

Forecast of electricity consumption in Yakutia – Strategizing Horizon 2032

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Abstract. The paper presents the results of strategizing the development of the electric power industry on the territory of the Republic of Sakha (Yakutia) in accordance with the scenarios of the development of the fuel and energy complex until 2032. The purpose of the research was to build electricity balances of the Yakutia for a long-term period taking into account the level of uncertainty. Scenarios for the development of the electric power industry have been developed using modeling methods considering the existing programs and schemes for the development of the electric power industry of the Yakutia. The assessment of the required capacity and electricity by 2032 was carried out on the basis of an assessment of the volume of prospective electricity consumption in accordance with the updated forecast of socio-economic development of the Yakutia until 2032. When forecasting individual indicators at the municipal level, disaggregation was carried out, considering the location of electric power facilities. The electricity balances in the forecast model are used to reflect the prospective consumption volumes and possible (potential) volumes of electricity production (generation) at the “available” capacity. In the proposed scenarios of electricity consumption and production, it can be noted that there is no tendency to reduce the electrical capacity of the domestic, regional product. The obtained research results can be used in regional economic management systems.

1 Introduction

Currently, the sustainability of the organization and spatial development of regional socio-economic systems largely depends on the competitiveness of these subjects of a market economy. According to R.I. Shniper, the competitiveness of a region is determined by its economic and territorial position, the level of development of transport infrastructure, the availability of natural and labor resources, scientific and technical potential, the balance of the credit and financial system, production capabilities, market potential, environmental situation, etc. [1, 2, 3]. In general, there are many conditions, but natural and labor resources are key, including ensuring the actual operation of other factors. Energy systems are of no small importance for ensuring the sustainable organization of regional socio-economic systems. This paper presents some results of the research devoted to the specifics of the

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strategizing of the fuel and energy industries of the Yakutia on different forecasting horizons, under different conditions and scenarios of socio-economic development of the region.

The purpose of the research is to build forecasts for the development of the Yakutia electric power industry for the period up to 2032, taking into account a moderate and strategic scenario for the development of the regional economy. In order to achieve the purpose of the research, the following objectives were set:

- Analysis of the current state, problems, and potential opportunities of the electric power industry;
- Monitoring the implementation of the forecast indicators of the current energy strategy until 2030 and discussing the results of the implementation of planned activities;
- Development of a forecast of electricity demand, taking into account the main directions and scenarios of socio-economic development of the republic;
- Development of proposals for mechanisms for the implementation of the main provisions of the electric power strategy;
- Determination of the essential circumstances that will affect the energy sector of the republic.

The research was conducted on the basis of the information base formed during the development of the Yakutia energy strategy and reporting documents of ministries, departments, FECs, as well as state statistics data [1; 11; 12; 13; 14]. A comparative analysis was carried out, including with respect to forecasts of the development of the fuel and energy sector of the republic, developed for different conditions (the base year 2008 and 2018) and on different forecasting horizons (22 years and 14 years, respectively, base year):

- Energy Strategy from 2008 to 2030 (development 2008–2009) [1; 11];
- Energy Strategy from 2018 to 2032 (correction 2020).

It should be noted that the accuracy of forecasts is affected by multiple conditions and factors. This research uses methods of econometric modeling and analysis of socio-economic phenomena. Methodological approaches are based on the following principles, including:

- Optimal horizon of strategic forecasting;
- Optimal strategy methodology;
- Aggregation or disaggregation;
- Optimal degree of aggregation;
- Level of risks, etc.

Often, miscalculations in assessing the prospects for socio-economic development lead to ambiguous results in the actual implementation of strategic plans. Uncertainty significantly affects the accuracy of forecasting, which causes a wide range of limitations (including paradoxical ones):

- Global uncertainty “on the one hand” and modern information society “on the other hand”;
- “Inside” and reliable information, quantity and quality of information;
- Growth of awareness and information resource “on the one hand” – the growth of uncertainty in management systems “on the other hand”;
- Multiplicity of approaches and expert methods with insufficient reliable data – foresight, cognitive technologies, cognitive modeling, “artificial intelligence,” etc.;
- Trade secrets, confidentiality, personal data processing “on the one hand” – target mix-marketing, PR, audit-IT, databases, big data “on the other hand”;
- Personnel hunger “on the ground,” labor resource transfer “on the one hand” – low-performance discipline “on the other hand,” etc.

In this regard, special attention should be paid to assessing the level of uncertainty when developing strategic planning documents, given that the level of uncertainty increases with an increase in the forecasting horizon.

