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ELECTRICITY CONSUMPTION ISSUES IN THE AGRO-INDUSTRIAL COMPLEX OF KAZAKHSTAN

ҚАЗАҚСТАННЫҢ АГРОӨНЕРКӘСІПТІК КЕШЕНІНДЕ ЭЛЕКТР ЭНЕРГИЯСЫН ТҰТЫНУ МӘСЕЛЕЛЕРІ

ВОПРОСЫ ПОТРЕБЛЕНИЯ ЭЛЕКТРОЭНЕРГИИ В АГРОПРОМЫШЛЕННОМ КОМПЛЕКСЕ КАЗАХСТАНА

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Abstract. Conservation and reasonable consumption of electricity is an important direction in the process of production, storage and processing of agricultural products. *Aim - the* role of energy in agro-industrial complex is outlined, ways of using alternative energy sources and energy efficient technologies in the agrarian sector of Kazakhstan are determined. *Methods* - analysis and systematization to calculate volumes and identify economic links in livestock and crop production at the regional level. The method of generalizations allowed us to focus on the systematization of problems of creating energy infrastructure in remote rural areas. *Results* - review of foreign and domestic literature from the position of modern achievements in agro-industrial production and energy on the example of economically developed countries; reflected the issues of modern development of the agrarian industry of the republic on the basis of the analysis of gross output of agricultural products and goods; showed the level of regional economy of the country, analyzed the consumption of electricity in rural areas from 2015 to 2024; assessed the coverage of the spread of renewable energy resources, which over the past 11 years. Suggestions for the need to increase the generation of the electric system are justified. *Conclusions* - a positive relationship between the rate of capacity building in the agro-industrial complex and the introduction of energy saving processes based on increasing productivity in the agricultural sector has been established; the use of energy saving sources stimulates the development of rural areas and the improvement of social conditions of agricultural producers.

Аңдатпа. Электр энергиясын сақтау және орынды пайдалану ауыл шаруашылығы өнімдерін өндіру, сақтау және қайта өңдеу процесіндегі маңызды бағыт болып табылады. *Мақсаты* - АӨК-дегі энергетиканың рөлі айқындалды, Қазақстанның аграрлық секторында баламалы энергия көздері мен энергия тиімді технологияларды пайдалану жолдары айқындалды. *Әдістер* - өңірлік деңгейде мал шаруашылығы мен өсімдік шаруашылығындағы экономикалық байланыстардың көлемін есептеу және анықтау үшін талдау және жүйелеу. Жалпылау әдісі шалғайдағы ауылдық аудандарда энергетикалық инфрақұрылым құру проблемаларын жүйелеуге баса назар аударуға мүмкіндік берді. *Нәтижелер* - шетелдік және отандық әдебиетті агроөнеркәсіптік өндіріс пен энергетикадағы қазіргі заманғы жетістіктер тұрғысынан шолу; ауыл шаруашылығы өнімдері мен тауарларының жалпы шығарылымын талдау негізінде республиканың аграрлық саласын қазіргі заманғы дамыту мәселелері көрсетілген; елдің өңірлік экономикасының деңгейі көрсетілді, 2015 жылдан 2024 жылға дейін ауылдық жерлерде электр энергиясын тұтыну талданды; соңғы 11 жылда аграрлық салада тұрақты өсуді көрсететін жаңартылатын энергия көздерінің таралуын қамту бойынша баға берілді, агроөнеркәсіптік кешен үшін энергия объектілерінде шектеулер байқалады, қайта өңдеу өнеркәсібі, тамақ өнімдерін шығару үшін энергетикалық табиғи ресурстарды ұтымсыз пайдалану, энергияны үнемсіз тұтынуға байланысты фермерлердің өндірістік шығындарының өсуі орын алады. Электр жүйесін генерациялауды арттыру қажеттілігі бойынша ұсыныстар негізделген. *Қорытынды* - аграрлық секторда өнімділікті арттыру негізінде АӨК әлеуетін арттыру қарқыны мен энергия үнемдеу процестерін енгізу арасында оң өзара байланыс орнатылған; энергия үнемдейтін көздерді пайдалану ауылдық аумақтарды дамытуды және ауыл шаруашылығы өндірушілерінің әлеуметтік жағдайларын жақсартуды ынталандырады.

