International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2023, 13(1), 477-488.

The Impact of Energy Production on the Introduction of ICT and the Growth of AIC in Kazakhstan

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Received: 29 September 2022 **Accepted:** 08 January 2023 **DOI:** https://doi.org/10.32479/ijeep.13765

ABSTRACT

The presented work is devoted to the organization of the electric power industry and the agro-industrial complex of Kazakhstan. Here is given an economic analysis of the production capacity of the development of power plants. It is noted that more than 80% of electricity generation is carried out by coal-fired thermal power plants. Important attention is paid to the significant wear and tear of machinery and equipment at thermal power plants and state district power plants. The key focus of the work is on econometric modeling to identify patterns and quantify the impact of electricity production and digital farms on increasing agricultural production. The results of the regression model are substantiated using the applied statistical package EViews. A medium-term econometric forecast for the development of the agricultural sector is presented, considering the introduction of digital farms. Problems are revealed and measures to stimulate the construction of new energy facilities are considered. Also, proposals were made to enhance the use of investment projects of alternative energy sources in the country. At the same time, an important emphasis is considered at the level of enhanced development of ICT in the energy and agro-industrial complex. It has been established that the digitalization of the energy and agro-industrial complex sectors contributes to the economic growth of Kazakhstan.

Keywords: Power Generation, Electric Power, Wear and Tear of Electrical Equipment, ICT, Agricultural Production, Digital Technologies, Kazakhstan

JEL Classifications: L94, M15, P28, Q12, Q13, Q16

1. INTRODUCTION

Over the 30 years of independence of the republic, the amount of foreign direct investment in the energy sector has exceeded over 200 billion US dollars.

In the republic, the national electric network (NES) provides electric power services inside and outside the country (Russia, Uzbekistan, Kyrgyzstan). For 2022, the available capacity in the country is over 15,000 MW, and the design capacity of energy sources is approximately 20,000 MW.

In our country, adopted in 2022 "Energy balance up to 2035." It considers the modeling and forecasting of the organization of the energy sector based on the construction of new generating capacities with elements of digital technologies.

It is expected that by 2035 total electricity loads will reach approximately 22.7 GW. In addition, the amount of consumption will be approximately 153 billion kWh. Given the high wear and tear of electrical technologies and electrical engineering, it is quite obvious that the country will not have enough production capacity.

The amount of energy produced in 2021 equals 114.4 billion kWh. In 2021, the results of electricity generation by renewable energy facilities amounted to 4.2 billion kWh.

According to forecasts for 2022, electricity generation will be 117.4 billion kWh.

It should be noted that the volume of electricity consumption for 6 months of 2021 increased by 6% compared to the same period in 2020. For example, in the southern zone of the country, consumption increased by 10%, in the northern and western zones of the country by 6% and 2%, respectively. According to the estimates of the Ministry of Energy of the Republic of Kazakhstan in accordance with the forecasts of the balance of electricity and capacity for 2021-2027, possible increase in electricity consumption by about 2.4% (Zakon.kz 2022).

In addition, by 2027 there will be a shortage of electric power at the level of 898 MW. We point out that already now there is a shortage of control power in the amount of 1000 MW.

For example, already in 2022, a shortage of electricity in the republic is predicted at the level of 4.6 billion kWh. The shortage of electricity generation is caused by such factors as: Growth in consumption due to the introduction of new investment projects, high wear and tear of equipment at the state district power station and thermal power plant (60-70%), significant energy losses during energy transportation (30-40%), as well as during peak loads.

According to the World Nuclear Association, today there is a rather active process of development of nuclear energy in the world (World Nuclear Association 2019).

Let us single out that Kazakhstan has a powerful potential for the creation of nuclear energy. For example, the republic ranks first in the world in the production of uranium, which is necessary for the production of nuclear fuel. Here we are talking about the Ulba Metallurgical Complex, where a division for the production of nuclear fuel was opened.

The introduction of new energy sources will create prerequisites for economic growth and ensure the energy independence of our republic.

2. LITERATURE REVIEW

The energy and agro-industrial sectors use advanced information technologies to quickly collect the necessary big data (Goel et al., 2021). Agricultural drones, precision farming, smart technology in the network of wind, water and solar energy, equipment in digital farms and power plants using artificial intelligence are actively used here. All digital technologies make it possible to increase agricultural harvest, increase the productivity of the power industry and make objective decisions on the management of the agro-industrial complex and the energy sector.

According to Lioutasa et al. (2021), digital technologies provide an opportunity to have a direct impact on achieving food security. At the same time, the issues of increasing the production of agricultural products are also being addressed. The main issues of digitalization of the agro-industrial complex involve meeting public expectations and reducing harmful environmental impacts.

The digitalization of the energy sector involves the reduction of harmful emissions, decarbonization and the operation of transport on coal. The authors of Judson et al. (2022) argue that the development of digital infrastructure improves the well-being of citizens and the state of the environment. Digital technologies, note Salahuddin et al. (2016) contribute to the development of innovations, reduction of harmful emissions and renewable sources in the country's energy system.

Digital and information platforms are focused on the introduction of sensors, energy drones, and big data in the energy sector. This involves controlling and monitoring the operation of power equipment in automatic mode (Van Veelen et al., 2021)). In other words, such electronic technologies contribute to the efficient management and stability of energy regimes.

Young entrepreneurs are highly educated and innovative. In particular, young farmers are using new information technologies to reduce labor intensity and manual labor (Vecchioa et al., 2022). Indeed, it costs a lot of money, but the costs are justified due to the high agricultural yield.

