

Growth of investments as a condition for increasing energy efficiency of the Irkutsk region's economy

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Abstract. The energy efficiency of the Russian economy lags far behind the developed countries of the world that worsens its socio-economic development. To increase energy efficiency, it is necessary to introduce innovative solutions that require large investments. The object of the research is the economy of the Irkutsk region that energy efficiency growth, being the most important priority of socio-economic development, is of particular relevance due to its high energy intensity. The purpose of the study is to perform an energy-economic analysis of the Irkutsk region, and to determine the impact of investment on the energy efficiency growth. The methodological approach developed by the authors and used in this research is based on the balance and statistical methods. In course of the research, retrospective fuel and energy balances (FEB) of the Irkutsk region have been developed, and the energy efficiency indicators have been calculated on their basis. The main directions for the fuller use of the fuel and energy resources (FER) have been identified, the implementation of which will significantly increase the energy efficiency indicators. It will require an increase in investments in the fuel and energy complex (FEC) by 1.7-2 times by 2030 as compared to 2016.

1 Introduction

The economy of the Russian Federation (RF) is characterized by high energy intensity in comparison with the industrially developed countries of the world. The energy intensity of the gross domestic product in the Russian Federation (at purchasing power parity) is 3.3 times higher than in the UK, 2.6 times - than in Germany, 2.3 times - than in Japan, 1.8 times - than in the US, 1.4 times - than in China, and 1.3 times - than in Canada [25, 26]. The increase in the energy efficiency will allow increasing energy consumption with the same volumes of FER production or with their insignificant growth, which will save substantial

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amounts of material, financial, and labor resources, and reduce the harmful impact of the anthropogenic factor on the environment [24].

To solve the problem of improving energy efficiency, various methods and approaches are used that have shown their scientific and practical validity, but there are a number of unresolved issues concerning the modeling of the influence of various factors on the energy intensity. In particular, the problem of forecasting the energy intensity of the GRP, depending on the dynamics of investment in the economy and the fuel and energy sector, remains insufficiently studied.

The implementation of measures ensuring the growth of the energy efficiency requires significant investments, which leads to the need to take them into account when predicting the innovative development of the FEC (the ratio of costs and effects from them). All this predetermined the relevancy of the research aimed at revealing the influence of the investment component on the dynamics of the energy intensity in the GRP of the Irkutsk region.

2 Relevancy of the problem

According to the data of the Federal State Statistics Service for 2015, the energy intensity of the gross regional product (GRP) of the Irkutsk region was 2.4 times higher than the Russian average, but there are a number of objective factors for this: cold and prolonged winters; features of the industry specialization of the region, expressed in a large number of raw materials and high-energy industries (metallurgy, machine building, oil refining, petrochemicals, polymer production, timber processing, etc.); low population density, which increases the length of transport, energy, and communication infrastructures and leads to the increased energy costs and increased losses.

In addition to the objective reasons for the high energy intensity of the GRP in the Irkutsk region, there are problems that need to be eliminated in the future, such as technological backwardness in a number of industries, which is confirmed by the high specific costs of FER for the production. For example, in the Irkutsk region, the production of 1 m³ of wood consumes twice as much fuel as the average for Russia, for processing 1 thousand m³ of timber - 1.6 times, for production of 1 Gcal of thermal energy by boiler-houses - by 1.2 times as much.

The goals to increase the energy efficiency of the economy, to ensure an uninterrupted, safe and economical energy supply to the economy and the population of the region is one of the most important directions of innovative development for the Irkutsk region [27]. To achieve these goals, a long-term target program "Energy saving and improving energy efficiency in the territory of the Irkutsk region for 2011-2015 and for the period to 2020" was accepted. Investments for the implementation of the program are about 2 trillion rubles (in 2010 prices), and as a result of that, the energy intensity of GRP of the region for the period 2011-2020 should decrease by 31%.

In addition, the Government of the Irkutsk region is working to attract investors to the region. In 2016, the Agency for the Investment Development was established, in 2017 - the Investment Council under the Governor of the Irkutsk Region. The Ministry of Economic Development has an investment portal where investment projects, which are planned to be implemented in the region, and measures of the state support for investors, are represented [15, 23]. All measures taken should improve the investment attractiveness of the Irkutsk region both within the country and abroad, and the growth of investments, their use for innovative technological development of the economy and the fuel and energy complex should increase the energy efficiency of the region.

3 Research tasks

In the framework of the research, the task is to perform the energy-economic analysis of the economy of the Irkutsk region using the available retrospective data, and on its basis, to determine the influence of the investment component on the growth of the energy efficiency in the region. To conduct a comprehensive energy-economic analysis of the Irkutsk region's economy, it is necessary to develop fuel and energy balances for the period of 2005-2016. Using statistical methods, it is needed to construct correlation-regression dependencies of the main indicator of the energy efficiency of the regional economy – dependencies of the GRP energy intensity from investment dynamics. Also the task includes elaboration of the forecast for the growth of investments that provide for an increase in the energy efficiency in the Irkutsk region.