Аннотация. Сохранение и разумное потребление электроэнергии важное направление в процессе производства, хранения и переработки сельхозпродукции. *Цель* - обозначена роль энергетики в АПК, определены пути использования альтернативных источников энергии и энергоэффективных технологий в аграрном секторе Казахстана. *Методы* - анализа и систематизации для расчета объемов и выявления экономических связей в животноводстве и растениеводстве на региональном уровне. Метод обобщений позволил сделать акцент на систематизацию проблем создания энергетической инфраструктуры в удаленных сельских районах. *Результаты* – обзор зарубежной и отечественной литературы с позиции современных достижений в агропромышленном производстве и энергетике на примере экономически развитых государств; отражены вопросы современного развития аграрной отрасли республики на основе анализа валового выпуска продуктов и товаров сельского хозяйства; показан уровень региональной экономики страны, проанализировано потребление электроэнергии в сельской местности с 2015 по 2024 гг.; дана оценка по охвату распространения возобновляемых энергоносителей, которые за последние 11 лет демонстрируют устойчивый рост в аграрной сфере, отмечаются ограничения в энергообъектах для агропромышленного комплекса, имеют место нерациональное использование энергетических природных ресурсов для перерабатывающей промышленности, выпуска продуктов питания, рост производственных затрат фермеров ввиду неэкономного потребления энергии. Обоснованы предложения по необходимости повышения генерации электросистемы. *Выводы* – установлена положительная взаимосвязь между темпами наращивания потенциала АПК и внедрением энергосберегающих процессов на основе увеличения производительности в аграрном секторе; использование энергоэкономичных источников стимулирует развитие сельских территорий и улучшение социальных условий сельхозпроизводителей.

Keywords: agribusiness, energy, renewable energy, energy efficiency, energy infrastructure, processing potential, food, improving farmers' conditions.

Түйінді сөздер: агроөнеркәсіптік кешен, энергетика, жаңартылатын энергия көздері, энергия тиімділігі, энергетикалық инфрақұрылым, өңдеу өнеркәсібінің әлеуеті, азық-түлік, фермерлердің жағдайын жақсарту.

Ключевые слова: агропромышленный комплекс, энергетика, возобновляемые источники энергии, энергоэффективность, энергетическая инфраструктура, потенциал перерабатывающей промышленности, продукты питания, улучшение условий фермеров.

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Introduction

The AIC is a fundamental component of the global economy, especially playing a key role in the economies of developing countries. Being the main source of food, it also provides a significant share of the world's income and employment. According to FAO (Food and Agriculture Organization of the United Nations…) [1], the agricultural sector employs 67% of the world's population. It accounts for almost 40% of GDP and more than 40% of global exports. And analysts are confident that the importance of this sector will only increase in the future. Important changes in production activities demonstrate significant changes in the agrocomplex caused by technological innovations, climate challenges and increased energy consumption.

The volume of total agricultural production in Kazakhstan for 6 months of 2024 amounted to 1.6 trillion tenge. The greatest contribution here was made by an increase in production in livestock farming by 3.5% and in crop production - 3%.

Kazakhstan's energy sector plays a key role in the national economy, including in the AIC. The country has sufficient quantities of: oil, gas and coal. In RK, 60 449 billion kWh of electricity were produced in the first six months of 2024. The consumption volume amounted to 60 169 billion kWh. In particular, the share of renewable energy sources (RES) includes 6.47% for the noted period (Half-year results in the energy sector…) [2]. The modern AIC is characterized by high energy intensity, which is due to the use of energy intensive technologies at all stages of production. Energy, especially renewable energy sources, has a multifaceted impact on the AIC. It not only helps reduce costs and improve the efficiency of food products, but also stimulates the macroeconomic development of the industry as a whole.

Rising gas prices can stimulate Kazakhstani agricultural companies to accelerate the introduction of RES. In addition, active implementation will reduce dependence on external energy supplies. Increasing agricultural production is impossible without significant energy costs. This is especially true in such energy-intensive processes as: irrigation, harvesting, mechanization and transportation. Affordable and stable energy accelerates the development of the AIC, increasing production and reducing costs.

Despite the fact that reforms are being implemented to a certain extent, there are still problems in improving the development of the energy system for the AIC. The main problem is that there is no mass production and purchase of means of generating electricity from natural energy sources, such as wind and solar radiation. In addition, their use, especially in remote rural areas, is at a low level. At the same time, today the aspects of efficient distribution and consumption of electricity in the AIC, including agriculture, are acute. The issues of modernization and construction of energy infrastructure and assessment of the potential for energy saving in order to optimally provide agricultural producers in the regions of Kazakhstan require a serious solution.

