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Assessment of the Impact of Electric Power Production on the Economic Growth of Kazakhstan

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ABSTRACT

This scientific research is devoted to the analysis of the impact of the development of the energy industry on economic growth in Kazakhstan. The work assesses the economic development of the country using the example of a comparative analysis of the state of the GDP level from 2011 to 2023. Particular emphasis is placed on increasing industrial production of finished goods. It stands out here that to ensure economic growth, the rapid pace of development of the domestic energy sector is not enough. The study emphasizes that electricity generation mainly comes from thermal power plants using coal. There is a high level of equipment depreciation and wear and tear, which leads to significant harmful emissions, delivery losses and a decline in electricity generation. Some attention is paid to intensifying the construction of renewable energy sources. Here, an economic and mathematical model was built and forecasting was implemented in order to determine the factors affecting the growth of electricity generation in Kazakhstan. To solve energy shortage issues and achieve economic growth, an investment mechanism is proposed using the example of PPP infrastructure energy projects. In order to enhance the influx of investment in the reconstruction and construction of new Kazakh energy facilities, mutually beneficial cooperation between the state and business within the framework of PPP approaches is justified. Key problems are identified and measures for economic growth and stimulation of development of the energy complex are proposed. It is recommended to intensify investments in the construction of nuclear power plants, new renewable energy facilities and innovative power plants.

Keywords: Economic Growth, GDP, Electric Power Industry, Power Plants, Renewable Energy Sources, Electricity Generation
JEL Classifications: C22, D2, D24, L16, O4

1. INTRODUCTION

In February 2024, the World Bank presented the "Kazakhstan Economic Development Report." The report emphasizes that according to forecasts in 2024. The pace of economic development of our republic will slow down at 3.4% (World Bank, 2024). According to the World Bank, real GDP will increase to 4.5-5% in 2025. The reasons for this growth will be: increased production and oil exports. In addition, stable rates of investment inflow into industrial production will continue.

Let us note that the OPEC organization expects an increase in global oil demand by 4.7 million barrels per day in 2023 and 2024. And already in 2045, this demand will increase to 116 million barrels per day (Haitham Al Ghais, 2024). According to our estimates, this increase in oil demand is caused by an improvement in the economic situation in many countries around the world, a slight reduction in interest rates and a decline in inflation. Despite certain global tensions and trade wars, especially high demand should be expected from China, the countries of the Middle East, and India.

GDP value in 2021, 2022 and 2023 in Kazakhstan was equal to 197.11, 221.23 and 261.418 US dollars, respectively (Sularu, 2023). In other words, over the 3 years under review, GDP is increasing by 25%. Results 2023 demonstrate economic growth of the Republic of Kazakhstan (RK) by 5.1% (Bureau of National Statistics Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, 2024). For example, an increase occurred in the following sectors: construction, trade, mechanical engineering, communications. The decline was in - agriculture, mining.

However, according to the results of 2023, the deficit of the “consolidated budget” and “current account” remains at the level of 1.8% and 3.3% of total GDP, respectively. In our opinion, this is due to increased funding for social programs and a decrease in oil production and exports. It should be noted here that, according to agreements with OPEC+, Kazakhstan has a certain oil production quota. In addition, there are some interruptions in the transportation of oil and gas, for example, in the Caspian Pipeline Consortium (CPC). In addition, traditionally there remains a high demand for imported goods: equipment, medicines, food, etc.

It should be noted that in the structure of Kazakhstan’s exports, for many years in a row, there has been a high concentration of energy carriers, for example, oil. Significant price volatility and, considering the reduction in oil production according to the OPEC+ recommendation, budget revenues have decreased.

Of particular concern is the pace of development of the energy sector, which ensures the activities of the entire real sector of the economy.

In the Republic of Kazakhstan in 2022, the country’s electricity generation was at the level of 112865.9 million kWh, 2021. - 114447.9 million kWh, and in 2020-108085.8 million kWh. Electricity consumption was equal in 2022 - 112944.6 million kWh, in 2021 - 113890.3 million kWh and in 2020 - 107344.8 million kWh. The shortage of electricity is mainly covered by imports from Russia (Adilet, 2023).

Digitalization of the Kazakh electricity industry is proceeding at a rather slow and limited pace due to a lack of investment funds. At the same time, it is worth noting that automated systems for power regulation, monitoring and control (WAMS/WACS), commercial metering, data collection (SCADA/EMS), individual elements of “Smart Grid,” etc. are gradually being introduced.

Halkos and Aslanidis (2023) argue that all states face electricity generation problems. Access to electricity determines the level of social well-being of the population both within rural areas and in large cities. State regulation of the energy complex, the level of wear and tear, reasonable prices for electricity, and the use of renewable energy sources are important here to achieve the sustainability of the country’s economy.

One of the serious problems in the electricity sector of Kazakhstan is the high wear and tear of energy equipment, which is over 50%. This wear and tear of equipment leads to downtime, accidents and instability of power supply to cities and towns across the country. Today, at least 37 domestic thermal power plants (CHPs) must undergo modernization and reconstruction (Independent Newspaper, 2023).

2. LITERATURE REVIEW

Rahman et al. (2023) in their study highlight the importance of government energy policy using the example of economic development of South Asian countries. The authors conducted regression econometric modeling using a production function. The model’s findings demonstrate a high correlation between the impact of country spending, capital levels, electricity consumption and finance on the growth of 4 South Asian countries. According to Pata et al. (2024), there is a direct relationship between energy consumption, RES sources, CO_2 emissions and economic development. The econometric assessment was carried out using the example of the US economy according to the method of analyzing cause-and-effect relationships and the Fourier function. Other conclusions of the study (Nibedita and Irfan, 2024) are based on the fact that there is a cointegration relationship between GDP, energy security, renewable energy sources, innovation, energy efficiency, and globalization. The work uses panel data from the “economies of the E7 states”: Russia, China, Indonesia, India, Brazil, Mexico and Turkey from 1995 to 2018. Here, factors are identified that reveal the level of diversification of the energy balance in the long and short term.

Wang et al. (2024), using indicators from 10 key energy consuming states in the world (2001-2020), implemented an energy efficiency assessment using the “SBM-UN” methodology. According to the modeling results, the main factors influencing the maintenance of energy efficiency are: Growth of GDP and capital costs, the volume of investments and the structure of electricity consumption. Zhong et al. (2019) studied electricity consumption, labor force employment, and economic growth using China as a case study. Here, the autoregressive lag (ARDL) testing method was used at the 1971–2009 level. A direct cause-and-effect relationship was found between the above three indicators in the short and long term. The findings prove that energy is a key source of economic growth. The scientific work of Jamil (2022) aims to test the relationship between energy consumption and economic growth in 3 countries: India, China and Pakistan from 1971 to 2021. The results of the study characterize a unidirectional cause-and-effect relationship at the level of economic development and energy consumption. In other words, the energy sector appears to be an important factor influencing the economic growth rates of the three countries.

Halkos and Tsirivis (2023) carried out an analysis of variables in 31 countries to determine the significance of public policy implementation using the influence of renewable energy facilities, GDP per capita, accumulated capital on the level of CO_2 emissions in the electricity sector from 1995 to 2018. The article by Hieu and Mai (2023) addresses research issues on the relationship between economic development and the consumption of traditional and non-traditional energy. They selected data from 80 developing countries from 1990 to 2020 using the long-term quantile regression (MMQR) technique. A positive relationship between GDP and energy consumption was revealed. At the same time, the authors recommended strengthening government support for investments, introducing subsidies and tax breaks in order to stimulate the sector and development of renewable energy sources. In 2024, a study was presented that substantiated the assumption of a close relationship based on the "ecological Kuznets curve" on the impact on economic growth of such variables: renewable energy consumption, the degree of urbanization and the level of financial development (Nuţă et al., 2024). The observation period was 1995-2019 using the practical example of developing countries in Eurasia. A certain relationship between the level of natural resources, trade liberalization, institutional variables and investment inflows appears to be the most positive according to Huang and He (2023). These experts substantiated that natural resources in each specific country can be an incentive or obstacle to the development of economic growth.

In their work, Fahim et al. (2023) emphasizes the uninterrupted operation of energy supplies for the stability of development of the entire national economy. Harmful emissions are forcing many countries to pay attention to renewable energy. In particular, ASEAN states should organize solar energy development to decarbonize the region's energy sector. Information technology and innovation (Salahuddin et al., 2016) stimulate the development of the energy sector and the construction of new energy facilities using alternative sources. Judson et al. (2022) emphasize in their research that competent organization of digital energy infrastructure has a beneficial effect on reducing harmful emissions and improves the social condition of the population. The effectiveness of energy management directly depends on the introduction of innovations, high-quality engineering personnel and the development of energy infrastructure. Currently, it is necessary to strengthen the implementation of energy monitoring and modernization of energy technologies and equipment. Information systems used in energy production appear to be successful investment projects in the energy sector, according to Yu et al. (2022).