2 Forecast of the GRP of the Yakutia

In particular, it should be noted that the energy strategy of the Yakutia from 2008 to 2030 was developed in accordance with the 2020 Scheme. Within the framework of the 2020 Scheme, it was supposed to implement some large “megaprojects” on the territory of the Yakutia, including in the processing industry [10]. Very ambitious plans included, among other things, the creation of metallurgical and gas chemical production and were based on a high level of economic growth in the region. The average annual rate is 106.4%–107% in the period from 2008 to 2030, according to the strategic scenario presented in Fig. 1.

Thus, the total growth of the gross regional product [GRP] of the Yakutia in the period from 2008 to 2030 should have been at least 392% (“in 2008 prices”) [11]. Very high indicators of economic growth had to be ensured by the introduction of new generating capacities in the electric power industry. Among other things, it was planned to create the South Yakut hydroelectric complex, commissioning of new capacities in Central and Western Yakutia. A possible local shortage of electricity was supposed to be compensated by power flows between energy districts within the framework of the unified electric power system of the republic.

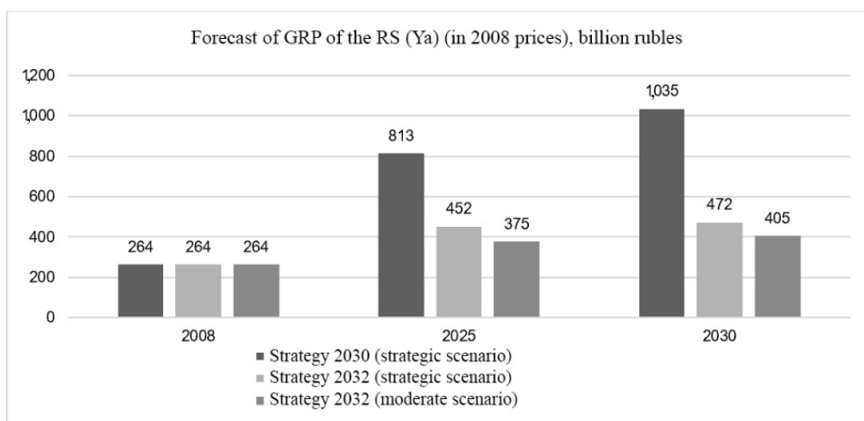


Fig. 1. Forecast of the GRP of the Yakutia (comparative analysis). Source: Calculated by the authors.

However, the implementation of the strategy for the development of the electric power industry of the Yakutia in the period from 2008 to 2018 was significantly influenced by objective (mainly macroeconomic and geopolitical) factors and conditions. They, in conditions of global uncertainty with a high level of subjectively positive sentiment, were not taken into account as risks in strategizing: consequences of the global economic crisis (2007–2008); crisis of 2014–2015 related to the fall in prices on the oil market; slowdown in the pace of economic growth in Russia.

As an alternative option in 2020, a relatively moderate forecast of the socio-economic development of the Yakutia – consequently, a moderate, close one to inertial rates of development of the FEC of the republic – was considered.

The moderate development forecast is based on the assumption that GRP growth rates in the period up to 2032 will not exceed 103% per year, including based on trends that have developed since 2008. While maintaining this rate of economic growth, the updated forecast of socio-economic development assumes a total GRP growth in the period from 2008 to 2032 at the level of 177%–180% (“in 2008 prices”) (Fig. 1).

The planned volume of electricity consumption under the predicted scenarios (moderate, strategic) of the socio-economic development of the republic (including the Arctic zone) is shown in Fig. 2.

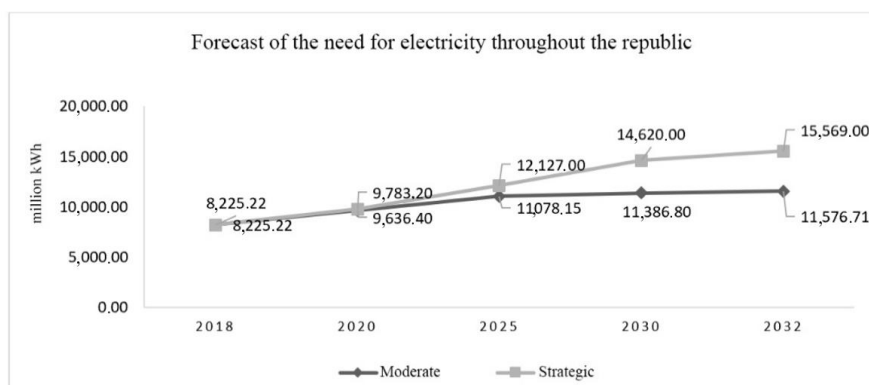


Fig. 2. The forecast of electricity demand, million kWh. Source: Compiled by the authors.