Therefore, improving energy efficiency in the AIC is one of the key areas of sustainable development RK. This will reduce production costs, reduce the negative impact on the environment and increase the competitiveness of agricultural products.

Literature Review

Zhang J., Drury M. [3] characterized the process of stable organization of the agrarian sphere and its impact on the economy as a whole. According to Xu J., Li Y., Zhang M. et al. [4], digital technologies are a significant incentive for optimizing the activities of the AIC. At the same time, attracting investments in research projects serves as a guarantor of ensuring food security of the country, this is indicated by Cimino A., Coniglio I., Corvello V. et al. [5] in their scientific article. As noted by Dimitrijević M.S. [6], in 2023 these technologies will contribute to the qualitative and quantitative growth of food production in the global economy. Other scientists Hales J., Kemper J., White S. et al. [7] noted that human health, the level of food security, and the growth of food quality are completely dependent on the development of the agricultural sector.

In the study, Zor U., Esen A., Canbulut M. et al. [8] focused on the approaches of existing digital tools, the organization and implementation of agro-innovative methods in rural regions of the state. In recent years, due to the growth of the world population, the demand for agricultural products has increased. For example, in the article by Sun Z., Zhan Y., Liu L. et al. [9] the influence of stabilization of the AIC, which directly affects the quality of life and population growth, is studied.

Sustainable development of the agrarian sphere directly affects the achievement of food security. In addition, the development of other industries that supply means of production for agriculture depends on it. In the work of Akimbekova G.U., Nikitina G.A. [10], important aspects of the development of the agricultural sector are presented, and recommendations

and priority vectors for improving the development of the economy of the AIC of Kazakhstan are highlighted. In the article by Boros A., Gordos B., Tőzsér D. [11] a bibliometric analysis of the relationship between sustainable water resources management and green innovations in the AIC is given. According to Luan X., Yasmeen R., Shah W. [12]. the efficient use of energy resources in the AIC with minimal damage to the environment is a common global problem.

According to Ren Renewable energy statistics (Ren Renewable energy statistics) 13], this approach makes agriculture more sustainable and environmentally friendly. The development of the energy sector affects the economic growth of Kazakhstan, including the agro-industrial complex – this is emphasized by Smagulova Sh., Chereeva B., Zhakupova S. et al. [14]. The work of Emezirinwune U., Adejumobi I.A., Adebisi O.I. et al. [15] emphasizes the critical need for the integration of energy and agriculture. The sustainability of rural areas directly depends on the level of development of the agro-industrial complex as a whole.

Materials and methods

The methods of logic and generalization were used for argumentation and meaningful presentation of the results of scientific research on ensuring energy efficiency in agricultural production. In order to assess foreign practical experience, the article used the method of critical analysis of scientific literature. From the position of measuring the level of gross output of agricultural products and comparative assessment of the degree of possible energy consumption in the agricultural sector, empirical research methods were used.

The analysis and systematicity methodology used in the noted work made it possible to identify facts and certain evidence for the introduction of non-renewable energy sources in the national economy. In our opinion, energy resource conservation is an important condition influencing the favorable organization and formation of agricultural sectors. All these materials and provisions are reflected in the adopted Concept of Development of the AIC of Kazakhstan for 2021–2030 (On approval of the Concept for the development of the agro-industrial complex…) [16].

Statistical materials for scientific research on achieving energy efficiency in the agro-industrial complex sectors are documents of international energy and agricultural organizations (for example, FAO), the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the RK, the Ministry of Agriculture of the Republic of Kazakhstan, the Ministry of Energy of the Republic of Kazakhstan etc.

Results

Agriculture is an important branch of the agro-industrial complex, which annually attracts about 38% of the budget's income. It can be noted that the agriculture of our republic is in 2nd place in the world in terms of growing grain crops - 967 kg per 1 person. True, the productivity of livestock is quite low and here RK ranks 142nd in the world (Bureau of National Statistics Agency…) [17]. The dynamics of GDP output in agriculture in Kazakhstan for 2013-2023 in table 1 shows sustainable changes that are associated with a number of economic and natural factors, as well as the level of technical and energy support.