Government spending should be increased (Smagulova et al., 2022) to modernize the energy sector. Smagulova et al. (2023) propose using measures to increase the digitalization of energy saving and energy efficiency, primarily in the manufacturing sector. This will allow more energy to be stored and transferred to increase economic diversification. The economic growth of the state directly depends on electricity generation and government management. At the same time, scientists Boni et al. (2023) place significant emphasis on the sustainability of environmental regulation and the harmfulness of polluting CO_2 emissions. The article states that the slowdown in economic growth is dictated by the weak level of government regulation in the energy sector. In order to determine what factors, affect economic growth, economic and mathematical modeling was carried out (Hlongwane et al., 2023). Statistical results revealed that in the long term, electricity production significantly affects the output of goods in SADC countries.

One of the methods for assessing the efficiency of using state-owned objects is the index method. This method shows the influence of specific factors on a particular process depending on the sector of the economy under consideration (Chereyeva et al., 2023).

Over the past three decades, economists have become increasingly interested in applying PPP approaches. This mechanism is, according to Gupta and Sharma (2023), used throughout the world to finance infrastructure development in all sectors of the economy. Considering that the PPP model is becoming increasingly popular today, Kukah et al. (2022) examined the motivations for public and private companies to participate in energy projects. For the public sector, the study found that the main drivers were achieving better value for money, access to additional capital, improved service efficiency and an improved ability to deliver updated energy infrastructure. And for private sector enterprises, the process of participation in the PPP model includes: receiving investment support, improving their international image, making a profit and sharing risks with the public sector. Kaminsky (2022) carried out research on the organization of PPP projects for renewable energy and the functioning of the corresponding infrastructure. Her findings highlighted the challenges and investment success factors inherent in the PPP model.

In order to identify some of the success factors and barriers in PPP projects in the field of renewable energy, Othman and Khallaf (2022) implemented a questionnaire survey among 60 experts. Here the respondents were representatives of the private, public and academic spheres. The following conclusions were obtained: The results showed that almost all states are working to attract private sector capital to these projects. In addition, their further research in this area (Othman and Khallaf, 2023) demonstrated that the main obstacles to PPPs in renewable energy appear to be political, organizational and regulatory barriers. At the same time, it was found that, unlike the public sector, the private sector detects and assesses risks more effectively. Others have noted (Pinilla-De La Cruz et al., 2022) that there is a need for ongoing debate on the adequacy of PPP approaches to address energy issues in a sustainable development environment.

3. ASSESSMENT OF THE DEVELOPMENT OF ECONOMIC GROWTH IN KAZAKHSTAN

In 2023, Kazakhstan's GDP increased by approximately 17% than in 2022 (Bureau of National Statistics Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, 2024).

Based on the data in Table 1, a significant drop in GDP in 2016 can be traced. We believe this was influenced by the introduction of a floating exchange rate system in the second half of 2015.

The decline in GDP from 35 to 16% should be explained by the presence of Covid, fairly high inflation, global volatility and uncertainty (2020-2022). Essential for maintaining economic development in 2021-2023. is the sale of foreign currency from the National Fund of the RK. This measure was necessary to support sectors of the national economy and aggregate demand in connection with the pandemic and post-Covid consequences in the republic. The introduction of anti-Russian sanctions played a certain positive role for the national economy. In this regard, some companies moved from Russia and strengthened their presence against the backdrop of a favorable market for raw materials and tax benefits for investors in Kazakhstan. For example, the following enterprises came to the country: "PepsiCo" and "Pfizer" (USA), "Rehau" (Germany), etc. Thus, the analysis of industries where there has been an increase, in our opinion, is associated with the influx of foreign, private and public investment.

It is worth noting that over the past 10 years there has been an increase in trade between the states of Central Asia in the amount of 11 billion US dollars (an increase of 2.5 times) (Kapital, 2024). Including the share of the Republic of Kazakhstan in trade here is approximately 5.5 billion US dollars.

However, in Kazakhstan, there is a moderate growth in the production of services, rather than goods, at an accelerating pace.

Table 1: Dynamics of economic growth in the Republic of Kazakhstan

S. No	Years	GDP value, bill. US dollars	Change by 2023, %
1.	2023	261.42	-
2.	2022	220.62	16.4
3.	2021	197.11	24.6
4.	2020	171.08	34.6
5.	2019	181.67	30.5
6.	2018	179.34	31.4
7.	2017	166.81	46.2
8.	2016	137.28	90.43
9.	2015	184.39	29.5
10.	2014	221.42	15.3
11.	2013	236.63	9.5
12.	2012	208.00	20.4
13.	2011	192.63	26.3

Source: Bureau of National Statistics Agency for Strategic Planning and Reforms of the RK (Bureau of National Statistics Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, 2024)

To ensure the growth of production of goods, it is necessary, including the supply of electricity. Here it must be pointed out that for stable GDP growth a rapid supply of electricity is required. However, in Kazakhstan, the pace of production and the level of electricity supply is falling. Let's consider the indicator of the "GDP volume index by production method" in Kazakhstan from 2010 to 2023 (Table 2). From the data in Table 2 one can see that the main sectors of the real sector of the economy are declining. It shows that the production of goods during the period noted decreased by 20%. At the same time, the supply of electricity also drops by 28%. From this we can conclude that the rate of decline in electricity supply is higher than the rate of decline in the production of goods as a share of GDP.

4. ANALYSIS OF THE ENERGY COMPLEX OF KAZAKHSTAN

Kazakhstan Electricity Grid Operating Company (KEGOC JSC) is the main operator of the general energy system of Kazakhstan. KEGOC contributes to the organization of innovative energy infrastructure and stimulates the sustainability of the electric power industry for the clean energy transformation. The authors of Cai and Menegaki (2019) determined that the amount of clean energy consumption directly affects the growth of economic development of the state. Here, based on an empirical analysis of 21 OECD countries, it was found that energy policy formulation needs to be improved. Let us highlight that about 55% of all electricity is consumed in industrial sectors. Approximately 30% is consumed by the population and approximately 15% by the oil and gas sector (Caravan.kz, 2024). By mid-2023 in Kazakhstan, under the management of KEGOC, there are 387 overhead power lines (length is 26,977.215) and 82 power stations (total voltage 35-1150 kV) (Kazakhstan Electricity Grid Operating Company, 2023). In general, the total electricity generation in Kazakhstan is realized by 207 power plants, which are commercial and state owned. The total capacity of the noted power plants in 2023, according to KEGOC, is 24,523.7 MW (Kazakhstan Electricity Grid Operating Company, 2023). Into the Law "On Electric Power Industry" from mid-2023. such changes have been accepted (Adilet, 2023). Thus, total electricity is now sold to a single purchaser from power plants. In the republic, all energy enterprises are classified by type of production as

Table 2: Structure of GDP by the production method

Classifier of types of economic activities	Years in % to the total volume of GDP													
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Production of goods	45.1	42.0	40.5	38.3	37.6	35.5	36.6	36.9	37.9	37.4	38.6	40.4	40.0	36.3
Agriculture, forestry ang fishing	4.5	4.9	4.2	4.5	4.4	4.8	4.6	4.6	4.4	4.4	5.4	5.1	5.2	4.3
Industry	32.9	30.7	30.1	27,8	27.3	24.7	26.1	26.8	28.2	27.5	27.1	29.6	29.5	26.4
Mining and quarrying	19.5	17.7	17.1	15.2	15.2	12.7	12.9	13.6	14.9	14.5	12.2	14.1	14.5	12.6
Manufacturing	11.3	11.0	11.0	10.7	10.2	10.1	11.3	11.2	11.4	11.4	13.1	13.6	13.4	12.3
Electricity, gas, steam and air conditioning supply	1.8	1.7	1.7	1.6	1.6	1.7	1.7	1.7	1.6	1.4	1.6	1.6	1.4	1.3
Water supply; sewerage, waste management and remediation activities	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.3	0.3	0.2	0.2	0.3	0.2	0.2
Construction	7.7	6.4	6.2	6.0	5.9	6.0	5.9	5.5	5.3	5.5	6.1	5.7	5.3	5.6
Production of services	51.7	49.1	51.5	53.1	54.8	59.4	57.8	57.2	55.5	55.6	56.0	53.8	52.9	56.0