Structural shifts in the economy of the Yakutia weigh down the share of the extractive industry. The production of it is significantly more electricity-intensive. In the strategic scenario, the main increase in electricity consumption is assumed by mining, where large-scale programs for the extraction of gas, oil, coal, and polymetals are implemented. In this area under the strategic scenario, electricity consumption increases by 57%, increasing its share in the total demand for the period under review from 31.5% to 46.7%. Table 1 illustrates the structure of electricity consumption by type of economic activity.

Table 1. The structure of electricity consumption by the main consumer groups.

| Indicators | Strategic scenario, % (2018 baseline) | | | | |
|---|---------------------------------------|------|------|------|------|
| | 2018 | 2020 | 2025 | 2030 | 2032 |
| Electricity consumption by type of economic activity: | 62.8 | 63.7 | 68.8 | 69.8 | 71.1 |
| Agriculture, fishing | 0.4 | 0.4 | 0.3 | 0.2 | 0.2 |
| Extraction of fuel minerals | 31.5 | 34.0 | 42.6 | 45.1 | 46.7 |
| Manufacturing industries | 2.4 | 2.3 | 1.9 | 2.5 | 2.4 |
| Construction | 1.0 | 0.7 | 0.9 | 0.9 | 0.9 |
| Transport and communications | 16.9 | 16.3 | 14.7 | 13.7 | 13.8 |
| Other non-productive activities | 10.6 | 10.0 | 8.4 | 7.3 | 7.0 |
| Population | 10.8 | 10.2 | 8.5 | 7.4 | 7.1 |
| Losses | 12.0 | 12.5 | 11.1 | 12.1 | 12.1 |
| Own needs | 6.0 | 5.7 | 5.2 | 5.7 | 4.8 |
| Consumption in the production of heat | 8.5 | 7.8 | 6.3 | 4.9 | 4.9 |
| TOTAL consumption | 100 | 100 | 100 | 100 | 100 |

Source: Compiled by the authors.

In accordance with the moderate scenario of economic development, electricity consumption in the republic may increase by 41% by 2032 (compared to the base 2018) and amount to 11,577 million kWh. Under the implementation of the strategic scenario, electricity consumption in 2032 will increase by 89% and reach the level of 15,569 million kWh.

In order to implement the methodology of strategic planning, the paper presents an aggregated assessment of the volume of supply and demand in the republican (regional) electricity market. The enlarged forecast balances of electric power capacity for various scenarios of economic development are presented in Table 2.

Table 2. The balance of electricity capacity for various scenarios of the development of the Yakutia economy.

| Indicators | | 2018 | 2020 | 2025 | 2030 | 2032 |
|-----------------------------------|---|----------|----------|----------|----------|----------|
| Capacity (moderate scenario), MW | Demand for capacity | 1,604.64 | 1,770.84 | 1,992.32 | 2,028.07 | 2,061.12 |
| | Installed capacity at the end of the year | 3,210.14 | 2,863.85 | 3,025.72 | 3,328.22 | 3,328.22 |
| | Available power | 3,014.64 | 2,671.16 | 2,910.53 | 3,213.03 | 3,213.03 |
| | Excess (+)/Deficit (-) | 1,409.99 | 900.32 | 918.21 | 1,184.96 | 1,151.90 |
| Capacity (strategic scenario), MW | Demand for capacity | 1,604.59 | 1,956.79 | 2,340.30 | 2,747.78 | 2,929.59 |
| | Installed capacity at the end of the year | 3,210.14 | 2,855.43 | 3,017.30 | 3,876.80 | 3,876.80 |
| | Available power | 3,014.64 | 2,671.16 | 2,910.53 | 3,770.03 | 3,770.03 |
| | Excess (+)/Deficit (-) | 1,410.05 | 714.37 | 570.23 | 1,022.25 | 840.43 |
| | Demand for capacity | 1,604.59 | 1,956.79 | 2,340.30 | 2,747.78 | 2,929.59 |

Source: Compiled by the authors.

In general, the economy of the republic is projected to have a deficit-free electricity consumption for the entire period of strategizing until 2032, in accordance with both development scenarios (Table 3). At the same time, the implementation of the strategic scenario may require the commissioning of a significant amount of new generating capacities on the territory of the Western and Southern energy districts of the energy system of the republic.