Table 1 – Total agricultural output, 2013-2023, million tenge

Years	Agricultural output	Including:		
		plant products	livestock products	agricultural services
2013	2 949 485.0	1 683 851.4	1 256 871.7	8 761.9
2014	3 143 678.1	1 739 436.4	1 393 762.0	10 479.7
2015	3 307 009.6	1 825 236.7	1 469 923.1	11 849.8
2016	3 684 393.2	2 047 580.8	1 621 541.4	15 271.1
2017	4 070 916.8	2 249 166.9	1 810 914.1	10 835.8
2018	4 474 088.1	2 411 486.7	2 050 455.8	12 145.6
2019	5 151 163.0	2 817 660.6	2 319 496.7	14 005.7
2020	6 334 668.8	3 687 310.3	2 637 460.7	9 897.9
2021	7 515 433.5	4 387 236.5	3 116 973.5	11 223.4
2022	8 407 512.0	5 808 259.8	2 545 267.4	14 162.5
2023	7 625 150.9	4 552 416.7	3 012 510.4	11 606.6
Changes in the corresponding indicator in 2023 compared to 2013, %	258.5	270.3	239,6	132,5
Note: compiled based on data from source (Bureau of National Statistics Agency…) [17]				

Let us emphasize that the production of agricultural goods increased more than 2.5 times in 2013-2023. Analysis of the indicators in the table shows that in the period from 2013 to 2015 there was a moderate growth in GDP output in agriculture in RK. We believe that such growth is associated with the implementation of state programs to support agriculture. One of these programs was "Agribusiness-2017", aimed at increasing the efficiency of agricultural production. A significant impact here was on the development of crop production. In particular, the area sown with grain and oilseed crops increased. These crops have become an important component of the country's exports. In addition, the growth in demand for kazakh products from foreign markets, especially in the countries of Central Asia (CA) and China, played a role here.

It should be noted that from 2016 to 2018, a decrease in the rate of growth in the agricultural sector is visible. The reason for this was the economic crisis that began in 2015-2016. The crisis was caused by the fall in world oil prices. The fall in oil prices has had a negative impact on the economy of RK as a whole, which, in turn, has affected the state of agriculture. Financial difficulties have limited farmers' access to credit resources. Climate change and droughts in some regions of the country have had a negative impact on grain yields.

In 2019, the agricultural economy began to recover, thanks to improved prices for products and additional government support. However, the COVID-19 pandemic in 2020 made its own adjustments. Thus, on the one hand, the imposed restrictions disrupted logistics chains, which led to a decrease in export volumes. On the other hand, the pandemic caused an increase in demand for food products in the domestic market, which partially offset the losses. The increase in exports of grain crops and meat products, thanks to the government's efforts to diversify sales markets, in our opinion, has successfully affected the development of the entire AIC.

Thus, the total production of goods in total monetary terms in 2023 amounted to 7 625.2 billion tenge, which is 8.4% lower than in 2022. In 2023, RK faced drought in some regions, which negatively affected the yield of major agricultural crops, such as wheat and barley. In addition, from our point of view, the negative factors were: a decrease in sown areas, an economic crisis, and a lack of investment. Thus, the decline in this industry is the result of the complex impact of natural, economic and structural factors. In the regional context, for 6 months of 2024, the highest rates were achieved by Turkestan, Kostanay, Zhambyl, Almaty and other regions (table 2). In addition, the amount of investment in fixed assets increased here by 5.4% or 68.7 billion tenge compared to the same period of the first two quarters of 2023 (Bureau of National Statistics Agency… livestock farming in the RK) [18].

Table 2 - Gross agricultural output by region, 2023, million tenge

Regions of RK	Agriculture, forestry and fisheries		Including production:						
			agriculture		plant growing		animal husbandry		agricultural services
	2023	FVI 2023 in % to 2022	2023	FVI 2023 in % to 2022	2023	FVI 2023 in % to 2022	2023	FVI 2023 in % to 2022	2023
RK	7 25 150.9	91.7	7 576 533.7	91.6	4 552 416.7	85.9	3 012 510.4	104.5	11 606.6
Abai	432 956.1	104.3	432 232.0	104.2	211 615.9	105.6	220 432.5	102.7	183.6
Akmola	698 041.5	73.2	693 610.9	73.1	397 746.2	62.0	295 682.5	106.6	182.2
Aktobe	361 588.6	97.8	358 818.7	97.5	169 544.4	92.1	188 724.3	104.0	550.0
Almaty	704 756.2	99.7	700 471.6	99.6	370 238.1	96.1	328 792.6	104.9	1 440.8
Atyrau	117 916.7	100.1	115 021.0	99.8	52 411.2	97.3	61 595.4	102.2	1 014.3
West Kazakhstan	290 502.1	99.8	290 337.3	99.8	118 070.4	95.9	171 335.7	103.2	931.3
Zhambyl	523 804.7	96.8	521 477.1	96.7	338 858.0	93.8	180 670.0	102.8	1 949.1
Zhetysu	456 542.1	101.7	455 838.7	101.7	283 085.1	102.5	172 258.6	100.3	495.0
Karaganda	427 955.2	94.8	426 924.9	94.7	239 411.2	90.5	187 152.6	101.9	361.1
Kostanay	642 072.8	83.2	639 493.3	83.1	501 499.7	80.3	136 753.1	102.4	1 240.6
Kyzylorda	217 064.0	103.4	214 170.9	103.8	151 841.4	105.0	61 827.3	101.3	502.3
Mangistau	32 715.5	105.1	32 052.3	107.3	5 012.4	103.7	27 032.2	108.2	7.8
Pavlodar	391 833.6	85.6	390 320.3	85.5	205 957.9	73.3	184 246.9	112.5	115.5

