Energy consumption structure and economic growth in the Russian Federation

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Abstract. Energy consumption is an indicator of the level of economic development in almost any country. Russia is in fourth place in the world in terms of the amount of electricity generated. Between 1990 and 2017, the amount of electric energy consumed in the country increased by one percent, however, the capacity of power plants in the Russian Federation increased by 27.7%. The largest consumption of fuel and energy resources is accounted for by mining (63-70%), production and distribution of energy, gas and water (28-30%), manufacturing (28-29%), transport and communications (21-22%), other activities (8%), construction (2.2-3.7%), agriculture (3-3.5%). Four Russian federal districts use over 80% of electric energy: Ural, Siberian, Volga and Central. In the structure of consumption of fuel and energy resources in 2018, the largest share belongs to mining - 53.3%; domestic use of electric energy by urban and rural population - 14.4%; transportation and storage - 8.1%, trade - 3%, agriculture - 1.7%, construction - 1.1%, information and communications - 0.6%, other types of economic activity - 9%. The largest share in the structure of the gross domestic product is occupied by production (26%), wholesale and retail trade (14%) and other. The economic growth of any country is primarily associated with energy consumption.

1. Introduction
The production of electric energy is very important for the development of the economy of any country. The study of the dynamics of the electric balance, the structure of consumption both by branches of the economy and by territories allows us to identify the most powerful sectors and subjects of the economy. The aim of our study is to study the state of development of the industry by industry and territorial characteristics (federal districts of the country). In the work we used monographic and statistical research methods.

Between 1990 and 2017, the capacity of power plants in the Russian Federation increased by 27.7%, including thermal power plants - by 27.3%, hydroelectric power plants - by 22.6%, nuclear power plants - by 38.1%.

If we compare the shares of power plants, the largest share belongs to thermal power plants - 70%. The share of hydroelectric power plants decreased from 20.3% in 1990 to 19.5% in 2017. While their absolute value increased by 22.6%. The proportion of nuclear power plants increased from 9.5% to 10.2%, i.e. by 0.7 percentage points. The structure of electric energy consumption across sectors of the economy and across the Russian Federation is heterogeneous. We will try to find out this difference.
2. Literature review

Most modern scientists associate economic growth with increased energy consumption. In addition, the growth in demand for electric energy is directly dependent on total population growth. In support of this, the conclusions of Indian researchers should be cited as follows: “the rapid growth of the Indian economy contributes to the growth of demand for electric energy; in order to meet the growing demand for electricity, its annual growth of 10% should be ensured, and energy consumption per capita should increase within 3500 kW per hour» [1].

In addition, Australian scientists believe that "a population growth of 1% contributes to an increase in demand for electric energy by 4%, and the large-scale development of available renewable energy sources (hydropower) will enhance energy security [2].

Other researchers also believe that there is a “direct causal relationship between energy consumption (for example, in agriculture) and economic growth» [3]. Issues of economic development of territories already considered in our work [4], and the mechanism of formation of competitive advantages in the digital economy in work [5]. The work of Chinese researchers said, that "China has the largest electrical system in the world, in 2018, a 6.5% GDP growth required an 8.5%» [6].

Moreover, another problem of our time is the lack of energy resources. According to Chinese scholars, "the regional protectionism of local monopolists makes it difficult for more efficient (less expensive) but not local electricity producers to enter the Chinese market» [7].

The shortage of energy resources is proposed to be addressed through renewable energy sources. And since most scientists categorize “energy sources into six main types: coal, oil, gas, electricity, heat and new renewable energy sources and five sectors: residential, commercial, industrial, transport, agricultural» [8], the issues of energy conservation and energy security are of particular relevance.

In this regard, Indian scientists express concern about energy security issues [9]. Other Indian scientists believe that "the industrial sector is the largest energy consumer in India and in the world," "energy conservation is a cost-effective approach to any energy optimization program» [10].

According to British scientists, by 2050 "there will be a transition from fossil fuels to a low-carbon economy» [11]. An assessment of the relationship between the growth of renewable energy sources and economic growth was made in the work of Polish scientists [12]. Issues from the transition from non-renewable to renewable energy also concern researchers from Ghana [13].

A separate area of research in the works of modern scientists is devoted to climate change. According to most scientists, "the increase in temperature is linearly dependent on the increase in energy consumption» [8]. According to Japanese scientist Sugiyama, M., “climate change is driving increased demand for electric energy» [14].