Source: Bureau of National Statistics Agency for Strategic Planning and Reforms of the RK. Bureau of National Statistics Agency for Strategic Planning and Reforms of the Republic of Kazakhstan (2024)

Table 3: Initial data

Years	EP production, million kW.	Consumption (Mtoe)	emissions (MtCO2)	population, thousand people	The number of state- owned enterprises of the EE industry, units.	Consumption of EE by the housing sector, thousand tons of topl	Consumption of EE by the state and comm. org., thousand tons of topl.	Energy intensity in GDP, tons per thousand US dollars	Export of EE, million kWh	The interest rate of the National Bank, %	Infla- tion, %
	Y	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10
2010	82646,5	69	217	16321,9	143	1145,9	986,2	1.82	1756,6	7,0	7,97
2011	78701,6	77	232	16577,2	141	1101,8	932,9	1.8	1808,7	7,5	7,43
2012	83566,6	74	234	16792,1	130	1029,3	869,3	1.59	2932,7	5,5	6,06
2013	87631,0	82	251	17035,6	123	984,3	753,6	1.5	2996,5	5,5	4,9
2014	86936,3	65	203	17288,3	122	999,9	728,7	0.36	2917,1	12,0	7,54
2015	92170,6	55	176	17542,8	117	1035,8	702,6	0.27	3964,1	15,0	13,53
2016	99864,2	64	191	17794,1	107	1049,4	587,8	0.34	4772,3	13,0	8,29
2017	103128,0	65	204	18037,8	100	1461,4	671,3	0.34	5692,4	10,2	7,22
2018	107268,8	74	205	18276,5	95	1522,8	703,5	0.37	5041,6	9,75	5,43
2019	106483,2	73	195	18513,7	95	1331,0	690,0	0.35	2418,8	9,25	5,43
2020	108628,0	66	202	18755,7	95	1226,0	659,0	0.32	2323,5	9,0	6,37
2021	115079,2	70	214	19001,0	98	1189,0	631,0	0.32	2662,5	10,25	8,4
2022	112866,0	71	221	19635,0	119	1127,0	698,0	0.32	1838,4	16,0	17,7

Years	Number of employees in the EE, thousand people.	Investments in EE, billions of US dollars	Depreciation of fixed assets in the EE, %
	X1 1	X1 2	X13
2010	21,4	2.3	35,0
2011	28,2	2.4	34,0
2012	32,0	2.8	34,2
2013	26,0	2.9	37,5
2014	41,8	3.1	30,6
2015	37,2	2.9	31,2
2016	37,6	1.4	30,1
2017	31,2	1.7	32,4
2018	29,1	1.6	35,4
2019	28,8	2.4	75,4
2020	27,6	1.8	73,0
2021	29,0	1.8	71,7
2022	22,4	1.7	72,0

Source: Bureau of National Statistics Agency for Strategic Planning and Reforms of the RK (Agency for Strategic planning and reforms of the Republic of Kazakhstan, 2023) follows: TPPs (thermal power plants)-87%; CES (condensing power plants)-49%; CHP (combined heat and power plants)-36%; HPPs (hydroelectric power plants)-12% and GTPPs (gas turbine power plants)-2.3% (Factories.kz, 2022). The largest thermal power plants that produce and sell electricity to all consumers of Kazakhstan on the wholesale market include Ekibastuz State District Power Plant-1 and State District Power Plant LLP, Zhambyl State District Power Plant JSC, Eurasian Group, State District Power Plant LLP Kazakhs' Corporation, "Karaganda Energy Center" and others.

CHP plants are classified as industrial power plants, where there is a combined generation of electrical and thermal energy for large enterprises and neighboring cities. This can include: CHPP-2 of Arcelor Mittal Temirtau JSC, CHPP-3 of Karaganda-Zhylu LLP; Balkhash CHPP, Pavlodar CHPP-1 of Aluminum of Kazakhstan JSC, Shymkent CHPP-1,2 (Yuzhpolimetal JSC), etc.

The largest hydroelectric power plants include such energy enterprises as: Aksuskaya, Ust-Kamenogorskaya, Bukhtarminskaya, Shulbinskaya, JSC Kazzinc, etc.

The largest power plant is GRES-1 Ekibastuz. It includes 8 large power units with a production capacity of 500 MW each. Another large hydroelectric power station is Aksu State District Power Plant, which generates about 16% of electricity from the total republican volume.

For example, in the 1st quarter of 2023, electricity production was 31 billion kWh. This is 0.9% higher than for the same period in 2022. And total electricity consumption for the 1st quarter of 2023 reached 30.9 billion kWh (an increase of 1.4% over the same period in 2022). Energy transmission companies include: KEGOC JSC, MAEK Kazatomprom (Mangistau Nuclear Power Plant), AlmatyEnergoSbyt LLP; Samruk Energy JSC, Aktobe CHPP JSC, AlES JSC (Almaty Electric Stations), AstanaEnergoSbyt LLP, Atyrau Zharyk JSC and others.

A serious problem with the mentioned energy enterprises for transporting electricity to consumers seems to be that they were built 35-40 years ago. Modernization and reconstruction are taking place here at a slow pace, which indicates a significant degree of wear and tear of 70% and above. Therefore, there are serious indicators of loss of electricity delivery of 20% and above, and harmful emissions into the atmosphere are also increasing. Thus, using the example of China, Du et al. (2020) determined that large companies that invest in the development of innovations in the energy sector emit less harmful substances into the atmosphere. The authors propose a methodology for establishing quotas for emissions of harmful gases between different enterprises. As a result of this technique, CO_2 emissions are significantly reduced and the environmental situation of the state is improved.

Approximately more than 5-6 years ago, Kazakhstan was a net exporter of electricity. However, in recent years there has been a significant shortage of electricity. There is a shortage of electricity in the republic, which leads to its shortage, especially in the industrial sector.

In particular, in January 2023, the electricity shortage was observed in the amount of 4.2 million kWh, in February-23.3 million kWh. And in 2022, a shortage of electricity was observed for 8 months, especially in the evening. If you look at the region, then in Southern Kazakhstan the deficit has been observed for more than 12 months. Therefore, it is necessary to cover the need of the Southern zone through redistribution from different regions of the republic. In addition, in parallel there is a process of reducing reserves of production capacity.

Let us highlight that the total electricity consumption in 2023 was approximately 115.06 billion kWh. This means that there was an increase of 1.9% compared to 2022. However, electricity production did not change and was equal to 112.82 billion kWh, i.e. almost in production mode by 2022. Consequently, the deficit will already be in 2023. With a decrease in electricity generation occurred at the level of 1,519 MW. According to KEGOC JSC estimates, the overall balance of electric power will be with a significant deficit by 2030: approximately up to 6.2 GW. Let us note that the energy deficit in the country is covered by purchasing electricity from neighboring regions of Russia, but at a higher cost than in our country. This demonstrates that this industry is directly dependent on Russia. Consequently, it can be stated that there are certain threats to Kazakhstan's energy independence.

Research results from Zhou (2023) prove the need to attract investment in energy innovation and renewable energy sources. In addition, there is an important emphasis on the use of energy conservation and carbon neutrality strategies due to energy shortages. Therefore, alternative sources seem to be an important factor in the growth of electricity generation. The active development of renewable energy sources (RES) in Kazakhstan began in 2013. This process of organizing RES was caused by the transition to decarbonization and a decrease in the use of coal. For the 1st quarter of 2024 in the republic, 144 stations operate at the level of renewable energy sources (RES), with a total electrical capacity of 2.8 GW. Including 16 new RES facilities built and put into operation in 2023, with a capacity of approximately 495.6 MW. In 2022 12 units of renewable energy enterprises were commissioned with a total capacity of 385 MW. In 2023 there were a total of 133 renewable energy facilities operating in the country with a capacity of 2527 MW (Table 6).

Based on the results of 2023, electricity generation by RES facilities is equal to about 5.9% of the total electricity production in Kazakhstan.

In the country, the selection of RES investment projects began to take place on the basis of an auction mechanism in 2018. This made it possible, firstly, to focus on the most efficient and rational technologies. Secondly, implement a transparent process for selecting potential investors. Thirdly, optimize the tariff policy for consumers from the commissioning of renewable energy sources.