Researchers Khanna and Kaur (2019) note that the use of artificial intelligence in the agro-industrial complex involves the introduction of smart agricultural technologies and innovations. All smart agro innovations affect the growth and quality of food production. At the same time, farmers optimize the costs of production and mineral fertilizers, capital mobility and increase the yield of agricultural products.

The effectiveness of energy management directly depends on the introduction of innovations, high-quality engineering personnel and the development of energy infrastructure. At present, it is required to strengthen the implementation of energy monitoring and modernization of energy technologies and equipment. Information systems used in energy production seem to be successful investment projects in the energy sector, according to Yu et al. (2022).

The authors of Veskioja et al. (2022) emphasize that the transition to renewable energy sources is currently acute. According to the UN Sustainable Development Goals, it is required to reduce greenhouse gas emissions. The growth in the production of goods and services, unfortunately, has a negative impact on nature and climate. In this regard, the use of new information technologies will contribute to a large amount of emissions into the atmosphere. All these innovative transformations stimulate sustainable organization and development of efficient energy production.

Today, the use of communication and information technologies can be actively implemented for the growth of the agribusiness sector (Zhang et al., 2021). The Internet enables farmers, scientists, consultants the right to have access to new information in the field of agricultural technology. Public and private resources should help develop rural areas.

The digitalization of the agro-industrial complex to create added value implies more profit for agricultural producers. The Internet promotes the transformation of agriculture through the rapid dissemination of information between farmers, dealers and agribusinesses (Kudama et al., 2021). For example, using mobile devices, you can get data on prices for agricultural products, mineral fertilizers, seeds, etc. Accordingly, for farmers, this saves time and financial resources for searching for information.

In reality, information technology has a direct impact on reducing energy consumption in industry (Ren et al., 2021). The introduction of electronic systems at energy enterprises increases labor productivity. The study showed that the active use of the Internet at power stations reduces harmful carbon dioxide emissions. The use of intelligent equipment reduces the intensity of energy consumption, but at the same time increases energy efficiency and the level of energy production.

According to Baidya et al. (2021), smart technologies can effectively influence the activities of renewable energy sources. Therefore, the smart grid in the energy sector has a positive impact on the production and management of the ecological environment. Information technologies and innovations in the energy sector provide free access to electricity consumption even in remote rural areas.

The development of a digital agro-industrial complex involves the use of a huge amount of data, according to Rijswijk et al. (2019). The process of digitization of agricultural companies is necessary to create a database, search for partners, track market prices, information on the cost of new equipment, etc. Such digital platforms save time, optimize the management process and the costs of agricultural producers.

Today, the agro-industrial complex sector appears to be the driver of the real sector of the national economy of Kazakhstan (Smagulova et al., 2022). In particular, over the past 3 years, the agricultural sector has accounted for approximately 5% of the GDP structure. Here there was an increase in the average annual level of labor productivity up to 18%. First of all, this is due to the introduction of new digital technologies and an increase in government spending in the agro-industrial complex, especially during the Covid pandemic in 2020-2022.

3. ASSESSMENT OF ENERGY DEVELOPMENT IN KAZAKHSTAN

In Kazakhstan, the length of all electrical networks is 467,422 km. This includes National and regional electrical networks. At the same time, it is important to note that the level of depreciation of power networks is about 65-70%. This affects significant losses during transportation and reduces the consumption of electricity by companies and households. Therefore, the issue of attracting investment in the energy sector is acute.

The common operator of the Unified Energy System of the country-JSC "KEGOC" performs the following functions: Provides services for the transmission, consumption and technical operation of electricity; carries out the volume and distribution of reserves; cooperates with energy systems of foreign countries on energy regulation; implements the management of the information system for accounting and consumption of electricity, etc.

In Kazakhstan, electricity generation is carried out by 190 power plants of various forms of ownership. Over the past 3 years, the growth in the total capacity of power plants, production and consumption of energy has been characterized (Table 1).

Over 80% of electricity production in the republic comes from thermal power plants (TPPs). An analysis for 2022 shows that about 70% of energy sources operate on coal. Coal-fired power plants have high equipment wear and old boilers.

Let us highlight, as Kazakh scientists Smagulova et al. (2015) noted 7 years ago, electricity is produced mainly from coal. At the same time, the main part of electricity generation, both before 2015 and in 2022, is associated with thermal power plants. Comparative analysis showed that, just like 7-8 years ago, the Northern zone (Karaganda and Pavlodar regions) seems to be the key producer in the amount of approximately over 75% of all electricity generated. However, this zone consumes about 70% of all electricity. The main industrial plants and production complexes are located here, and more than 40% of the country's inhabitants live here.

In the energy structure, power plants are classified into power plants - national, industrial and regional.

The national power plants include thermal power plants that are engaged in the generation and sale of electricity on the wholesale republican market: JSC Station Ekibastuzskaya GRES-2 and Zhambylskaya GRES named after T. Baturova; LLP "Ekibastuz GRES-1" named after B. Nurzhanov and "Main distribution power station Topar"; ES JSC "EEC" ERG, "Eurasian Group," etc.

The Ekibastuz power plants of GRES-1 LLP and GRES-2 JSC are located in the Pavlodar region. The installed power capacity of these stations in the region is 8014 MW.