Table 3. The balance of electricity for various scenarios of the development of the economy of the Yakutia.

| Indicators | Conditions | 2018 | 2020 | 2025 | 2030 | 2032 |
|---|-----------------|----------|-----------|-----------|-----------|-----------|
| Electricity (moderate scenario), million kWh | | | | | | |
| Requirement of | mid-season year | 8,225.22 | 9,636.40 | 11,078.15 | 11,386.80 | 11,576.71 |
| Production of electric energy | | 9,868.29 | 11,498.24 | 12,584.06 | 14,237.06 | 14,237.06 |
| Excess (+)/Deficit (-) | | 2,526.07 | 1,861.84 | 1,505.91 | 2,850.26 | 2,660.35 |
| Requirement of | low-water year | 8,225.22 | 9,636.40 | 11,078.15 | 11,386.80 | 11,576.71 |
| Production of electric energy | | 9,868.29 | 11,159.24 | 12,245.06 | 13,823.40 | 13,823.40 |
| Excess (+)/Deficit (-) | | 2,526.07 | 1,522.84 | 1,166.91 | 2,436.60 | 2,246.68 |
| Electricity (strategic scenario), million kWh | | | | | | |
| Requirement of | mid-season year | 8,224.94 | 9,783.20 | 12,127.00 | 14,620.00 | 15,569.00 |
| Production of electric | | 9,868.29 | 11,404.90 | 12,505.13 | 17,510.29 | 17,510.29 |

| | | | | | | |
|------------------------|-------------------|----------|-----------|-----------|-----------|-----------|
| Excess (+)/Deficit (-) | | 2,526.35 | 1,621.70 | 378.13 | 2,890.29 | 1,941.29 |
| Requirement of | low-water year | 8,224.94 | 9,783.20 | 12,127.00 | 14,620.00 | 15,569.00 |
| Production of electric | | 9,868.29 | 11,270.81 | 12,371.03 | 17,366.50 | 17,366.50 |
| Excess (+)/Deficit (-) | | 2,526.35 | 1,487.61 | 244.03 | 2,746.50 | 1,797.50 |

Source: Compiled by the authors.

The forecast of the development of the electric power industry on the territory of the Yakutia is based, among other things, on the following basic assumptions:

- Volume of generating capacity on the forecast horizon does not change significantly in the direction of decrease (it remains at the level of “not less than the base”).
- In order to meet the electricity demand, additional capacities can be put into operation, including new capacities at the operated electric generation facilities (a new thermal power plant in the Southern Energy District, a new power unit at the Neryungrinskaya State District power plant, a new thermal power plant in the Western Energy District, a new power unit at the Svetlinskaya hydroelectric power plant).
- The amount of power generated by using renewable energy sources is negligible.
- Deficits arising in individual energy districts can be provided by flows within the unified energy system of the republic.
- The prospective economic specialization of the Yakutia is mining (the Strategy of Spatial Development of the Russian Federation until 2025). In this regard, and also taking into account the prevailing macroeconomic conditions, the “export” of electricity outside the republic is not predicted with the possibility of minor flows.

Also, the analysis of the balance situation revealed a decrease in the capacity of energy sources in the decentralized electricity supply sector during 2019: Scheme and Program for the Development of the Electric Power Industry of the Republic of Sakha (Yakutia) for 2020–2024 [SPD] [13]. This indicator characterizes, among other things, the features of the modern system of statistical accounting and reporting applied to enterprises using electric generating capacities for their own production needs. A significant part of enterprises that do not sell electricity is not covered by the statistical reporting system. This makes it difficult to analyze such decentralized capacity on the territory of the republic. However, to ensure compliance of the forecast model used in the research with the main provisions of the SPD, it is advisable to consider the electric generating capacities used for the own production needs of enterprises in the volumes presented in the SPD. Due to the fact that the official documents do not reflect the ownership of these capacities to a particular energy district, these capacities are taken into account in the consolidated balance sheet as a whole for the republic.

In mining industries, there may also be factors that worsen and complicate production, which also lead to an increase in electrical capacity. In the economy of Yakutia, all these trends will operate, however, in different spheres of activity in different ways. An increase in the scale of electricity consumption means an increase in its distribution, and hence losses in the networks. However, at the same time, an increase in the use of energy for the own needs of electricity and heat producers is not expected.

The growth of the population and housing stock, together with an increase in the comfort of people’s living conditions, will increase the absolute amount of electricity released to the population, but the share of this group in total consumption will decrease slightly.