According to Bórawski et al. (2023), in order to reduce harmful emissions and fuel price uncertainty, emphasis should be placed on the efficiency of energy policy management. Despite the fact that European countries (for example, Poland) use coal as fuel to produce electricity, it is necessary to switch to alternative energy sources. The authors built an autoregressive model (GARCH) and mathematically substantiated the forecast for continued growth in coal prices until 2025. A serious disadvantage of domestic energy companies is the presence of a significant share of coal-fired non-maneuverable power plants. Currently, their number in Kazakhstan represents more than 70%. For example, similar coal power plants in the United States account for 27%, in the European Union - 20%, in Russia-17%.

Currently, the republic is heavily dependent on coal, where more than 70% of production capacity runs on coal. This also demonstrates a certain shortage of maneuverable generating capacities, such as gas turbine and hydroelectric power plants. All this persistently characterizes and suggests a serious influx of investment in decarbonization.

It should be noted that the cost of Kazakh electricity remains one of the cheapest in the world. For example, according to GlobalPetrolPrices.com, the cost of electricity in Kazakhstan for households is $0.048 per 1 kWh. And for the "business" sector - $0.064 per 1 kWh. (data for March 2023).

5. DATA AND METHODOLOGY

The work will carry out regression-correlation analysis, which will make it possible to assess the closeness of the relationship when conducting econometric modeling (Dursun, 2022).

Multiple regression analysis consists of establishing the relationship between independent and dependent variables, i.e. predictor variables and criterion variable (Dougherty, 2011). Multiple regression analysis allows you to introduce additional variables so that the constructed equation reflects the values of several, rather than just one, predictor variables. The purpose of introducing additional variables is to improve our predictions of the criterion variable.

For the multiple linear regression model, the study used the following equation:

Y=a_1*X_1 + a_2*X_2+a_3*X_3 ……. a_n*X_n+b (1)

Where *a, n* are the coefficients, *Xn* are the variables and *b* - is the bias estimate.

In order to test and analyze the data to determine the best mathematical model, the ordinary least squares (RSS) method was used:

$$RSS = \Sigma(yi–\hat{y}i) \quad (2)$$

Where, Σ is the total sum, *yi* is the actual response value for the *i*-th observation, *ŷi* is the predicted response value for the regression model. In economic and mathematical modeling, the exponential smoothing method was used to carry out time series forecasting. In addition, to analyze the quality level of the model, the properties of the retro forecast were assessed. In order to carry out correlation and regression analysis, the "Gretl" program was used. This program "Gretl" is a statistical software package for implementing econometric estimation. This program makes it possible to carry out calculations and mathematical modeling of statistical data with minimal time.

The general statistical base for modeling was taken from the official websites: Agency for Strategic planning and reforms of the RK, Kazakhstan Electricity Grid Operating Company, Kazakhstan Center for Public-Private Partnership.

6. MODEL RESULTS

In order to determine which factors, have the greatest impact on electricity production in Kazakhstan, econometric modeling was implemented. The following hypotheses were put forward in the course of the study:

Hypothesis 1: the growth of electricity production is positively influenced by an increase in the population.

Hypothesis 2: Investments do not have a significant impact on the growth of electricity production.

Hypothesis 3: the growth of electricity production is negatively affected by the increase in wear and tear of power equipment and technologies.

The indicators were selected considering their expected impact on the output of the electric power industry (Table 3). It should be noted that this industry provides for the activities of all sectors of the national economy of Kazakhstan. The "Gretl" application program was used to implement multiple analysis. The proposed program is quite convenient for data testing and econometric research. Based on the determination of the dependence between the variables (*X1-X13*), a correlation analysis was performed (Table 4). The regression assessment will make it possible to identify certain factors that have an impact on electricity production.

Based on these factors, a model is being built for the dependent variable (*Y*). Here we will demonstrate the gradual elimination of factors that do not affect (*Y*). The results of the correlation analysis can be shown using the correlation coefficient. The results of the correlation analysis showed that there is a direct relationship between Y and factors *X3* (r = 0.9631), *X12* (r = 0.7045) and *X13* (r = 0.7195).

At the same time, there is an inverse relationship between *Y* and factors *X4* (r = −0.8521), *X6* (r = −0.7811) and *X7* (r = −0.7915). According to statistics, there are fewer state-owned enterprises (*X4*) in the country than private companies producing electricity. Therefore, state-owned enterprises generate less electricity and have little impact on energy production. In our opinion, the inverse relationship between *Y* and electricity consumption by government and commercial organizations (*X6*) may be related to the slow pace of economic development in Kazakhstan. In addition, some rates of decline in consumption can be attributed to the pandemic and the post-pandemic crisis. There is also the presence of global inflation, the increased price of energy and the increased cost of a kilowatt of electricity.

Currently, we believe that the low energy intensity of GDP (*X7*) is due to the fact that the volume of energy and fuel consumption to GDP is decreasing due to uncertainty, volatility and low economic development of the state. In this model, only those factors that have a direct impact on increasing electricity generation were selected. Accordingly, these factors directly affect the economic growth of the state.

Let's analyze the dependent variable *Y(X3)* to build model 1. Here the results are presented in Table 5.

The regression coefficient is $R^2 = 0.927$, which means there is a close relationship. In other words, population growth of 92.7% affects the volume of electricity production. Next, we will check the model in order to objectively evaluate the coefficients of the regression model (Table 7). In order to determine the adequacy of the constructed model, it is necessary to test for heteroscedasticity, normal distribution of residues and autocorrelation.

To determine the significance of the regression model, the White test and the Breusch-Godfrey test were performed, which showed the absence of heteroscedasticity and autocorrelation.

Next, we will conduct a test for the normal distribution of residues (*N*), the results of which confirm the reliability of the model. The test result characterizes the normal distribution of residues (Table 8).

The null hypothesis is the normal distribution (*N*): Chi-squared (2) = 1.024, P-value 0.59924. Now let's consider the normal distribution of the residuals of the resulting regression model (Figure 1). The normality of the distribution of a number of residues means the uniformity of the variances of observation. A normal distribution is a collection of objects in which the extreme values of a certain feature-the smallest and largest-rarely appear. Based on the calculations performed, it can be concluded that the residues are distributed according to the normal law. In this Figure 1: On the abscissa axis is the dependent variable *Y*: uhat 1, and on the ordinate axis is the density of the distribution. The histogram has the appearance of a "bell" with a significant amount of values located closer to the center. At the same time, fewer values are on the tails of the "bell." So, according to Figure 1, a test for the normal distribution of residues (*N*) of the presented model was obtained. Based on the visual analysis of the histogram, it can be concluded that the condition of normality of the distribution of residues is fulfilled.

Note that the test for heteroscedasticity is performed using the "White test". The presence of heteroscedasticity of random errors leads to ineffective estimates. In addition, in this case, the classical estimation of the covariance matrix of "OLS" parameter estimates turns out to be biased and untenable. Consequently, statistical conclusions about the quality of the estimates obtained may be inadequate. In this regard, testing models for heteroscedasticity is one of the necessary procedures for building regression models. Only in the absence of heteroscedasticity can we talk about the significance of the constructed model.

To evaluate the autocorrelation of the model, we will check using the "Breusch-Godfrey test" (Table 9). The peculiarity of this test is that it can be used almost always, and it allows you to check

Table 4: The correlation matrix

Indi-cators	Y	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13
Y	1													
x1	−0.1599	1												
x2	−0.3680	0.8555	1											
x3	0,9631	−0.1564	−0.3213	1										
x4	−0,8521	0.2172	0.5115	−0.7571	1									
x5	0.5545	0.0358	−0.2724	0.4178	−0.6331	1								
x6	−0,7811	0.3750	0.5256	−0.7557	0.8582	−0.2444	1							
x7	−0,7915	0.5771	0.7383	−0.7941	0.8237	−0.3731	0.8983	1						
x8	0.2078	−0.3439	−0.4189	0.0723	−0.4918	0.4459	−0.5070	−0.4418	1					
x9	0.4725	−0.6766	−0.6568	0.5733	−0.2851	−0.0176	−0.5732	−0.7476	0.2143	1				
x10	0.2416	−0.4352	−0.2335	0.3998	0.1567	−0.2483	−0.1368	−0.3022	−0.1741	0.7999	1			
x11	−0.1644	−0.5539	−0.5260	−0.1476	−0.1584	−0.2522	−0.3819	−0.4033	0.4863	0.3413	−0.0780	1		
x12	−0,7045	0.0792	0.2299	−0.6008	0.5400	−0.5899	0.4589	0.4179	−0.3252	−0.2836	−0.1277	0.2827	1	
x13	0,7195	0.1283	−0.0405	0.7709	−0.4837	0.2192	−0.3580	−0.3806	−0.4802	0.1512	0.1921	−0.4528	−0.3214	1

Table 5: Model 1: Analysis of the dependent variable Y (X3)

Indicators	Ratio	SE	t-statistics	P-value
const	−116763	18069,4	−6,4619	<0,0001
x^3	12,0174	1,01289	11,8644	<0,0001
Mean of dependent variable	97305,41		Standard deviation of dependent variable	12541,32
Balance amount	1,37e+08		Standard error of the model	3526,546
R-square	0,927519		Corrected R^2	0,920930
F (1, 11)	140,7639		P-value (F)	1,31e-07
Log-likelihood	−123,5453		The Akaike Criterion	251,0906
Schwartz Criteria	252,2205		The Hennan-Quinn criterion	250,8584
The rho parameter	0,011314		Stat. Darbin-Watson	1,613044

the autocorrelation of any order. The first-order autocorrelation test was performed in the model. The absence of autocorrelation of residues ensures the consistency and effectiveness of estimates of regression coefficients.