Table 1: Installed capacity of power plants and electricity generation

Years	Total capacity of power plants, MW	Electricity, kWh	
		Working out	Consumption
2019	15 182	106.0	105.1
2020	22 936.6	113.8	108.8
2021	23957.3	113.5	110.7

Source: Ministry of Energy of the Republic of Kazakhstan. (2022), Power industry. Available from: https://www.gov.kz/memleket/entities/energo/activities/215?lang=ru [Last accessed on 2022 Sep 05]

We emphasize that the Pavlodar region occupies the first place in terms of production and provides about 40% of the electricity in the country.

In particular, one of the large power plants-the Ekibastuz energy complex-was designed to operate on the high-ash Ekibastuz coal mined in the northern part of the country. This type of fuel produces serious emissions of harmful carbon and greenhouse gases.

In order to reduce harmful emissions, it is necessary to intensify the introduction of innovative technologies for the enrichment and deep processing of coal. Such measures will allow the production of stone tar, special coke, as well as coal gas. In addition, it will improve the environment (Peña et al., 2022), climate and reduce harmful emissions.

At the same time, hydraulic power plants are used in the republic, such as: AES Shulbinsk HPP LLP and Ust-Kamenogorsk HPP NPP, as well as Bukhtarma HPP Kazzinc LLP, etc.

Today, industrial power plants include combined heat and power plants (CHP) with combined generation of heat and electricity and energy. These include: Zhezkazganskaya CHPP of Kazakhmys energy LLP, PVA CHPP, CHPP-2 of Arcelor Mittal Temirtau JSC, Balkhash CHPP, CHPP of JSC SSGPO ERG, Eurasian Group, CHPP-3 of Karaganda Energocenter LLP and etc.

As of mid-2022, 37 (CHP) companies with different types of ownership are operating in Kazakhstan. In particular, including: two units CHPPs are state-owned (MAEK Kazatomprom LLP), three units CHPP - in quasi-state ownership (AlES JSC), ten units CHPP-in communal ownership (cities: Astana, Kostanay, Uralsk, Taraz, etc.), and twenty-two units CHP is privately owned.

It should be emphasized that more than half of CHPPs have an overestimated service life. For example, 9 units CHP have been in operation for over 30 years and 28 units-for over 50 years. In general, the average age of operation of all thermal power plants in the country is more than 60 years.

So, the main sources of heat supply in the Karaganda region are CHPP-2, CHPP-3. Their total installed capacity is within 2.4 thousand Gcal/h.

In particular the total capacity of the CHPP of Aluminum of Kazakhstan JSC and CHPP-3, located in the Pavlodar region, is 2.3 thousand Gcal/h. Here it is worth noting the rather high wear and tear of equipment at these CHPPs. For example, at CHPP-3 wear is 51.2%, and Aluminum of Kazakhstan-74.3%. This seems to be a practically high level of depreciation of power equipment.

We believe that the significant deterioration of power engineering in the country is associated with the presence of low tariffs for the transportation of heat. Accordingly, the CHPP does not have enough of its own resources to carry out repair work on heat pipelines.

It is worth noting here that the total length of heating networks in the republic is -1337 km, of which about 8-10 km are being replaced annually.

In 2022 work is underway to reconstruct existing CHPPs. For example, the modernization of cable networks of the country's large metropolis-the city of Almaty and the construction of the 2nd stage of transit between Atyrau and the West Kazakhstan regions of the republic are being carried out.

Power plants at the regional level include CHPs, which are engaged in the transmission of electricity through power transmission institutions and power grid organizations.

In particular, the Zhezkazgan CHPP of Kazakhmys Energy LLP (built in 1952) is part of the Kazakhmys Holding Company. This CHPP has an electric capacity of 252 MW, and its thermal capacity is 564 Gcal/h.

The Eurasian Group (ERG) includes the Pavlodar CHPP-1 of Aluminum of Kazakhstan JSC (built in 1964). The mentioned CHPP has an electrical capacity of 350 MW, while it has a thermal capacity of 1,182 Gcal/h.

One source of heat and electricity in the North Kazakhstan region is the Petropavlovsk CHPP (built in 1961). Particularly in 2021 about 2.700 billion kWh of electricity was produced. And the amount of domestic consumption of this region amounted to approximately 1.730 billion kWh. This thermal power plant has an electrical and thermal capacity of 541 MW and 713 Gcal/h, respectively. Depreciation of technical equipment is more than 50%.

In order to address the issues of depreciation of equipment, the process of building new and modernizing old power plants is actively underway. For example, to finance the Kentau CHPP-5 (commissioned in 1952). distributed about 760 million tenge. And to increase the production capacity in the amount of 240 MW at the Kyzylorda CHPP, it is planned to build a new combined cycle plant.

The energy industry is experiencing an exodus of skilled production engineers and electricians due to low wages and insufficient social assistance. Personnel from this industry move to related areas, where the payment of engineering and technical workers and electrical fitters is 2-3 times higher. In particular, in Pavlodarenergo the shortage of personnel decreased in 2022 up to 12%, and in 2021-14%. Serious problems for electrical engineers exist at the thermal power plants-"Astana-Energy," "Ust-Kamenogorsk," Stepnogorsk, Sogrinskaya and others.

It should be noted that by the middle of 2022-340 MW of electrical capacities have already been commissioned. And by the end of 2022 another 240 MW will be built, i.e. in total, it is planned to bring the total capacity to 580 MW in the republic. However, this is almost 2 times lower than the planned volume, which is equal to 1.1 GW.