3 Discussion

The peculiarities of the development of the FEC and, in particular, the electric power industry in the Yakutia are studied quite systematically. The research results are presented in some scientific papers by N. A. Petrov, I. D. Elyakova, V. R. Kiushkina, P. A. Marinychev, N. S. Volotkovskaya, and others [3, 11–15; 6; 7].

Other researchers suggest applying technologies for converting the DG of the northern regions to gas fuel. It will increase the efficiency of the power plant by reducing the amount of expensive diesel fuel and reducing the cost of electricity generated. All the scenarios under consideration are aimed at reducing economically justified electricity tariffs and reducing subsidies for local generation facilities [15].

The research also shows that the quality of sectoral and intersectoral strategic planning is affected by a high degree of uncertainty in modern management systems, both at the national level and the level of the region, industry, enterprise. Modern energy is developing to a large extent in accordance with the conjuncture in the resource markets, in accordance with the market behavior of large mining and energy generating companies.

It should also be noted that there are significant differences in the forecasting horizons – 22 years in the Strategy 2008–2030 and 14 years in the Strategy 2018–2032. Modern conditions call into question the expediency of goal setting with an accuracy of “up to a year” for a period of more than 15 years. Beyond the planning horizon of 15 years (three five-year plans or more), the modern economy makes it possible to form a so-called “target vision” of long-term prospects based on “very basic” initial trends. Also, among the main macroeconomic factors influencing the development and implementation of strategic planning documents at the federal and regional levels, including the development of the energy strategy of the Yakutia until 2032, there may be:

- Instability of the oil and financial markets;
- Cyclical (structural) crisis in the global economy;
- Reduction of global GDP growth to 2.3% in 2019 (3% in 2018);
- Inversion of the US yield curve in 2019;
- Decline in business activity indices in developed countries;
- Uncertainty with COVID-19.

4 Conclusion

This paper presents a comparative analysis of the results of strategic planning for the development of the FEC of the Yakutia, conducted in 2008–2009 [1; 11] and 2020. Among other things, two different approaches to setting goals and objectives of strategizing were analyzed.

In the first case (Strategy 2008–2030) [1; 11], the developers set very ambitious goals based, among other things, on very positive macroeconomic forecasts. However, it is possible without serious consideration of geopolitical risks, risks of post-crisis “compression” of the world economy, etc. At the same time, the methodology of strategizing in 2008 was not properly supported by legislation since the modern regulatory framework governing strategic planning in Russia stands on the platform of the Federal Law On Strategic Planning in the Russian Federation, which was adopted in 2014.

In the second case (Strategy 2018–2032), the development of the main provisions of a possible energy strategy of the Yakutia until 2032 and scenarios for the development of the electric power industry are mainly due to the moderate pace of socio-economic development of the republic. The novelty of the research is the presentation of a forecast assessment of the long-term demand for electricity in various variants of the socio-economic development of the Yakutia, taking into account the forecast assessment of the implementation of large

industrial investment projects. At the same time, the methodology of strategizing uses the main provisions of the legislation regulating strategic planning, as well as the provisions of newly developed strategic planning documents at the federal and regional levels.

When developing the forecast of electricity consumption, the following important circumstances are taken into account, among other things, which will significantly affect the energy sector of the republic:

- Within the framework of the target vision of the development of the electric power industry of the Yakutia, the electric power complex of the republic is being investigated as a promising nodal element of the Unified National Energy System [UNES] of Russia in the Far East according to the scheme: “Eastern Siberia (Irkutsk power system) – Yakutia – Far East (Magadan power system).”

- The development of the UNES and the wholesale electricity and capacity market [WECM] calls into question the effective functioning of enterprises producing and selling electricity in technologically and geographically isolated power systems, including in the Arctic zone of the Republic.

- One of the alternative mechanisms for the development of energy systems in the Arctic zone may be a state policy aimed at combining electricity and heat energy using a single infrastructure, logistics, technologies, unified management systems, including financing and subsidies.

- In modern conditions, one of the challenges affecting the regional energy system may be the uncontrolled process of development of “split” energy. Modern technologies allow economic entities of various levels and sizes to generate electricity “for their own needs” with costs that ensure a sufficient level of efficiency of such production. In the perspective of the target vision, this process can lead to a significant change in the market situation on the regional energy market, to the “erosion” of the regulated tariff, etc. It is advisable to develop preventive mechanisms and tools for state regulation of the development of “split” energy.

The obtained research results can be used in regional economic management systems to study the organization and development of the FEC, fuel and energy infrastructure facilities, pricing features, and state regulation of the economy.

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