As a result of the conducted testing, it was revealed that the constructed regression model lacks heteroscedasticity and autocorrelation. Here the errors are distributed according to the normal law.

This resulting regression model best demonstrates the relationship of the variable (*X3*) affecting the value (*Y*). As shown by the regression analysis, the constructed model will look like this:

$$Y=12{,}0174X3–116763 \quad (3)$$

As a result of the calculations, the multiple regression equation was obtained. We believe that an economic interpretation of the model parameters is possible: an increase in *X3* by 1 unit of changes leads to an increase in *Y* by an average of 116763 units. The statistical significance of the equation was verified using the coefficient of determination and the Fisher criterion. It was found that in the studied situation, 92.7% of the total variability of *Y* is explained by a change in factors *X3*. We also determined that the model parameters are statistically significant. The regression model is adequate, and it can be used in forecasting. The test for the distribution of the residuals of the regression model *Y(X3)* showed that the errors are distributed according to the normal law.

Table 6: Types of renewable energy facilities in Kazakhstan, 2023

S. No	Types of renewable energy sources	Number of RES, units	Power, MW
1.	Hydroelectric power plants	39	269,605
2.	Solar power plants	43	1148,0
3.	Wind power plants	48	1107,5
4.	Biogas power plants	3	1,77

Source: News Central Asia

Table 7: White test for heteroscedasticity

Indicators	Ratio	SE	t-statistics	P-value
const	1,94159e+09	8,34965e+08	2,325	0.0424
x^3	−220819	93464,4	−2,363	0.0398
sq_x^3	6,29212	2,60976	2,411	0.0366
Incorrected R-square=0,472030				
Test statistics: TR^2=6,136391				
P-value=P (Chi-squared (2) > 6,136391) = 0,046505				

Null hypothesis: no heteroscedasticity

Table 8: Frequency distribution for the model

Interval	Middle	Frequency	Relation (%)	Intensity (%)
<−4991.6	−6332.7	1	7.69	7.69
−4991.6 −2309.5	−3650.6	2	15.38	23.08
−2309.5 −372.64	−968.43	4	30.77	53.85
372.64 −3054.8	1713.7	2	15.38	69.23
≥3054.8	4395.8	4	30.77	100.0

Table 9: The "Breusch-Godfrey test" for first-order autocorrelation

Indicators	Ratio	SE	t-statistics	P-value
const	298,233	20896,5	0,01427	0,9889
x^3	−0,0171344	1,17661	−0,01456	0,9887
uhat_1	0,0143385	0,423396	0,03387	0,9737
Incorrected R-square=0.000115				
Test statistics: LMF=0.00114687				
p-value=P (F (1, 10) > 0.00114687) = 0.973651				

Null hypothesis: There is no autocorrelation

The following is a graph of the observed and calculated values of *Y*, which is shown in Figure 2. Based on the results of the retro forecast, it will be possible to make a forecast using a regression model with a 95% probability.

The confidence interval for the *X3* value is (9.78802; 14.2467). For the purpose of making a forecast, let's imagine that the annual population growth (*X3)* is 2%. Then in 2023 the population will be: 20027.7 thousand people, 2024-20428.25 thousand people, 2025-20836.82 thousand people, 2026-21253.56 thousand people, 2027-21678.63 thousand people. The results of the change in the volume of electricity production under these conditions are shown in Figure 3.

The predicted values and the confidence interval of the *Y* value are presented in Table 10.

Thus, with a constant population growth of 2% annually (2023-2027), electricity production will increase to 143757.7 million kWh in 2027.

It should be noted that there is an inverse relationship between the production of electricity and the volume of investments in the industry. This may be typical when there is a decrease in capital inflows into this industry. Investments in fixed assets imply the costs of new construction, expansion, as well as reconstruction and modernization of fixed energy assets. However, so far not enough investments are attracted in our country, so there is a slight increase in energy production. In particular, additional costs are reflected in the price of a kilowatt of electricity, and lead to their growth. It also takes some time until the investments made will bring direct growth in electricity generation. At the same time, an increase in the price of electricity, as a result, may lead to some temporary decrease in demand. This suggests the presence of an inverse and possibly close ($r \leq -0.7$) relationship between the studied parameters. Next, we will analyze the variable *Y(X12)* to build the following model 2 (Table 11). The observations of 2010-2022 (*T = 13*) were used in the construction of the model.

Here we got such a regression coefficient equal to $R^2 = 0.496$. At the same time, there is an average relationship, a change in the volume of investments. That is, attracting investments affects the volume of electricity production by 49.6%. Appropriate tests were conducted to determine the significance of the regression model (Table 12). They demonstrated the absence of autocorrelation and heteroscedasticity. Dependent variable model: uhat 2.

Figure 1: Distribution of model residuals (uhat 1)

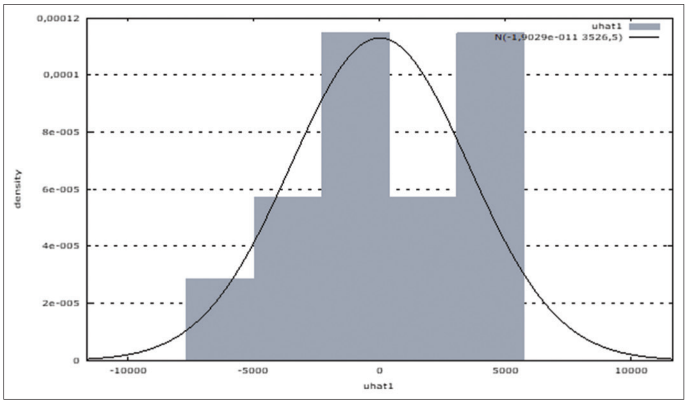


Figure 2: Retro forecast *Y(X3)*

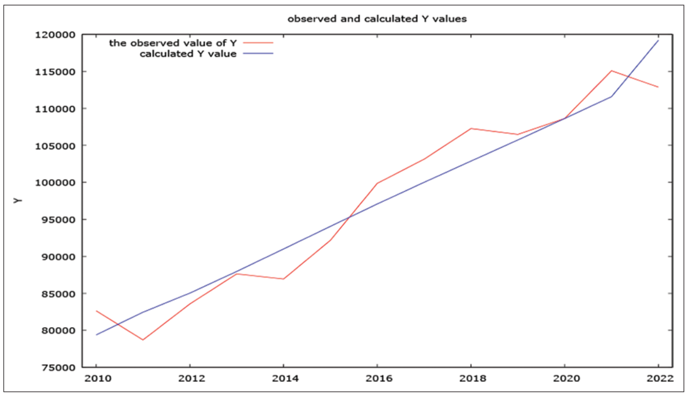
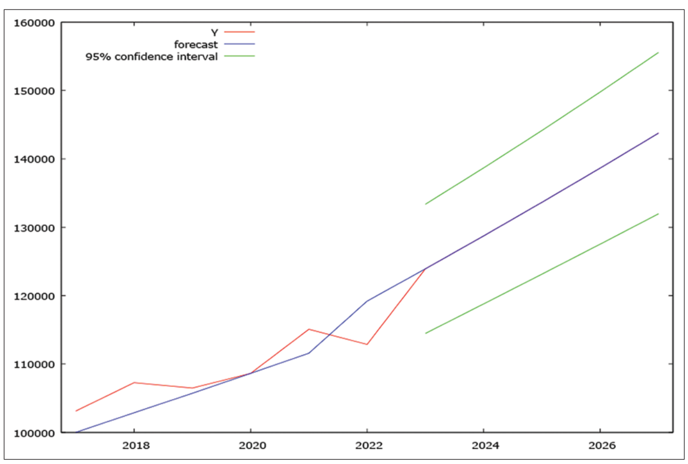


Figure 3: Forecast values of *Y*, 2023-2027



The "Breusch-Godfrey test" demonstrated the effectiveness of estimating regression coefficients (Table 13).