In the course of the study, such factors were identified that influenced the non-fulfillment of forecast indicators. These include: The ongoing pandemic in China, global inflation, anti-Russian sanctions, a tense geopolitical situation, disruption of logistics, etc. All these reasons led to a disruption in the supply of energy equipment, a serious increase in prices for energy technologies, an increase in transport routes for the delivery of components and spare parts for maintenance of CHP and GRES.

In the energy system of the republic, there is a negative impact of mining, which affects the shortage of electricity.

Thus, until 2020 in Kazakhstan, on average, energy consumption grew by 2% per year. However, since 2021, the increase in consumption has increased by more than 6%.

Despite the fact that the overall energy system as a whole function in a balanced way, there are problems of lack of electrical power during peak hours. During the analysis, it was found that the work of illegal digital mining entities, due to the growth of connected capacity, dramatically increases the load on the energy sector.

Important attention should be paid to the development of renewable energy projects. Let us highlight that the possible total hydro potential of alternative energy can be estimated on average at the level of 62 billion kWh per year. At the same time, the potential of solar energy and wind energy is 92 billion kWh each.

For example, the amount of electricity produced by stations using renewable energy sources (RES): Small hydroelectric power plants, wind, biogas and solar power plants in the first two quarters of 2021 alone is equal to 2005.5 million kWh. While for the same period in 2020 production amounted to 1470 million kWh (or 1.4% growth).

For example, in the Karaganda region, the process of organizing energy production using renewable sources is actively underway. By mid-2022, there are 7 renewable energy facilities in the region with a total production capacity of 218.7 MW. At the same time, there are 4 solar power plants (capacity 216 MW), 2 bioelectric power plants (2 MW), 1 hydroelectric power station (0.6 MW).

The number of production and export of crude oil according to the results of 2021 equal to 85.9 and 67.6 million tons, respectively. According to forecasts for 2022, the volume of oil production and export will be approximately 87.5 and 69.0 million tons.

Based on the data in Table 2, the volume of production of petrochemical products (PCP) over the past three years has been behaving in different directions. For example, in 2021 there is a decline in the production of oil and gas condensate production of ANPZ LLP.

According to the “Energy Balance” by 2035, the construction of various types of energy capacities is predicted (Table 3).

Table 2: Production of petrochemical products in Kazakhstan, 2020-2022

NO	Years	Volume of PCP production, thousand tons
1	2020	360
2	2021	190
3	2022	560

Source: Internet-Portal of the CIS. (2022), On the development of petrochemical industry in Kazakhstan. Available from: https://e-cis.info/news/566/99275 [Last accessed on 2022 Aug 25]

Table 3: Forecast of the structure of new energy capacities in Kazakhstan

No	Types of energy production	Volumes of production capacities, GW
1.	Renewable energy sources	6
2.	Gas generation	5
3.	Hydroelectric power plants	2
4.	Nuclear generation	2
5.	Coal generation	1.5

Source: Agency Khabar 24. (2022), The Ministry of Energy of the Republic of Kazakhstan has developed the energy balance of the country until 2035. Available from: https://24.kz/ru/news/policy/item/535246-minenergo-rk-razrabotalo-energeticheskij-balans-strany-do-2035-goda [Last accessed on 2022 Sep 11]

4. DATA AND METHODOLOGY

The main goal of statistical analysis of time series is to study the relationship between regularity and randomness in the formation of series values (Dursun, 2022), assessing the quantitative measure of their influence.

In this work, the purpose of regression analysis is to establish the form of relationship between variables, evaluate the regression function and predict the values of the dependent variable (Dougherty, 2011), as the ratio of the standard deviation to the mean according to the formula:

$$Cv = \sigma/\mu \qquad (1)$$

Where, Cv - is the coefficient of variation, σ - is the standard deviation, μ - is the mean deviation.

When checking the statistical significance of the coefficient of determination, the calculated and tabulated values of the Fisher F-test were used. The calculated value is determined by the formula:

$$F = (R2/(1 - R2))\ ((n - m - 1)/m \qquad (2)$$

Where R^2 is the coefficient of determination, n is the number of samples, m is the number of factors.

The regression model is expressed by the following equation:

$$Y = f\,(X1) + f\,(X2) + f\,(Xn) + (\varepsilon) \qquad (3)$$

Where, Y - efficiency, independent variable, $f(X)$ - connection function, X - dependent variable, ε - random error.

Patterns that explain the dynamics of indicators in the past (Kovalev and Medvedev, 2019) are used to predict their values in the future.

The model was built on the basis of the applied statistical package EViews.

The statistical base for economic calculations was used from the official websites of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan and National Bank of Kazakhstan.

5. MODEL RESULTS

In the country, the volume of gross agricultural output is increasing every year. Empirically and considering economic laws, it is safe to say that several factors influence it. To do this, we will build an economic model in order to determine the factors affecting the volume of agricultural production in Kazakhstan. We will also make medium-term forecasts based on a preliminary calculation of the volume of agricultural production in the coming years.

The hypothesis of the model is as follows: the following factors have the greatest influence on the increase in Gross Agricultural Output in Kazakhstan: the level of electricity production and digital agricultural farms.

To this end, we will conduct an econometric analysis based on the construction of a multiple regression model. For this, the following indicators for the period 2017-2021 will be used: Gross agricultural output (*Y*), Investment in agriculture (*X*1), Number of people employed in agriculture (*X*2), Change in the price of agricultural producers (*X*3), Inflation Rate (*X*4), Average Monthly Nominal Wage (*X*5), National Bank Interest Rate (*X*6), Electricity Production (*X*7), and Total Number of Digital Agro Farms (*X*8). We explore the interdependence between factors affecting agriculture. Because, in our opinion, these factors directly affect the increase or decrease in the volume of gross agricultural output (Table 4).