4 Theories

The authors elaborated a methodical approach to the energy-economic analysis and assessment of the region's energy economic efficiency based on the TEB [1, 2], which further develops studies of the Russian and international scientists in this field [3-21], since it takes into account both the regional specificity and the investment policy of the region, as well the state energy policy pursued by the Government of the Russian Federation. In the process of research, an information computational complex (ICC) was created by the authors, that consists of the information and reference system (IRS) and a system of models: single-product balances of certain types of the fuel and energy resources, the summary TEB, the energy analysis and statistical analysis of the factors affecting the energy efficiency of the region's economy was used. The IRS is utilized to provide the researcher with an access to the information that is presented in a form that is user-defined and convenient for the analysis. This study determines the impact of the investment component on the energy efficiency, which is taken into account through such indicators, as the total investment in the economy and the investment in the sectors of the FEC.

5 Results of the research

Irkutsk region, one of the largest regions of Russia on the east of the country, with an area of 4.5% of the country, has a large economic potential. In 2016, the contribution of the Irkutsk region to GRP of Russia was 1.5%, to the industrial production - 1.8%, to the fixed assets of the economy - 1.4%, and to the investment in the fixed assets - 1.8% [15].

To implement the energy-economic analysis, the fuel and energy balances of the Irkutsk region for 2005-2016 have been developed (Table 1).

Table 1. TEB of the Irkutsk region*, million tons of fuel equivalent.

Year	Production of primary TER	Import of TER	Export of TER	Production of electricity and thermal energy	Expenses of TER for the production of electricity and thermal energy	Total losses of TER	End use of TER
2005	16.1	14.1	-10	13.6	-15.6	-4.9	-15.3
2006	15.5	15	-10.2	13.5	-15.5	-5.1	-15.2
2007	15.7	16.3	-10.6	12.8	-15.7	-6.6	-14.8

2008	17.5	16.5	-13.2	13	-16.9	-6.9	-13.9
2009	17.7	16.8	-15	12.7	-15.2	-5.3	-14.2
2010	21.3	18.3	-19.1	14.2	-16.6	-5.9	-14.6
2011	27.6	19.3	-25.5	13.7	-16.4	-6.1	-15.3
2012	35	20	-29.7	13.9	-17.9	-9.2	-16.1
2013	35.4	21.7	-32,5	12.6	-15.7	-8.8	-15.8
2014	36.7	19.3	-32.3	12.6	-15	-7.6	-16.1
2015	40.6	18	-35.1	11.7	-13.8	-7.4	-16.1
2016	48.1	18.3	-39.4	11.8	-14.1	-10.8	-16.2

Note * TEB is represented in the aggregated form.

The production of primary fuel and energy resources for the period increased three-fold (mainly due to the oil production), export of energy resources – by 3.9 times. A negative fact is an increase in the total losses of fuel and energy resources by 2.2 times (mainly due to the flaring of associated petroleum gas). We also note the instability of the energy efficiency factor in energy (the ratio of the energy production to the consumption of the fuel and energy resources), which varies in the range of 77-87% (depending on the generation of hydroelectric power stations).

A major role in solving the problem of increasing the energy efficiency in the economy of the Irkutsk region is played by a reduction in the specific fuel consumption for the production of energy carriers, reduction of the fuel and energy losses in the production, transportation and consumption, production of a high degree of redistribution in the fuel and energy sector, primarily in the oil and gas industry (oil and gas chemistry). The implementation of these measures requires a large amount of investment.

For the formation of the equation of the multiple regression model for the energy intensity of GRP of the Irkutsk region, the data obtained from retrospective TEBs-the gross consumption of the primary fuel and energy resources (the sum of the production of the primary fuel and energy resources, and their import and export, see Table 1), and the Federal State Statistics Service investment data have been utilized [28, 29] (Table 2).

Table 2. Dynamics of indicators for the formation of the equation of the multiple regression model of GRP energy consumption in the Irkutsk region in 2005-2016.

Year	Gross consumption of the primary fuel and energy resources, million tons of fuel equivalent	Total investment*, billion rubles	Investment to the FEC*, billion rubles	Energy intensity of GRP*, kg of fuel equivalent / thousand rubles
2005	20.2	366.8	62.3	78.3
2006	20.3	432.0	69.1	70.2
2007	21.4	534.9	96.3	67.9
2008	20.8	585.7	117.1	63.6
2009	19.5	506.6	131.7	59.6
2010	20.5	538.5	183.1	58.6
2011	21.4	604.2	205.4	58.6
2012	25.3	690.6	241.7	63.3
2013	24.6	740.3	259.1	60.3
2014	23.7	766.3	275.9	55.5
2015	23.5	652.8	248.1	54.8
2016	27.0	767.1	306.8	61.2

Note - * in the prices of 2005

Using the method of the least squares, the equation of the multiple regression model for the energy intensity of GRP of the Irkutsk region is formed:

$$Y_1 = 26,220 + 3,328 \cdot X_1 - 0,037 \cdot X_2 - 0,085 \cdot X_3, \quad (1)$$

Where:

Y_1 – energy intensity of GRP, kg of fuel equivalent / thousand rubles;

X_1 – gross consumption of primary fuel and energy resources, million tons of fuel equivalent;

X_2 – total investment, billion rubles;

X_3 – investment to the fuel and energy complex, billion rubles.