A model was built based on the regression estimate. This model shows the average relationship between electricity generation (*Y*) and investment inflow (*X12*). The equation of the model is presented as follows:

Y=130970-15195.8X12 (4)

Here is the economic interpretation of the model: a decrease in *X12* by 1 unit of changes leads to a slight increase in *Y* by an average of *130970* units. That is, it confirms that the lack of investment has a negative impact on the rate of energy production.

Table 10: Forecast of electricity production volume considering population growth: *Y (X3)*

Years	Y	Forecast	SE	95% confidence interval
2023	123917,9	123917,8	4292,37	114470,4-133365,3
2024	128731,5	128731,4	4517,65	118788,1-138674,6
2025	133641,4	133641,3	4772,08	123138,0-144144,6
2026	138649,5	138649,4	5053,36	127527,1-149771,8
2027	143757,7	143757,7	5359,3	131961,9-155553,5

Next, a test was performed on the distribution of the residuals of the *Y(X12)* model. It can be seen here that, in general, the errors are distributed according to the normal law. Therefore, we present the values of the observed and calculated values of *Y* (Figure 4).

The resulting retro forecast suggests that the investment growth rate is very low. Here, certain residual values are observed for the *Y* value. In general, in our opinion, subsequently, as the rate of invested investment costs of power plants will increase, the volume of electricity production will also increase. At the same time, obviously, the price per kilowatt of energy will be positively adjusted. According to forecasts, this will lead to the creation of a market balance between supply and demand for electricity. Now let's build the latest Model 3 (Table 14) for the dependent variable *Y(X 13)*.

For model 3, we obtained a regression coefficient equal to R^2 = 0.517. It can be seen that there is an average relationship here. It can be said that a 51.7% change in wear affects the low rates of electricity production.

In order to determine the significance of the resulting model 3, the "White and Breusch-Godfrey tests" were implemented. So, the "White test" showed the absence of heteroscedasticity (Table 15).

The "Breusch-Godfrey test" demonstrated the absence of autocorrelation and heteroscedasticity (Table 16).

Considering the regression analysis, model 3 is constructed. This model characterizes the average relationship between electricity production (*Y*) and capital depreciation (*X13*). Here is the form of the resulting equation:

Y=75852.4+470.7X13 (5)

One can interpret the model as follows: an increase in *X13* by 1 unit leads to a slight increase in *Y* by an average of 75,852.4 units. We emphasize that the deterioration of technologies and power engineering negatively affects the rate of electricity production.

Then we did a test for the distribution of the residuals of the model *Y(X13)*. It is shown that the errors are distributed according to the normal law. The following is a graphical analysis of the observed and calculated *Y* values (Figure 5).

The constructed retro forecast shows that the rate of depreciation of fixed assets in the industry is very high. The graph shows

Table 11: Model 2: Estimation of the variable *Y (X12)*

Indicators	Ratio	SE	t-statistics	P-value
const	130970	10544,9	12,42	8,16e-08
X12	−15195,8	4615,39	−3,292	0,0072
Mean of dependent variable	97305,41		Standard Deviation of Dependent Variable	12541,32
Balance amount	9,51e+08		Standard error of the model	9296,227
R-square	0,496339		Corrected R^2	0.450552
F (1, 11)	10,84009		P-value (F)	0.007174
Log-likelihood	−136,1461		The Akaike Criterion	276,2922
Schwartz Criteria	277,4221		The Hennan-Quinn criterion	276,0599
The rho parameter	0,542151		Stat. Darbin-Watson	0.732864

Table 12: "White test" for heteroscedasticity

Indicators	Ratio	SE	t-statistics	P-value
const	−9,22374e+08	4,11763e+08	−2,240	0.0490
X12	9,51909e+08	3,82956e+08	2,486	0.0322
sq_x12	−2,13285e+08	8,44227e+07	−2,526	0.0301
Incorrected R-square=0.394007				
Test statistics: TR2=0.394007				
P-value=P (Chi-squared (2) >5,122092) = 0.077224				

Null hypothesis: No heteroscedasticity

Table 13: The "Breusch-Godfrey test" for first-order autocorrelation

Indicators	Ratio	SE	t-statistics	P-value
const	−7703,74	9738,66	−0.7910	0.4473
X12	3649,18	4309,62	0.8468	0.4169
uhat_1	0,640179	0.291574	2.196	0.0528
Incorrected R-square=0.325265				
Test statistics: LMF=4,82062				
p-value=P (F (1, 10) >4,82062)=0.0528337				

Null hypothesis: there is no autocorrelation

Table 14: Model 3: Analysis of the dependent variable *Y (X13)*

Indicators	Ratio	SE	t-statistics	P-value
const	75852,4	6733,60	11,26	2.22e-07
X13	470,700	136,979	3,436	0,0056
Mean of dependent variable	97305,41	Standard Deviation of Dependent Variable		12541.32
Balance amount	9,10e+08	Standard error of the model		9096.800
R-square	0.517717	Corrected R^2		0.473873
F (1, 11)	11,80817	P-value (F)		0.005561
Log-likelihood	−135,8642	The Akaike Criterion		275.7283
Schwartz Criteria	276,8582	The Hennan-Quinn criterion		275.4961
The rho parameter	0.618771	Stat. Darbin-Watson		0.662056

Table 15: "White test" for heteroscedasticity

Indicators	Ratio	SE	t-statistics	P-value
const	−3,88976e+08	5,20520e+08	−0,7473	0,4721
X13	2,19918e+07	2,27836e+07	0,9652	0,3572
sq_x³	−224838	14824	−1,047	0,3199
Incorrected R-square=0.319385				
Test statistics: TR2=4,152009				
p-value=P (Chi-squared (2) > 4,152009) = 0.125430				

Null hypothesis: no heteroscedasticity

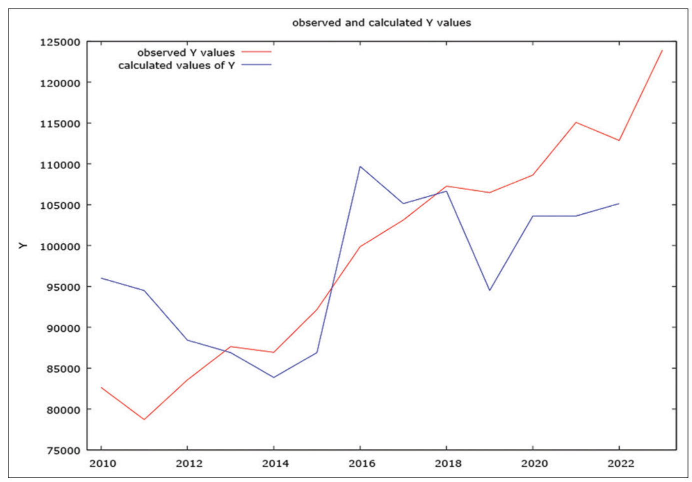
significant residual values for the *Y* value. In our opinion, with an increase in the annual rate of attracting budget and private

Table 16: "Breusch-Godfrey test"(dependent variable: uhat 1)

Indicators	Ratio	SE	t-statistics	P-value
const	4368,12	5636,36	0,7750	0,4563
X13	−92,2531	115,033	−0,8020	0,4412
uhat_1	0,680582	0,254679	2,672	0,0234
Incorrected R-square=0.416612				
Test statistics: LMF=7,14126				
p-value=P (F (1, 10) >7,14126)=0.0233995				

Null hypothesis: there is no autocorrelation

Figure 4: Retro forecast *Y(X12)*



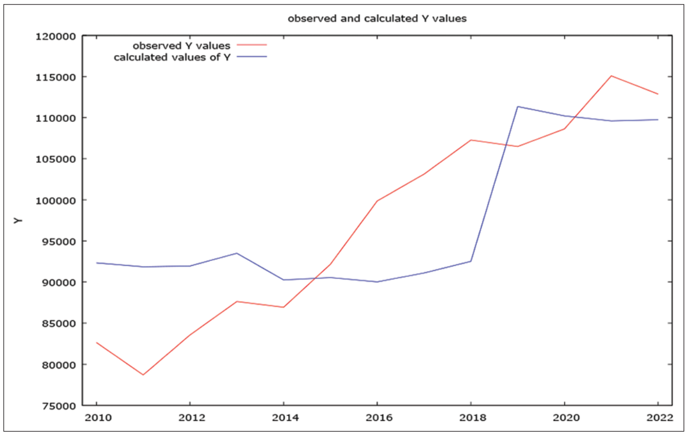
financing, it will be possible to increase innovations in the electric power industry. According to forecasts, the introduction of new technologies and the acquisition of an innovative fleet of machines will lead to the renewal of electrical equipment and significant modernization of energy facilities in Kazakhstan.