Agency for Strategic planning and reforms of the Republic of Kazakhstan. (2022), Statistics of industry. Main indicators. Available from: https://stat.gov.kz/official/industry/151/statistic/7.

Agency for Strategic planning and reforms of the Republic of Kazakhstan. (2022), Statistics of industry. Dynamic Tables. Available from: https://stat.gov.kz/official/industry/151/statistic/8.

National Bank of Kazakhstan. (2022), Inflation trends. Available from: https://www.nationalbank.kz/en/news/inflyacionnye-tendencii/rubrics/1767.

As we can see in Correlation Table 5, the growth in Gross Agricultural Output was positively associated with electricity generation (0.92) and the number of digital farms (0.98). Also, a fairly good level of correlation that affects the increase in gross agricultural output can be traced to the following factors: Investments in agriculture (0.79) and Average monthly nominal wages (0.83).

The average correlation between the other factors of agriculture is low. Since the correlation analysis realistically shows the situation, we continue the analysis with variables *X7* and *X8*. Thus, we perform a linear regression analysis of the dependence of the indicator *Y* on the factors *X*7 and *X*8.

As a result of computer calculations, the value of the multiplicity correlation coefficient $R = 0.996$ (Table 6). This is directly related to electricity generation and the total number of digital farms. The coefficient of multiple determination was $R^2 = 0.991$, and the variation of factor *Y* was 99.2% of the factors *X*7 and *X*8 included in the model.

Table 4: Statistical indicators for building a model

Years	Gross output of agricultural products (services), mln USD (*Y*)	Investments in agriculture, mln USD (*X*1)	Number of people employed in agriculture, million people (*X*2)	Change in the price of producers of agricultural products, % (*X*3)	Inflation rate, % (*X*4)	Average monthly nominal wage, USD (*X*5)	Interest rate of the national Bank, % (*X*6)	Electricity generation, million kWh (*X*7)	Total number of digital agricultural farms, units (*X*8)
2017	12487.4	4000.0	1.3	2.6	7.22	463	10.5	103,128.0	8
2018	12979.2	3000.7	1.2	7.8	5.43	472	9	107,268.8	27
2019	13458.2	2000.7	1.2	15.3	5.43	488	9.25	106,483.2	35
2020	15340.0	5000.1	1.1	15.9	6.37	498	9	108,628.4	62
2021	15950.0	7000.3	1.1	13.2	9.5	610	9.5	115,079.2	75

Sources: Agency for Strategic planning and reforms of the Republic of Kazakhstan. (2022), Statistics of agriculture, forestry, hunting and fisheries. Main indicators. Available from: https://stat.gov.kz/official/industry/14/statistic/7

Table 5: Correlation of factors

Indicators	*Y*	*X1*	*X2*	*X3*	*X4*	*X5*	*X6*	*X7*	*X8*
Y	1								
X1	0.7923434	1							
X2	−0.937148558	−0.590365724	1						
X3	0.713311401	0.14105628	−0.820433143	1					
X4	0.604524671	0.907494543	−0.329150031	−0.031496163	1				
X5	0.833445746	0.815201912	−0.695875826	0.431513647	0.838233402	1			
X6	−0.403835861	0.114742864	0.696022273	−0.733357655	0.394822787	−0.117584718	1		
X7	0.9242758	0.641272442	−0.938349703	0.75417631	0.506022896	0.874450268	−0.570471958	1	
X8	0.987053409	0.715221592	−0.969263789	0.775261312	0.528127071	0.834182365	−0.519010896	0.168877452	1

Analysis of variance obtained on the basis of Table 7. Here our equation is statistically significant.

Null hypothesis about the statistical significance of the parameters of the regression equation *H0*; *bj* = 0. This indicates the importance of the coefficient $t_{X7} = -1.93 < tkr = 2.365$ with Student's *t*-test.

The confidence interval of the coefficients of the influencing factor *X7* and *X8* is as follows (Table 8):

$-210.4721394 \leq B_{X7} \leq 79.86499142$

$18.5976992 \leq B_{X8} \leq 149.3085573$

According to all estimates, the model is adequate, statistically significant, there is no autocorrelation and heteroscedasticity. Here, the errors are distributed according to the normal law (Stock and Watson, 2019), so the resulting model can be considered successful.

The resulting regression equation is:

Y=28435.6644−65.30357398*X7+83.95312825*X8)/2

This equation can be used for analysis and forecasting.

In conclusion, it can be seen that correlation is a factor that has had a significant impact on the change in the growth of gross output over the past 5 years. According to the model data, it can be seen that as a result of regression calculations, these factors include: the production of electricity levels and the total number of digital agricultural farms.

Factors that had a moderate impact were the change in the price of agricultural producers, investment in agriculture and the average monthly nominal wage.

Now let's determine the confidence interval of the regression parameters. To do this, we use the calculations in Table 5 (Correlation of factors).