Smoothing the growth in demand for electric energy, according to some researchers, can be achieved through digitalization. Some researchers note that “digitalization can help increase energy efficiency, reduce energy consumption, but also economic growth» [15]. According to Kazakh researchers, "the rapid pace of the digital economy is based on the development of innovation, while the technological revolution has become a source of economic growth with less energy consumption» [15].

Thus, the study of trends in the composition, structure of energy consumption by territorial, sectoral characteristics and the study of their impact on economic growth is a very topical issue and attracts the attention of scientists from various countries.

3. Results

According to the Federal State Statistics Service of the Russian Federation, electricity consumption in the Russian Federation for the period from 2005 to 2018 increased by 17.8%, including for the urban and rural population - by 46.3%, for the construction industry - by 32.5%, for mining. - by 17.8%, in the agricultural sector - by 12.5%, in the field of transport and storage - by 8.2%. In other types of economic activity - for electricity consumption - by 23.5%. The decrease in losses in electric networks amounted to 8.4%. 
Since 2012, information on electricity consumption in the field of trade has appeared in statistical reports, since 2017 - in the field of information and communication. In 2005, 53% of the total electricity in the country was spent on mining, 11.6% of the electric energy was spent on the use of urban and rural population, and 8.8%. In the field of transportation and storage, in agriculture - 1.8%, in construction - 1%, in other types of economic activity - 11.9%. Loss of electricity in power grids amounted to 12%. The main objective is to reduce electricity losses in the power grid, to prevent unauthorized consumption.

In figure 1, we consider the structure of electric energy consumption by economic sectors in Russia in 2018.

![Figure 1](image.png)

Figure 1. Electricity consumption structure by sectors of the economy of the Russian Federation in 2018[17].

From the data presented in figure 1, it follows that in 2018, 53% of electricity was consumed for mining, 14.4% for urban and rural use, 8.1% in transportation and storage, and in agriculture 1.7%, in construction - 1.1%, in the field of information and communications - 0.6%, in other types of economic activity - 9%. Electricity losses in electric networks account for 9.3%. The main objective of improving the development of the energy industry is to reduce electricity losses in the electricity grid.

Information about the gross domestic product we can see at the table 1.

| Table 1. Gross Domestic Product Production (at current prices; billion rubles) [17]. |
|------------------------------------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| Indicators                              | 2005 y.       | 2010 y.       | 2015 y.       | 2016 y.       | 2017 y.       | 2018 y.       | 2018 y. in %  |
|                                        |               |               |               |               |               |               | to 2005 y.    |
| Major release                          | 37021         | 82055         | 145956        | 153857        | 166329        | 185534        | 501.2         |
| prices                                 | 18503         | 42015         | 71329         | 76381         | 83174         | 92735         | 501.2         |
| Intermediate                           | 18518         | 40040         | 74627         | 77475         | 83156         | 92800         | 501.1         |
| consumption                            | 3092          | 6269          | 8467          | 8539          | 8946          | 11076         | 358.2         |
| Gross value added at basic prices      | 21610         | 46309         | 83094         | 86014         | 92101         | 103876        | 480.7         |

From the data of table 1 it follows that the volume of gross domestic product in the country for the period from 2005 to 2018 increased by 4.8 times. The size of net taxes on products increased by 3.6 times.

The largest share in the structure of the gross domestic product of the Russian Federation is held by manufacturing (25-26%), wholesale and retail trade (12-14%), mining (7-10%), transport and communications (7.6-8 %), construction (6.8-7.7%), operations with real estate (6%), state administration and military security; social insurance (5.7-6%), production and distribution of
electricity, gas and water (4.5-5.8%), agriculture and fisheries (3.5-3.9%), financial activities (2, 8-3%), healthcare and the provision of social services (2.5%), education (2%), the provision of other utilities, social and personal services (1.6%), hotels and restaurants (0.3%).

The electric labour capacity of workers in industrial enterprises increased by 8.2%, including in manufacturing - by 16.5%. The reduction in the electric labour capacity of workers in industrial organizations is noted in the field of mining, in providing electric energy, gas, steam, air conditioning - by 5.3%. Considering the structure of electricity production by regions of the Russian Federation, it should be noted that in 2005 the largest share of electricity was generated by the Central Federal District - 22%, Siberian - 21%, Volga - 19.7%, Ural - 15.8%, North-Western - 10%, Southern - 7.3%, Far Eastern - 4.3%. Considering the structure of electricity consumption by regions of the Russian Federation, it should be noted that in 2005 the largest share of electricity was consumed by the Central Federal District - 20.3%, Siberian - 21.6%, Volga - 19.1%, Ural - 16.4 %, North-West - 10.5%, South - 7.8%, Far East - 4.2%.