The correlation coefficient of the equation (1) (0.948) showed the presence of a significant statistical relationship between the variables and the GRP energy intensity. The statistical reliability of the obtained equation (1) is estimated from the significance level of the Fisher criterion, where $p = 2.52 \cdot 10^{-4} < 0.05$, which confirms the good adequacy of the description of connection between the GRP energy intensity and the explanatory variables.

To determine the measure of influence of each of the factorial signs, the elasticity coefficients were calculated, which showed that an increase in the gross primary energy consumption by 1% would cause an increase in the GRP energy consumption by 1.19%; an increase in the total investments by 1% would result in the decrease of the energy intensity by 0.35%; the growth of investments in the fuel and energy sector by 1% will cause the decrease in the GRP energy consumption by 0.25%.

With the use of the equation (1), the forecast of total investments in the economy of the Irkutsk region, and the fuel and energy sector in 2020-2030 is fulfilled. For this, the levels of reduction in the GRP energy consumption are set in comparison with 2016 (Table 3). The growth of the energy consumption for the period 2020-2030 is calculated using the TEB models.

The decrease in the energy intensity of GRP of the Irkutsk region by 30% in comparison with 2016 with the increase in the energy consumption by 30% is possible with the increase in total investment in the economy by 87%, and in the fuel and energy sector - by 2 times. With the increase in the energy consumption by 20% by 2030, a 20% reduction in GRP energy consumption is possible with a smaller volume of investment in the economy - by 61% compared to 2016, and in the fuel and energy sector - by 1.7 times.

Table 3 Forecast of the investment growth, depending on the decrease in the energy intensity and the growth of the FER consumption.

Год	Energy intensity of GRP*, kg of fuel equivalent / thousand rubles		Gross consumption of primary fuel and energy resources, million tons of fuel equivalent		Total investment*, billion rubles		Investment to the FEC*, billion rubles	
	20%	30%	20%	30%	20%	30%	20%	30%
2020	55.1	51.1	28.4	29.6	923.9	1041.7	369.6	416.7
2025	52.0	49.0	29.7	32.3	1028.5	1197.8	421.7	503.1
2030	46.2	42.9	32.4	35.1	1236.9	1431.9	519.5	615.7

Note - * in the prices of 2005

The growth of the energy efficiency of the regional economy depends on the implementation of technological factors in all spheres of economic activity. The introduction

of the energy-saving technologies and equipment into production processes will allow reducing the costs of production and consumption of the energy resources, and decreasing their losses. As a result, the achievement of the planned indicators of socio-economic development can be achieved with less energy and financial costs. The economic effect of the implementation of innovative technological factors of the energy efficiency growth in the Irkutsk region for the period 2017-2030 can reach 280-320 billion rubles (in the prices of 2016).

6 Conclusions

In course of the research, retrospective TEBs have been developed for the period of 2005-2016, based on which the energy-economic analysis has been performed. A number of issues in the fuel and energy complex have been identified, such as a significant increase in the total losses of the fuel and energy resources; high specific consumption of fuel for the production of electrical and thermal energy at thermal power plants and boiler houses; and large dependence of power generation on water resources. The identified issues affect the main indicator of the energy efficiency - the energy intensity of GRP, which within the period under study had multidirectional dynamics.

Using the method of the least squares, the equation of multiple regression of the energy intensity of GRP of the Irkutsk region is constructed, depending on the gross consumption of fuel and energy resources and the dynamics of investments. With the help of elasticity coefficients, the sensitivity of GRP energy intensity to the change of the factor variables has been revealed, and the influence of the investment component on the growth of energy efficiency of the region has been identified. With intensive innovation and technological development of the economy, the growth of total investment to 1.2-1.4 trillion rubles by 2030, and in the fuel and energy sector - up to 0.5-0.6 trillion rubles, the energy intensity of GRP of the Irkutsk region in the period 2017-2030 can be reduced by 20-30%.

The results obtained can be used to forecast the dynamics of changes in the energy intensity of GRP, depending on the investments invested in the economy and in the fuel and energy sector. With the help of the proposed model, the executive authorities of the region can receive information on the amount of investment needed to achieve certain growth rates of the energy efficiency in the region.

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