Table 6: Regression statistics

Regression statistics	
Multiple R	0.995513033
R-square	0.991046198
Normalized R-square	0.982092396
Standard error	203.0838517
Observations	5

Confidence interval of factor *X7*:

$-210.4721394 \leq B_{X7} \leq 79.86499142.$

This means that if the production level of electricity increases by 10 million kWh, then the volume of agricultural output can show an increase from −210.47 to 79.86 million US dollars. Confidence interval of factor *X*8:

$18.5976992 \leq B_{X8} \leq 149.3085573.$

Here we can say that if the total number of digital agricultural farms increases by 10 units, then the volume of agricultural output will increase from −18.6 to 149.3 million US dollars.

Now we can make a prediction using the obtained regression equation for the next period. The forecast period is 3 years. First, let's check the accuracy of the forecast. We compare the correspondence between the calculated values of Gross Agricultural Output (*Y**) and the initial values of Total Agricultural Output (*Y*) with the regression equation in the graph (Figure 1).

We notice the coincidence of points on the graph. The first row in the graph is *Y*-the main indicator, the second row *Y**-the predicted indicator in the future. When forecasting using dynamic data, it is important to follow the trends of recent years.

Figure 1: Initial (*y*) and estimated values (*Y**) of Gross agricultural output

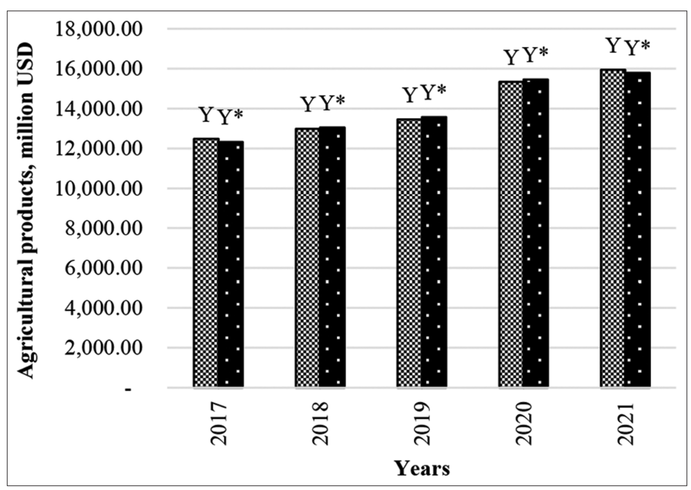

Table 7: Analysis of variance

Analysis of variance	*df*	*SS*	*MS*	*F*	*Significance F*
Regression	2	9129924.73	4564962.365	110.6844007	0.008953802
Remainder	2	82486.10167	41243.05084		
Total	4	9212410.832			

Table 8: Values of Variables X7 and X8

Indicators	Odds	Standard error	t-statistic	P-value	Lower 95%	Upper 95%
Y-intersection	28435.6644	8624.358555	3.297133836	0.080971696	−8671.955477	65543.28428
Variable X 7	−65.30357398	33.73931723	−1.935533358	0.192566221	−210.4721394	79.86499142
Variable X 8	83.95312825	15.18956634	5.527026012	0.031210898	18.5976992	149.3085573

The most difficult part of the forecast is the correct choice of the values of the influencing factors in accordance with the forecast period, on which the accuracy of the forecast depends. In practice, different approaches are used. For example, it is necessary to predict the growth of Y^* in 2024, when the number of digital agricultural farms ($X8$) will grow by 115% compared to 2021, and electricity production will increase ($X7$) will reach 120%

Y^*=28435.6644+290.1*115=33034.67

Y^*=28435.6644+75*120%=34212.84

As you can see, by 2024 it is possible to predict an increase in the volume of agricultural production due to several factors, in particular, the factors-electricity generation and the total number of digital agricultural farms.

6. DISCUSSION

In accordance with the budget program of the Ministry of Digital Development, 7.5 billion tenge will be allocated for the successful organization of information technologies in the period from 2021 to 2023. Including already in 2021, 1.9 billion tenge was allocated for the introduction of innovations and digital technologies, in 2022-2.7 billion tenge and 2.9 billion tenge-in 2023 (LSM.kz. 2022).

It is estimated that the use of new technologies will increase the overall share of local content in IT goods and services in 2022-up to 70%, 2023-70.5% and 2024-71%.

The government, in order to reduce the depreciation of electric power enterprises from 2020 to 2025 planned to build new power plants. According to the plan, they will generate up to about 30% of the total electricity production.

Including about 20% of new stations will use new digital technologies, considering the introduction of renewable energy sources (RES).

Yes, fall 2021 the 3rd unit was built, and in the winter of 2022- the 4th power unit of the Zhambyl GRES. This increased the production load of this GRES by 330 MW. That is, we raised the generation capacity from 280 MW to 610 MW and reduced the shortage of electricity in the Southern region. During the construction of the Zhambyl GRES, innovative energy technologies were introduced.

In 2022 a new digital map of the country's hydro potential has been compiled. This map for potential investors contains promising indicators of the physical hydro potential of the state of rivers in order to organize new hydroelectric projects. It also reflects the volume of facilities under construction and the actual performance of HPPs already built with the introduction of information technology.

For example, the experience and innovative technologies of «General Electric» (USA) can be used to organize types of hydrogen and nuclear energy. At present, turbines of the «GE» corporation are successfully used in the country at gas turbine power plants at the fields in Kashagan, Karachaganak, Tengiz, etc. For example, the use of American equipment has an impact on reducing carbon emissions at the Ekibastuz GRES-1 and the Badamsha wind farm. In addition, an environmentally friendly methane-hydrogen mixture has been introduced here as a fuel.