So, based on the obtained results of the model, we can draw the following *conclusions*.

Indeed, the increase in electricity production is most strongly influenced by the growth of the population index (*X3*) in Kazakhstan. In other words, the more the population increases, the more electricity is consumed. So, hypothesis 1 is confirmed.

According to statistics, the attraction of investments in the energy sector (*X12*) appears to be uneven. Over the 13 years under study, the volume of investments fell by almost *25%*. Accordingly, in order to stimulate the growth of electricity generation, it is necessary to significantly increase the inflow of investments. At

Figure 5: Retro forecast for model *Y(X13)*



the same time, special attention should be paid to the construction of new thermal power plants and alternative energy sources. It follows that hypothesis 2 of the model is confirmed.

Considering the initial modeling data, the depreciation rate of fixed assets (*X13*) increased by more than *2 time*s during the observation period. This indicates insufficient attraction of investments and financing, significant aging of electrical equipment and energy technologies. Therefore, hypothesis 3 is confirmed.

7. DISCUSSION

In our opinion, according to econometric forecasting data, the current dynamics of the forecast can be explained by the ongoing reform in Kazakhstan to reduce the share of state participation in the economy, which began in 2014. Private companies occupy the main share in the energy market. According to statistics, as of January 1, 2023, there were 1,871 companies operating in the energy industry, of which 6.4% of companies belong to the state. From which we can assume that the bulk of energy production comes from private companies.

At the same time, according to Ranking.kz, 68% of state district power plants and 55% of thermal power plants in the country have a service life of more than 30 years. And the critical level of equipment wears and tear at thermal power plants in Stepnogorsk, Uralsk, Taraz, and Kentau is over 80%.

That is, private energy companies invested practically little in upgrading electrical equipment and building new power units. They only took money for selling electricity, but made virtually no investments.

In addition, due to the fact that there is an absolute large availability of power equipment (albeit quite worn out at power stations), it is used more intensively. Here we are talking about the extensive use of available factors at energy enterprises. At the same time, the consumption of raw materials used (mainly coal) is also increasing. Therefore, there is still some increase in electricity production (*Y*). But the limit is coming and in the near future there are no more resources for increasing electricity production (*Y*). Therefore, there was such wear and tear on electrical equipment, power lines, energy technologies, etc. Improvement in the development of the infrastructure of the energy industry of the Republic of Kazakhstan will lead to a more efficient process of electricity production, increasing its volume. So, from 2019 to 2022. the amount of attracted investments in electricity production amounted to about 780.8 million US dollars.

Despite the fact that in the last 4-5 years the state has begun to invest more in the modernization and purchase of new electrical equipment and technologies, this is still not enough. In addition, the state began to allocate budgetary resources for the construction of new power plants.

In particular, based on the funds of the Programs “Lending to regions and cities of republican significance” and “Development of heat and power industry” in the period from 2020 to 2022. the state implemented 53 investment projects totaling 96.2 billion tenge.

However, the unattractiveness of investments and constant underfunding have led to a significant aging of domestic fixed assets in the energy industry. One of the serious problems in the energy sector appears to be ineffective management of energy transfer and conservation (Hossain et al., 2023). To solve this problem, it is proposed to use digital energy technologies for energy storage. It is worth highlighting that the use of innovative information technologies in the state’s economy is fully consistent with the provisions of the UN in the framework of achieving the Sustainable Development Goals (SDGs).

Due to the deterioration of power lines and power equipment, electricity losses during transportation range from 20 to 50%. This seems to be a fairly high indicator of losses in the republic’s economy.

At the same time, today there is no possibility of carrying out major innovations, repairs and reconstruction of capital assets in the energy industry. Here, the presence of high cost technologies and energy equipment leads to high costs. Plus, anti-Russian sanctions, global uncertainty and global inflation - all this together shows the establishment of high prices.

All these obstacles and threats, along with the ineffective and wasteful use of fuel and energy resources, demonstrate the unsustainable operation of the Kazakhstan energy system.

Hence, the following condition follows: In order to ensure uninterrupted energy supply and increase production energy capacity, the construction of new energy facilities and stations is required.

Foreign experience in the construction of power grids in Europe, Canada, the USA and other countries shows the need to use incentive tariff setting tools “RAB” (Regulated Asset Base). Here, the rate of return of the service is used, which includes the costs of purchasing energy equipment from the manufacturer and energy supplier.

We emphasize that in order to support the social strata of the population in Kazakhstan, the policy priority is to curb the growth of electricity tariffs. However, we believe that low tariffs do not encourage investors to invest in the electricity sector, because they become risky and unattractive.

To solve negative problems, in our opinion, tariffs for electricity consumption should be increased.

Following the Western example, using the RAB tariff setting mechanism, in Kazakhstan it will be possible to restore and modernize existing assets, as well as commission new state district power plants and thermal power plants. This is one of the effective and reliable sources of attracting investment in reducing the wear and tear of the generating capacities of the Kazakh energy sector.

We propose the use of PPP instruments in the electric power industry of Kazakhstan as another way out of the current difficult situation.

The results of econometric modeling showed that state-owned energy companies alone in the energy market cannot effectively influence the quality of energy infrastructure development. Let us point out that this is due to a lack of public investment only. It is necessary here to apply the conditions for the use of mixed capital of the state, business and foreign partners within the framework of the implementation of PPP instruments.

At the same time, using the PPP mechanism, based on the influx of budgetary and private foreign funds, it is obviously possible to increase the level of state and commercial energy enterprises using innovative energy technologies. In addition, investment projects based on PPP will be able to more intensively attract investments in the construction of new energy complexes.

In Kazakhstan, market conditions for the activities of energy enterprises: private, mixed and state-owned have begun to constantly improve. Most power plants do not fully meet the criteria of the Energy Monitoring Committee of the Ministry of Energy. For example, some energy companies have a high level of depreciation and technical wear and tear of equipment and power lines (power lines). This leads to increased costs for power plants to maintain worn-out equipment. Although these funds spent could be used to purchase new digital equipment for power plants. In this regard, we propose that some of the companies that do not have the funds to modernize and re-equip power plants be transferred to mixed management: business and the state on the principles of PPP.

Let us emphasize that in different parts of the world, the use of the PPP model and privatization took place with different results. In particular, in the CIS countries they were implemented differently. Developed countries, such as the USA, Canada, Great Britain, Norway, etc., have been constantly carrying out reforms in the electricity industry over the past 30-40 years. The main reasons for the implementation of significant reforms in the electric power industry were the following: Lack of investment, high electricity tariffs, low level of energy production efficiency, etc. Therefore, all reforms of Western countries were aimed at stimulating competition in this sector of the economy.

It is worth highlighting that Chinese scientists Gao and Zhao (2020) built a tripartite model of government, investors and the public based on evolutionary game theory. Based on the results of the study, it was revealed. 1. When outsourcing a PPP project in the construction of new energy and power generation, the 3 parties will ultimately achieve a balanced state, high profits and a win-win situation. Public participation plays an important role in facilitating the smooth development of outsourcing PPP projects. 2 Government, investors and the public under PPP outsourcing are sensitive to changes in their external variables. For example, improving environmental benefits in the process of generating electricity, compensating the price of electricity to residents of the country, etc. These changes will increase the economic and environmental benefits of implementing PPP projects. 3. The decision on the participation of investors and businesses in PPP projects is influenced not only by the benefits, but also by the amount of government compensation. Therefore, in order to actively involve the public, the government must maintain an appropriate fixed income and allocate a certain amount of compensation. In addition, security factors play a significant role in the choice of government strategy in PPP outsourcing projects.

Liu et al. (2022) assessed electricity reform using the UK as a case study. They divided this reform into three stages. The first reform is integrated into the vertical network (from generation, transmission and distribution to consumption). Based on stimulating technology development and implementing the privatization of the UK electricity industry. During this reform, electricity prices fell at the beginning due to great competition. However, then a few years later, the price of electricity rose again. This indicates that no policy is perfect.

The second reform is the liberalization of the electricity market and the development of competition. Here, bilateral contracts were used to replace complex trading mechanisms. Accordingly, capital can participate at all stages of generation in the electric power industry. The third stage is the integration and promotion of electricity generation based on the use of alternative sources to achieve decarbonization. Here conditions have been created to stimulate the growth of renewable energy and provide safe electricity to all consumers.

