introduction of the international quality and energy security indexes (SAIDI, SAIFI, MAIFI and D. R.) in the planning and reporting documentation of network companies. (Sakharova, IV 2013, *Modern economy: problems and solutions;* Saharova IV 2013, *Science Journal of Volgograd State University. Global economic system)*.
3. Organizing of the call-centers to conduct consumer surveys in order to monitor quality of energy supply and the possible value indicator the WTP/WTA. (Sakharova, IV 2013, *Modern economy: problems and solutions;* Saharova IV 2013, PhD thesis).

In Russian network companies the quality rating and energy security are mainly estimated by the frequency and duration of operational incident in medium and high voltage systems without monitoring their impact on the blackouts of ultimate customers. Quality monitoring in the low-voltage networks is carried out selectively (mostly on appeals of ultimate customers). (Sakharova, IV 2013, *Modern economy: problems and solutions;* Saharova IV 2013, *Science Journal of Volgograd State University. Global economic system)*.

In foreign practice, the following operational efficiency indicators of energy system are used to optimize the "tariff-quality" ratio of electrical supply.

- Customer Average Interruption Duration Index (CAIDI). This index makes assertions about the duration of outages and speed of problem solving;
- System Average Interruption Frequency Index (SAIFI). This index shows how many times a year there were cuts of electricity supply per an average consumer, and if certain consumers suffered more than once, every interruption is treated as a separate problem.

- System Average Interruption Duration Index (SAIDI). This index shows the average duration of power cut per one consumer during a year.
- Momentary Average Interruption Frequency Index (MAIFI) (Sakharova, IV 2013, *Modern economy: problems and solutions).*

Only indexes similar to SAIDI are used in the current RF environment. Among all the companies, which are included in JSC "Rosseti" ("Russian grids") (almost 70% of them), reliable indicators of the frequency and duration of consumers' outages are only in some of IDGC (interregional distribution grid company) they are 5-10 times worse those of foreign companies (The Strategy of development Russian Government 2013).

Let's consider the results of the calculation of the SAIDI index by the example of some electric grid companies in the RF (fig. 4).

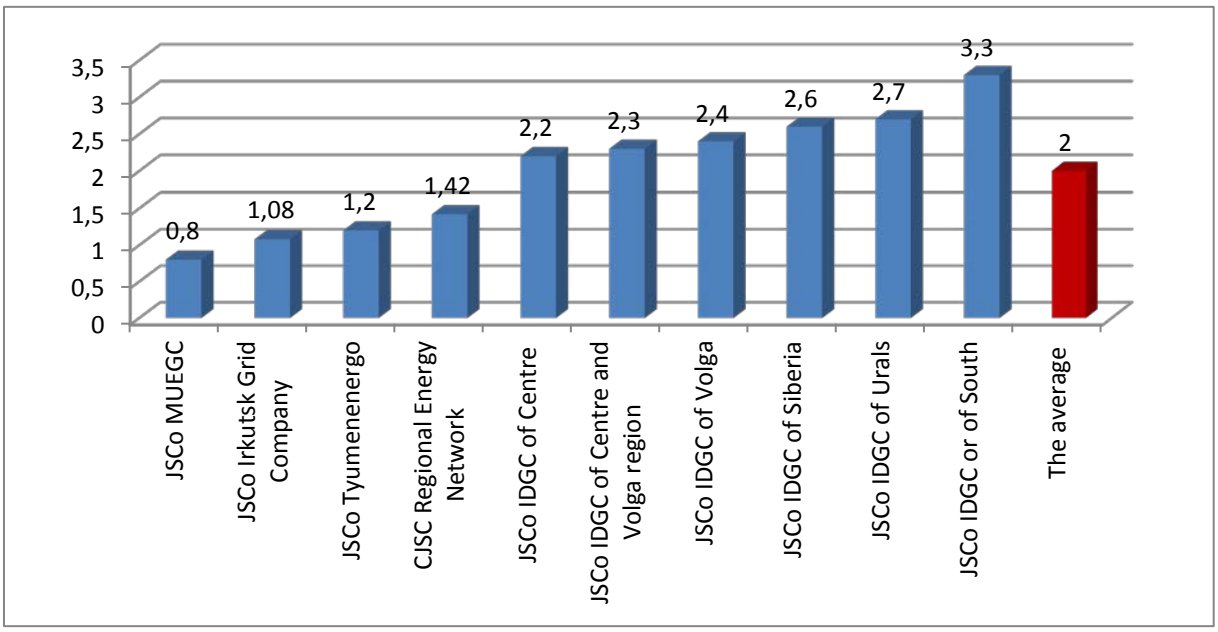


Fig. 4. The values of the SAIDI in the electric grid companies of Russia (6 kW and above transmission lines) in 2012. Source: Annual report 2012, 'Annual report JSC "Irkutsk electric grid company" for 2012'. (Russian), viewed 01 May 2015, <http://www.iesk.irkutskenergo.ru/gi/14438>.

The average value of the SAIDI index was 3.5 hours per customer a year in 2011 (Sakharova, IV 2013, *Modern economy: problems and solutions)* and 2 hours in 2012 for the examined Russian electric grid companies, calculating this indicator. While, for example, in Italy the value of this index was 3.1 hours in 2000, and had fallen to 1 hour per consumer a year by 2007.

These data shows a low quality and reliability level of consumers' energy supply in the RF and neediness to improve the introduced method of consumers' energy supply quality incentive.

Starting with 2014 it is planned to develop and implement a methodology of comparative analysis of network organizations' activity including international indexea of electrical supply quality.

By 2017 Russian network companies must ensure the reliability and electrical supply quality data collection in accordance to the international indexes (The Strategy of development Russian Government 2013).

5. CONCLUSION

Thus, the level of electric intensity is directly related to the level of economic development. The specific effect of the energy sector efficiency on the region economy is as follows: network infrastructure plays a catalyst role in the regional economical development. The grid infrastructure upgrading has beneficial effects on the regional economy, and inhibited access to it or its lack slows the economic growth and can contribute to the capital consumption and, consequently, increased losses, interruptions of electricity supplies, poor electrical supply quality (Bogachkova LY, Gribova, AP 2015).

To improve energy efficiency improvement and speedup of economic growth, it is necessary to develop the management of Russian electricity grid complex, which is advantageously conducted in the following directions:

the asset consolidation of the territorial grid organizations; application of RAB-regulation method; technological upgrading of the grid infrastructure based on Smart Grid; the introduction of new methods of record keeping of consumers' electric supply quality and reliability providing raising of efficiency in LGO (local grid operator) activity.

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