North Kazakhstan	760 684.5	83.2	757 523.8	83.2	577 626.4	79.7	179 154.0	104.4	743.4
Turkestan	971 965.3	102.6	963 616.4	102.4	637 631.6	101.7	325 236.1	104.1	748.7
Ulytau	70 652.6	72.8	70 636.2	72.8	14 825.9	39.8	55 804.4	97.7	5.9
East Kazakhstan	465 777.3	98.8	459 581.7	98.6	258 133.5	91.8	201 240.8	110.3	207.4
Astana	3 730.8	113.4	597.8	101.9	415.4	103.3	177.7	98.5	4.7
Almaty	5 742.5	92.9	5 053.6	88.8	4 718.4	96.6	333.8	40.9	1.5
Shymkent	48 848.9	100.0	48 754.9	99.8	13 773.6	81.1	34 059.8	112.5	921.5
Note: compiled based on data from source (Bureau of National Statistics Agency…crop production in the RK) [19]									

The data in table 2 demonstrate that North Kazakhstan and Kostanay regions remain key grain producers in Kazakhstan. Grain production here has been growing steadily, which, in our opinion, was due to government support for the grain sector, including through subsidies and preferential lending programs for farmers.

The southern regions of Kazakhstan (Zhambyl, Almaty, Turkestan regions) specialize in growing vegetables, fruits and other crops that require favorable climatic conditions. Here, active support from the state, including programs to support irrigated agriculture, played an important role.

In Western Kazakhstan, Mangistau and Aktobe regions, according to our research, face the difficulties in agricultural production due to unfavorable climatic conditions and limited access to water. Since 2019, there has been an increase in livestock production in these regions. In our opinion, this is due to the development of livestock support programs, including the provision of subsidies for forage crops. In addition, the growth of meat exports, especially to the countries of the Middle East and CA.

This study places greater emphasis on the development of the Zhambyl region. This region performs a significant role in the agricultural economy of Kazakhstan. This value depends on favorable natural conditions for the activities of agricultural industries. Important vectors of the agricultural sector of the Zhambyl region include crop production, livestock farming, and processing of agricultural products.

According to the data in the table above, it can be seen that the number of agricultural products produced in the region has increased. For example, in 2010, production was at the level of 99 374.6 million tenge, and already in 2023 it increased and amounted to 521 477.1 million tenge. This characterizes a significant increase in agricultural output. Such achievements, from our point of view, can be associated with significant government subsidies, support for republican financing based on government programs, as well as the allocation of regional funds.

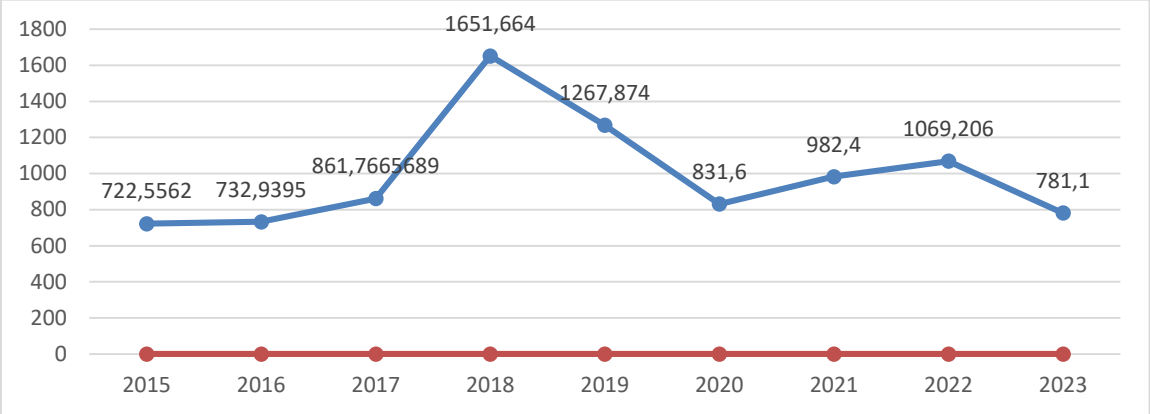
In the Zhambyl region, the main emphasis is on the cultivation of grain crops, including wheat, barley, as well as oilseeds and industrial crops. The area of crops in the region has increased significantly, which is associated with government programs to support agriculture, for example, the «Agribusiness-2020» program. The leaders in the production of agricultural products are the Shuya and Kordai districts, with output of 111 389.1 million tenge and 80 382.3 million tenge for 2023. At the same time, Zhambyl and Baizak districts in 2023 produced products worth 65 351.9 million tenge and 64 159.7 million tenge, respectively.