The share of electricity consumption in the federal districts in 2018 was distributed as follows: the Central Federal District produced - 20.5%, Siberian - 19%, Volga - 18.4%, Ural - 17%, North-Western - 10.3%, Southwestern - 6.6%, Far East - 5.9%, North Caucasus - 2.3%.

Consider the information on the production and consumption of electricity by federal districts of the Russian Federation in table 2.

| Indicators / Federal Districts | Produced | Consumed | Excess consumption over production, % | Excess consumption over production, % |
|-------------------------------|----------|----------|--------------------------------------|--------------------------------------|
| Russian Federation            | 953.1    | 940.7    | 98,7                                 | 1115.1                               |
| Central                       | 209.8    | 191.2    | 91,1                                 | 222.9                               |
| North-western                 | 95.0     | 98.6     | 103,8                                | 25.1                                 |
| Southern                      | 70.0     | 73.0     | 104,3                                | 80.3                                 |
| Volga                         | 187.5    | 180.0    | 96,0                                 | 192.7                                |
| Ural                          | 150.2    | 153.8    | 102,4                                | 197.5                                |
| Siberian                      | 200.0    | 203.0    | 101,5                                | 202.4                                |
| Far Eastern                   | 40.6     | 39.8     | 98,2                                 | 67.0                                 |

The volumes of electricity production in Russia in 2005 exceeded the volumes of consumption by 1.3%, in 2018 - by 0.6%. If in 2005 the volume of electricity production in the Central Federal District was 8.9% higher than the volume of consumption, then by 2018 the volume of consumption began to exceed the volume of production by 1.9%. In the Volga Federal District, production volumes in 2005 were 4% higher than consumption volumes, then by 2018, consumption volumes began to exceed electricity consumption volumes and began to exceed production volumes by 5.9%. In the Urals Federal District, in 2005 the volume of electricity consumption exceeded production by 2.4%, and by 2018 the situation changed and the volume of electricity production began to exceed consumption by 4.5%.

The largest share of electricity consumption by urban and rural population in 2018 is noted in the Central Federal District - 25.7%, Volga Federal District - 17.7%, Siberian - 15.5%, South - 10.2%, North-Western - 11.2%, the Far East - 8.3%, the Urals - 7.9%, the North Caucasus - 4.6%.
The largest consumption of fuel and energy resources is accounted for by mining (63-70%), the production and distribution of energy, gas and water (28-30%), manufacturing (28-29%), transport and communications (21-22%), other activities (8%), construction (2.2-3.7%), agriculture (3-3.5%).

Figure 2. Production and use of electricity (billion kilowatt-hour) [17].

Electricity production in the country increased by 1.1%, including thermal hydroelectric power plants - by 12%, nuclear power plants - by 72%. Electricity production by thermal power plants decreased by 11.8%.

Volumes of electricity generated increased by more than 1.1%, electricity consumption increased by 1.4%. The volumes of electricity received from outside the Russian Federation (import) decreased by more than 80%, the volumes of electricity supplied outside the borders of the country (export) decreased by 73%.

4. Conclusion
In the structure of electric energy consumption by federal districts, four districts own 75% of consumption: Central - 20.5%, Siberian - 19%, Volga - 18.4%, Ural - 17%.

In the structure of consumption of fuel and energy resources in 2018, the largest share belongs to mining - 53.3%; domestic use of electric energy by urban and rural population - 14.4%; transportation and storage - 8.1%, real estate transactions - 3%, agriculture - 1.7%, construction - 1.1%, information and communications - 0.6%, other types of economic activity - 9%.

Total 53% of electric energy is consumed for mining, this sector of the economy brings the country 25-26% gross domestic product. 1.7% of electric energy is spent on agriculture, agriculture brings 3.5% of gross domestic product. 1.1% of electric energy is spent on construction, the contribution of the construction industry to gross domestic product is 6.8-7.7%.

Thus, a reduction in the number of labor resources entails a reduction in energy consumption, as well as a reduction in employment and a reduction in household incomes, and inhibits the growth of gross domestic product. Hypothetically, gross domestic product growth could be even greater.

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