It should be noted that «GE» combined cycle plants were introduced during the conversion of 3 large thermal power plants in the metropolis of Almaty and a new gas power plant in the Turkestan region in the south of the republic to gas. Such installations have a positive effect on reducing harmful emissions, improving the environment and digital energy stability of the country.

It is worth noting separately that in recent years all international financial companies have refused to finance the construction of coal-fired power plants. Here we also have to agree with the opinion of Mujtaba et al. (2020) that in the near future new environmentally friendly fuels using a mixture of nanoparticles should be developed. In this regard, Kazakhstan needs to focus on the introduction of new energy projects for the construction of power plants using renewable energy sources. In addition, innovative technologies and the use of digital energy capacities should play an important role here.

According to forecasts, the production of RES electricity for 2022 will be about 4.5 billion kWh. Work continues to attract investors to the renewable energy sector. Estimated by the end of 2022 put into operation at least 10 renewable energy investment projects with a total capacity of 290 MW in the amount of $225 million. At the same time, great importance is attached to the use of digital technologies for the economical use and consumption of energy. In addition, some attention is paid to the use of renewable energy facilities in rural areas in the production of food products.

In Kazakhstan, according to the plan, it is expected until 2025 build about 2,400 MW of renewable energy (RES) production capacity. As a result, this will make it possible to attract approximately 300 million kWh or it is 6% of the total electricity.

Also, 53 renewable energy projects with a production capacity of 1074.80 MW will be built. Based on the implementation of the noted projects, it is predicted to attract about 600 billion tenge of investments. In addition, 3.5 billion kWh will be produced on this basis Green energy by 2025 considering the introduction of new digital technologies.

And by 2050 the share of alternative energy, including renewable energy, will be 50% of the energy balance of our republic.

It should be noted that in 2019, the Information System for Accounting for Oil, Gas and Certain Types of Oil Products (ISUN) was put into operation in the republic.

25 oil producing companies, 4 oil transportation organizations and 3 refineries are already connected to ISUN.

These activities were carried out on the basis of the implementation of the major national project "Technological breakthrough through digitalization, science and innovation."

The use of ISUN allows to carry out forecasts of oil and gas turnover in digital format, to automatically prepare reports of data from metering devices.

The introduction of such an automated Information system ensures the optimization of costs and various internal and external risks.

In September 2022, a separate new automated module was introduced on its basis.

It reflects the digital accounting of the sale of diesel fuel at a differentiated cost to different consumer groups. In particular, you can quickly track the sale of diesel fuel in real time.

Based on the growth of the level of the manufacturing sector in the structure of the national economy and ensuring the share of digitalization and import substitution in the petrochemical sector, investment projects have begun to be implemented.

For example, in 2021 a plant for the production of octane-boosting additives was launched in Shymkent (production capacity is 57,000 tons) and equipment for technical gases was introduced (production capacity is 54 million m^3).

In 2022 it is planned to complete the construction of a plant for the production of polypropylene using digital technologies (production capacity of 500 000 tons per year).

At the same time, the total loading of crude oil at the Shymkent oil refinery will increase by almost 16%, or from 5.2 million tons to 6 million tons.

This will make it possible to increase the output of fuels and lubricants (POL) in order to meet demand in the domestic market. First of all, it is relevant for agricultural producers.

By 2025, a project will be implemented to modernize the hydrotreatment unit at the Pavlodar Oil Refinery (POR). This, in turn, will lead to an increase in the productivity of this unit from 5.4 to 6 million tons. In addition, the introduction of new innovative technologies will make it possible to produce up to 160 thousand tons of winter diesel fuel. We point out that the production of such a winter type of fuel was previously absent altogether.

The technical modernization of the Aktau bitumen plant will lead to an increase in bitumen output from 400 000 to 450 000 tons per year.

The gas industry is implementing 10 new projects aimed at modernizing and putting into operation an innovative gas transmission system. Here we are talking about the growth of the resource base of commercial gas using waste-free technologies and reducing losses during gas transportation to settlements and agricultural facilities. For example, the «QazaqGaz» organization and «Honeywell» are planning to implement digitalization and modernize the infrastructure of the gas sector together with foreign companies «Baker Hughes» and «Solar Turbines».

The "Industry Strategy for the Digital Transformation of the Oil and Gas Complex of the Republic of Kazakhstan" sets a goal to increase the quality of digitalization of the oil and gas industry of the Republic of Kazakhstan (2023-2030).

It is assumed here, based on the use of information and communication technologies in the oil and gas industry, the use of electronic platforms in order to create a common digital ecosystem in the period 2023-2030. As a result, this will create favorable prerequisites for organizing advanced digital solutions in general for the economic growth of the country.

Currently, the Ministry of Agriculture is solving the issues of targeted distribution of diesel fuel to farmers. For example, it is planned to organize databases of contact data of agricultural companies, the amount of sown land, etc. The use of an electronic information system in order to ensure the overall need for fuel and lubricants in a territorial context will allow prompt distribution of fuel for farmers.

A new National project for the development of the agro-industrial complex for 2021-2025 has been adopted in the republic. According to this project, 2.7 trillion tenge will be allocated from the state budget for 5 years. Part of these financial resources will be allocated to electronic and digital technologies in the agro-industrial complex. These budgetary resources by 2025 will increase labor productivity per worker to 6.2 million tenge in the agricultural sector. In addition, by 2025 the export of agricultural products will increase by 2 times compared to 2020 in the amount of up to 6.6 billion US dollars.