Livestock farming in the region is focused on cattle breeding, sheep and poultry farming, meat and milk production. The number of cattle in the region has been steadily increasing by 2-3% annually. Meat and milk production have grown due to the introduction of modern technologies for feeding and caring for animals. In our opinion, the growth in agricultural production is associated with the introduction of digital technologies in the agricultural sector. We believe that the increase in the volume of food production is also associated with some use of innovations in the agricultural sector. This is supported by government support measures, active investment in the industry and the implementation of various agro-industrial complex programs.

The AIC is the largest consumer of electricity. Energy costs make up a significant part of the cost of agricultural products. Traditional energy sources, such as: coal, oil and gas - are characterized by price instability on the world market. In addition, the equipment used for their extraction and processing wears out over time, which leads to an increase in production costs. As a result, the cost of products manufactured using these types of fuel becomes higher and less predictable. It should be noted that currently agricultural sectors are based on large energy costs. This is especially observed in such activities as: irrigation, processing,

heating of greenhouses and vegetable storage facilities, etc.

From our point of view, the use of different types of RES: solar, water and wind energy, will obviously reduce the dependence of agricultural sectors of the economy on the use of large quantities of coal and gas. This is relevant in remote regions of Kazakhstan, where access to traditional energy sources is limited. Electricity consumption in agriculture can be seen in figure 1.



Note: compiled based on data from source (Bureau of National Statistics Agency…crop production in the RK) [19]

Figure 1 - Final consumption of electricity in agriculture, 2015-2023, %

From figure 1, we can observe the electricity consumption in the agricultural sector from 2015-2023. In the period 2015-2019, there is an increase in electricity consumption, in 2015, consumption was 7 225 562, gradually rising in 2019 by 1 267 874. This trend is observed due to the improvement in product prices and additional government support. In 2020, the volume of electricity consumption was 831 600, which is several times lower than in previous years. In our opinion, the COVID-19 pandemic, the deterioration of the state of the agricultural machinery fleet, and the restrictions adopted have led to a decrease in food production and exports.

In recent years, a trend of increasing electricity consumption can be seen. For example, in 2022, energy consumption increased to 1 069 206 units. In the post-pandemic period from 2021 to 2023, there is a positive trend in agricultural output. The growth of agricultural production due to increased investment, good weather conditions and overall global demand for agricultural products had a positive effect on electricity consumption. Energy saving has become an urgent problem for Kazakhstan in the last 10-15 years. The analysis showed that the limited and depreciated energy capacity, the high cost of energy production, and the lack of use of renewable energy sources have a negative impact on the production of food products.