We believe that the transformation of foreign experience in applying the PPP model using the example of the electric power industry in Kazakhstan requires a separate approach in each specific case. Here it is necessary to carefully evaluate, disassemble and conduct a thorough legal, organizational and economic analysis. Thus, the UK experience is instructive for Kazakhstan to now use the process of introducing certain privatization programs in the energy sector.

According to the PPP Center of the Republic of Kazakhstan, only two PPP contracts are being implemented in the energy sector of Kazakhstan as of 2023 (Table 17).

Table 17 shows data on two PPP projects in the energy sector. In particular, the first republican project is "Construction of a high-voltage power transmission line "Northern Kazakhstan - Aktobe

Table 17: Statistics of PPP projects in the energy sector of Kazakhstan, 2023

Project level	Type of contract	Number of projects	Total cost (million tenge)	Total cost ($ million)
Republican	concession	1	22,684	48
Local	service contract	1	2,320	5
Total		2	25,004	53

Source: Kazakhstan Center for Public-Private Partnership (2023), Database of PPP projects

region" (Batys Transit)."

This project was signed in December 2005 between the Ministry of Energy of the Republic of Kazakhstan and Batys Transit JSC within the framework of the Concession Agreement for the 3-year construction of an interregional power transmission line with a capacity of 500 kV. The project was completed at the end of 2008. The total length of power lines was 487 km. This project appears to be one of the first vehicles to utilize the PPP model in the country through infrastructure bond financing.

The social effect of the construction of the high-voltage power transmission line project includes the following results: the unified energy system has been improved, an energy basis has been created for the organization of the western region of Kazakhstan, the energy dependence of the Aktobe region on foreign purchases of electricity from Russia has been reduced, and the energy independence of the state has been formed.

The social effect of the project assumes that a 15-20% lower electricity tariff has been ensured, budgetary savings have occurred in excess of 5 billion tenge, and stability in tariff setting has been achieved.

Today, a local-level PPP project "Connecting power lines to the industrial zone of the Shieli region" is being implemented in the amount of 2.3 billion tenge. Commissioning was completed in mid-2019. The service period under the service contract is from June 16, 2019 to December 31, 2023.

It should be noted that the creation of the principles of public-private partnership in the energy sector was facilitated by new methodological approaches of the public administration system at the level of project management approaches in Kazakhstan.

Here we can note the construction of renewable energy facilities. As already noted, the share of renewable energy sources in total energy production is about 5%, which seems to be a negligible level.

However, renewable electricity infrastructure now appears to be an important technical strategy for providing energy to the entire population worldwide. In this regard, there is a need for active construction of a unified Kazakhstan infrastructure, including renewable energy facilities based on PPP principles. This will eventually make it possible to have a positive impact on the fight against the climate crisis and reduce carbon emissions.

In addition, the republic should pay attention to the development and use of photovoltaic strategies as a promising transition to economic decarbonization.

To address the issues of energy shortages and shortages, the issue of developing a plan for the construction of a nuclear power plant (NPP) in the country is being discussed. Organizing carbon-free energy throughout the world seems to be a fairly effective method.

Today in the world, nuclear power plants are considered the source of basic generation. In addition, Kazakhstan ranks first in the world in the production of uranium products. At the same time, all uranium is sold abroad due to the lack of domestic consumption.

Consequently, Kazakhstan has all the favorable foundations for the successful development of nuclear energy. At the same time, it is possible to use the PPP model for the construction of a new nuclear power plant. The estimated electricity production capacity of the new nuclear power plant is 2800 MW (MKKZ, 2023).

It should also be noted that the construction of a nuclear power plant takes a rather long cycle from 10 to 15 years. In addition, an appropriate infrastructure for nuclear energy must be built in parallel. Without the partnership of the state and foreign investors, such a large long-term project cannot be implemented.

8. CONCLUSION

Let's consider the main problems of management of companies in the energy sector and economic growth in Kazakhstan.

In the near term, serious risks remain to the pace of economic growth. This should include the continuation of anti-Russian sanctions and their impact on the national economy. As a result, certain disruptions in oil supplies for export via the Caspian Pipeline may continue.

There is significant wear and tear on the pipeline system and power equipment. For example, in the winter of 2022, a disaster occurred at the Ekibastuz Thermal Power Plant due to a boiler rupture and leakage. Similar major energy accidents occurred in the cities of Rudny, Ridder, and Temirtau.

Let us point out that the aging of existing production energy capacities reduces the management efficiency and productivity of the electric power industry.

The insufficiently reliable power supply management system in Kazakhstan appears to be a serious obstacle. This is primarily due to the deterioration and lack of energy capacity of the thermal power plant.

There is significant deterioration of the general energy infrastructure, and there is a shortage of qualified technical and engineering personnel in the country.

The lack of consistency between Kazakhstan's management strategy and the energy transition plan based on the PPP methodology leads to additional restrictive risks.

The lack of a pricing policy system for harmful emissions creates obstacles to determining the objective and real cost at the level of renewable energy sources. This significantly limits the possibilities of financing alternative energy.

There is a provision in the Republic where it is necessary to transfer assets to the state at the end of the PPP contract. As a result, this leads to the fact that such a requirement becomes unattractive for business against the backdrop of a decrease in the profitability of the project.

The shortage of electricity appears to be a significant obstacle. This is especially true for the southern densely populated regions. At the same time, there is a serious shortage of electricity, especially in the evening hours in the country. In addition, part of the deficit is covered by electricity supplies from Russia, which indicates the vulnerability of management of enterprises in the energy sector of Kazakhstan.

Insufficient rates of electricity generation and supply can lead to a reduction in industrial production and a decrease in the rate of economic growth in Kazakhstan.

To solve these threats and problems, we offer the following recommendations.

A reduction in inflation to 9.5% at the beginning of 2024 seems to be a definite stimulus for GDP growth. This became possible due to the general decline in inflation in the world and the tightening of monetary policy instruments by the National Bank of the Republic of Kazakhstan. In particular, we are talking about a gradual reduction in the key rate of the Main Bank of the country. Therefore, we believe that important attention should be paid to the optimization of interest rates.

At the same time, we must not forget about exchange rate fluctuations, including due to external pressure at the level of intensification of Russia's special operation in Ukraine. This plus everything also affects the growth of inflation in the Kazakh state.

In addition, from our point of view, the introduction of maximum prices for gasoline and diesel fuel for uninterrupted supply of the agricultural sector seems to be a factor in reducing inflation.

In order to increase electricity production, it is necessary to build new thermal power plants and renewable energy facilities. The government needs to develop a mechanism for providing financial support to private energy companies, as well as present a long-term action plan to modernize the energy industry.

The issue of reconstructing the entire energy system of Kazakhstan should be seriously considered. First of all, we need to find investors and potential businessmen who can engage in investment projects in the energy sector.

It is imperative to conduct an energy audit of energy-producing and energy-transmitting enterprises, on the basis of which it will be possible to take measures to save energy and increase energy efficiency in the country.

In order to attract investment resources to the energy industry, it is necessary to formulate a clear and predictable tariff policy. In addition, ensure objective indexation of energy tariffs at the level of annual inflation.

It is necessary to resolve the issue of constructing a nuclear power plant (NPP) as soon as possible.

We believe that for reasonable and economical consumption, as well as reducing electricity shortages, foreign experience in implementing RAB tariff setting tools should be used.

PPP approaches play a major role in attracting investment in the energy sector. Reducing the level of wear and tear on electrical power equipment can be achieved through reconstruction and renovation, which require investment in the energy industry through the use of the PPP model.

In this regard, we propose to use the PPP mechanism more actively to stimulate the development and effective management of energy enterprises in Kazakhstan.

This will help, to a certain extent, to carry out activities to modernize local commercial energy companies. For example, you can exempt commercial energy organizations from paying taxes for 5-7 years. Introduce a preferential interest rate for thermal power plants, thermal power plants and renewable energy facilities that are reconstructing and constructing new power units.

Overall, the energy industry is an area that should grow much faster and at a faster pace than economic growth. Thus, the implemented multifactor analysis of the impact of electricity generation on economic development showed the following results. It is necessary to increase electricity production at an accelerated pace, considering population growth, based on the intensification of the influx of investments in the construction of new power plants, modernization of energy facilities and the acquisition of innovative electrical equipment.

In turn, these recommendations for the development of the electric power industry, in our opinion, will improve and create positive preconditions for the formation of the quality of the GDP structure based on the industrial production of goods in Kazakhstan.

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