Consequently, the diversification and digitalization of the energy sector will make it possible to have a multiplier effect on the economy and promote the growth of industrial production, including in the agricultural sector.

7. CONCLUSION

Today, a large number of coal-fired power plants operate in Kazakhstan, which harm nature and emit significant amounts of carbon dioxide into the atmosphere. It is not possible to use the construction of new gas generation facilities on a large scale due to the limit of gas resources. In addition, gas prices tend to rise regularly.

Due to the large territory and the instability of weather and climatic conditions, the use of renewable energy sources cannot always be a permanent and basic resource for generating electricity.

For many years, the Kazakh energy sector has been experiencing a lack of funding and investment for the implementation of projects for reconstruction, major repairs and the construction of new energy facilities.

To substantiate the role of the energy system in the national economy, an econometric model was built in the work. With the help of the created model, we can analyze and predict the state of agriculture from an economic point of view. It should be noted that the analysis carried out through economic modeling makes it possible to increase the efficiency of agriculture. The simulation results showed that due to the growth of electricity production and the digitalization of the agro-industrial complex, it is possible to ensure the economic growth of agriculture.

In the past few years, there has been a shortage of electricity production in the republic. In our opinion, there are such important problems in the energy sector.

A serious problem of heat supply is a rather high wear and tear of heat networks. There is a lack of financial resources for the construction and renovation of main heating networks.

An important barrier to the sustainable development of the energy system is the formation of non-transparent tariffs of energy producing companies. These tariffs are subject to discretion by the Antimonopoly Committee. Thus, the prices for electricity and heat from CHP plants are regulated by two state institutions. For example, electricity prices are set by the Ministry of Energy, while heat tariffs are set by the Committee for the Regulation of Natural Monopolies. A differentiated methodology is applied here, which includes CHP costs for heat generation in the price of electricity.

There are barriers to the development of a competitive electricity supply market. Thus, almost the entire amount of electricity produced is carried out through bilateral contracts and agreements between power plants and consumers.

There are obstacles to the timely provision of fuel reserves and the stable supply of coal and fuel oil to thermal power plants and state district power plants. There is an accumulation of debts of consumers on payments to fuel suppliers.

Due to the uncontrolled increase in the activity of "gray" miners and the increase in accidents at power plants, since 2021, an energy shortage has begun to appear.

To address the issues of digitalization of the energy and agricultural sector, we propose the following activities.

We believe that for the uninterrupted supply and stable operation of the entire energy system, it is necessary to regularly modernize existing and build new stations using digital technologies.

For example, in the summer of 2022 an auction mechanism was introduced for the commissioning of flexible power plants. As a result of the auctions, there are already investors who will build new combined cycle plants in the Turkestan and Kyzylorda regions (total capacity of 1.2 GW).

In our opinion, it is necessary to further increase the construction of innovative flexible capacities, digital energy storage systems and new pumped storage power plants. It is necessary to increase the commissioning of new renewable energy facilities and the production of green hydrogen in the republic.

It is necessary to increase public funding in order to carry out major repairs, modernization and construction of new digital power plants in rural remote areas.

In order to reform the volume of fuels and lubricants, government measures should be strengthened to ensure transparency in the production and distribution of petroleum products. It is necessary to reduce the shortage of diesel fuel through the establishment of a differentiated pricing policy. Here it is necessary to distribute fuel and lubricants and liquefied gas to farmers at reasonable prices for spring and autumn field work. To support the agro-industrial complex, it is required to introduce a ban on the export of petroleum products by road.

From the standpoint of transforming the market for the supply of fuel and lubricants for farmers, it is required to introduce an electronic fuel distribution system. Such an information system will provide an opportunity for agricultural producers to independently purchase the required volume of petroleum products at reasonable prices.

It is necessary to increase the volume of oil refining and the production of fuels and lubricants before the spring-autumn field work for farmers.

At present, it is necessary to continue measures for the digitalization of the National Electric Grid. Here it is required to strengthen the production capacities of the energy system of the Southern and Western zones.

In order to increase the investment attractiveness of the energy sector and the agro-industrial complex, in our opinion, it is necessary to develop tools for capital inflow in the "single document" mode based on digital technologies. This will stimulate petrochemical and agricultural plants to produce high value-added products.

In our opinion, it is necessary to develop measures to increase the digitalization of energy saving and achieve energy efficiency. It is necessary to intensify the use of energy-saving technologies in the real sector of the economy, where energy consumption is highest. This will lead to increased diversification and growth of the national economy.

From our point of view, it is necessary to invest in projects to introduce digital energy storage systems. As a result of the accumulation of energy, it can be redistributed, especially during peak hours. Such maneuverable technical capacities will make it possible to reduce the deficit and promptly reload the required amount of electricity. This accumulation process can be implemented in the construction of new digital renewable energy facilities and gas stations.

We believe that it is necessary to carry out measures to reorient the oil and gas industry on a regular basis. This will accelerate the transition from raw material orientation to the production of goods with high added value.

Measures should be developed for the use of an automatic system for monitoring emissions of harmful substances and cleaning flue gases. This will provide an opportunity to improve the ecological situation and preserve nature.

It is necessary to continue work to identify illegal subjects of digital mining. It is also necessary to adopt legal instruments and restrictions on miners in order to reduce the shortage and import of electricity.

As a result of the implementation of the above proposals and recommendations, this will make it possible to achieve food, environmental and national security with the aim of sustainable development of the digital energy sector and the agro-industrial complex of Kazakhstan.

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