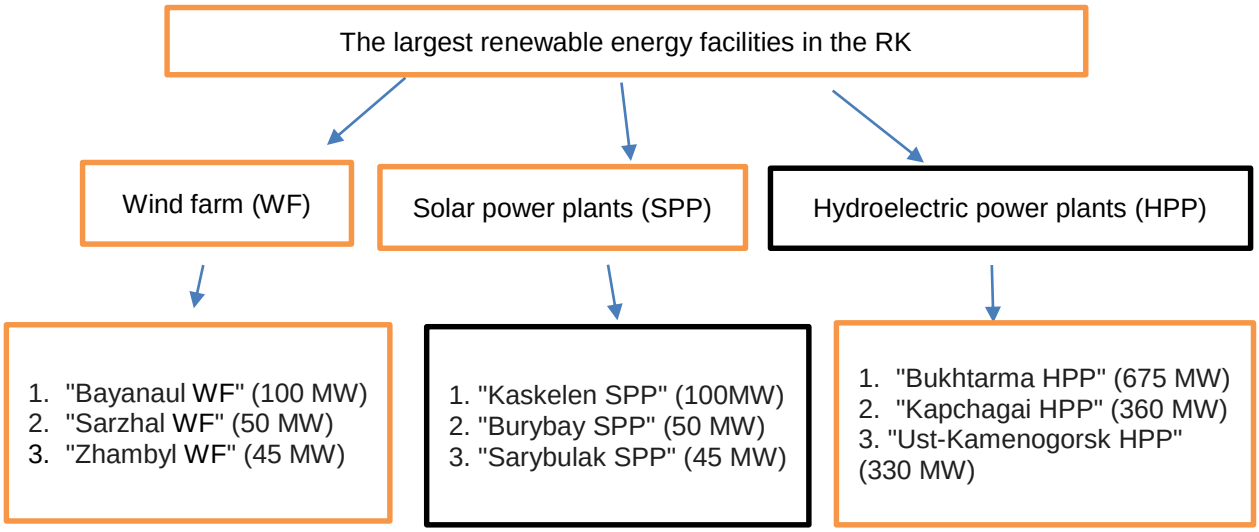
The use of innovative technologies: for example, drones, monitoring systems based on artificial intelligence, precision farming, helps to optimize agricultural processes. These technologies help to better manage resources, increase yields and reduce costs. To implement these innovative technologies in the AIC, high electricity consumption is necessary. It is worth noting that renewable energy sources have an important influence here. These include solar, hydro and wind installations, which can provide a stable power supply in remote rural areas. In our opinion, the introduction of autonomous solar systems for irrigation, heating greenhouses and storing products will reduce fuel costs and make farms more energy independent.

It should be noted that the volume of electricity generated by stations in 2023 amounted to 5.9%. This figure is 34% higher than in 2022 (or 4.4%). Over the past 10 years, the RES in RK has demonstrated significant growth (table 3).

We can see that table 3 shows an increase in the construction of renewable energy power plants by more than 10 times. In particular, the country is experiencing an increased influx of investment in new renewable energy facilities. For example, in 2023 alone, 10 new renewable energy power plants were built, with a production capacity of about 450 MW (On approval of the Concept for the development of the electric power industry…) [21]. Note that as of autumn 2024, the total number of renewable energy power plants is 206 units. This is about 5% of the total electricity generation. Figure 2 shows the largest renewable energy facilities in Kazakhstan.

Table 3 - Development of RES in Kazakhstan, 2013 to 2023

Indicator	Year											Changes in indicators in 2023 compared to 2013, times
	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	
RE capacity (MW)	178	228	333	444	555	777	1 000	1 222	444	1 666	1 800	10.1
Share of RE in generation, %	0.3	0.4	0.5	0.8	1.0	1.4	1.8	2.2	2.6	3.0	3.5	11.7
Note: compiled based on data from source (Ministry of Energy of the Republic of Kazakhstan….) [20]												



Note: compiled based on data from source (Kazakhstan power grid management company…) [22]

Figure 2 – Renewable energy facilities in Kazakhstan

By the end of 2024, the Government plans to build 6 more new renewable energy stations, the production capacity of which is projected to be about 197.1 MW. Renewable energy stations play a significant role in the organization and operation of the agricultural sector, including in the Zhambyl region. Thus, these facilities provide an opportunity to increase energy efficiency and optimize the costs of farmers and households. In particular, 22 new renewable energy stations with a capacity of up to 552.1 MW have already been built in the Zhambyl region. Thus, this includes 6 state district power plants with a capacity of 24.7 MW, 10 wind power plants (WPP) with a capacity of 276.2 MW, as well as 6 solar stations with a capacity of up to 252.1 MW.

Our study found that WPPs in the Zhambyl region are leaders in relation to other renewable energy facilities in terms of the volume of energy generated and the number of built projects. In particular, Zhanatas Wind Power Plant LLP set a new record for Central Asia by building a 100 MW wind power plant consisting of 40 turbines. The location of the wind power plant in the Sarysu district was not chosen by chance. The region is characterized by stable winds with an average speed of 7-8 meters per second, which makes it ideal for generating electricity from the wind.

The use of RES in the agricultural sector shows favorable preconditions for increasing energy efficiency and reducing energy costs. For this purpose, the government issues subsidies and various grants for the introduction of NRE stations in agricultural production. This helps to reduce energy costs and increase the profitability of agro-industrial enterprises. The energy sector, performing an important function in ensuring sustainable economic development, is in the process of active transformation in the context of modern globalization.

The abundance of sun in the south of Kazakhstan has provided advantages for the construction of innovative solar power plants (SPP). For example, in the Zhambyl region, the first SPP "Otar" with a capacity of 7 MW was built more than 10 years ago.

Energy, in particular renewable energy sources, has a significant impact on the development of the agro-industrial complex. Renewable energy sources affect the growth of production efficiency, cost optimization and reduction of coal and gas costs.

In our opinion, decentralization of energy production plays a special role here. In other words, in remote rural regions of Kazakhstan, it is necessary to install mini power plants using renewable energy sources so that farmers can use electricity in the production process next to consumption. This will ensure high efficiency and efficiency of energy consumption by agricultural producers.

It should be noted here that building large power plants in rural areas is unprofitable. But we believe that the construction and commissioning of mini power facilities based on renewable energy sources is quite justified from an economic point of view. In addition, this will allow for the expansion of the intellectualization of the renewable energy infrastructure based on the use of innovative technologies – “artificial intelligence”, etc. At the same time, as necessary, rural consumers will independently adjust their electricity consumption.

Therefore, the application of innovation and digitalization using the RES will enable us to predict and op-timize the operating modes and energy con-sumption in rural areas. Renewable energy sources help reduce energy dependence and costs in the agro-industrial complex. Integra-tion of renewable energy sources into agricul-ture improves energy supply to production fa-cilities. This reduces the risk of downtime caused by a lack of electricity or its unstable supply. The introduction of renewable energy sources in the agroindustrial complex stimulates the development of innovative technologies.

Discussion

The economic assessment carried out in this study confidently demonstrated that over the past 20 years, the energy intensity of production facilities in the agricultural sector has gradually increased. Thus, energy consumption in the AIC of Kazakhstan has increased by more than 100 - 150%. At the same time, the increasing wear and tear of agricultural machinery, the use of outdated agricultural technologies, the lack of mineral fertilizers and agricultural engineering personnel, and the constant increase in the cost of energy resources have led to a grave situation in the AIC.

The deficit remains one of the main problems faced by farmers. Therefore, we believe that the construction of reservoirs and various irrigation systems using RES will have a positive impact on the volume of non-irrigated land.

Deterioration of power plants and networks leads to frequent accidents, power outages and a decrease in overall energy efficiency. Unstable power supply has a negative impact on agricultural enterprises. Reduced productivity due to power outages can lead to crop losses and reduced income for farmers.

A major obstacle to the use of renewable energy sources is their dependence on natural factors. Wind turbines and solar panels depend on weather conditions, which makes the energy supply unstable. One of the key problems of the AIC in Kazakhstan is the insufficient development of energy infrastructure in remote agricultural areas, especially in the southern and western parts of the country.

The introduction of renewable energy sources can solve many of these problems, making the agro-industrial sector more sustainable and environmentally friendly. There is a shortage of electricity production based on alternative sources for the agricultural sector, there is a lack of energy technologies to save consumption in the production of food products. Recommendations are presented for the integration of renewable energy facilities that facilitate the organization of additional food production, improve the state of the regional economy, increase energy capacity and reduce the costs of agricultural producers for energy consumption.

Conclusion

1. One of the important factors for stimulating gross production in the agro-industrial complex is the high-quality development of energy infrastructure in the regions of Kazakhstan. It is substantiated that the construction and commissioning of new renewable energy facilities play a significant role here.

2. An economic and statistical assessment of the final consumption of electricity in agriculture was carried out. It is shown that uneven energy consumption is associated with worsening weather conditions, the Covid pandemic, disproportionate inflow of investments, and wear and tear of equipment. At the same time, it is noted that some increase in energy consumption in the agro-industrial complex is based on measures of state support for agricultural producers.

3. Ensuring energy independence of agriculture allows improving the infrastructure of

rural areas, promotes the introduction of innovations, sustainable growth, improved productivity and competitiveness of the agricultural sector of Kazakhstan.

4. Obstacles and threats to the insufficient development of energy facilities in agricultural regions are revealed. There is a shortage of electricity generation from alternative sources of the agro-industrial complex, there is a lack of innovative energy saving technologies and innovations for the growth of agricultural output. Recommendations are given for the implementation and integration of renewable energy sources, which stimulate the development of regional economies, create favorable conditions for attracting investment in agriculture, increase production capacity and reduce agricultural producers' energy costs.

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