

# Energy conservation and energy efficiency improvement in Russian agribusiness

Liliya Akhmetshina<sup>1\*</sup> and Kirill Grabovyy<sup>2</sup>

<sup>1</sup>Financial University under the Government of the Russian Federation, 125993, Moscow, Leningradsky, 49, Russia

<sup>2</sup>Moscow State University of Civil Engineering, 26 Yaroslavskoye Shosse, 109377, Moscow, Russia

**Abstract.** Energy saving and increasing energy efficiency of agribusiness are aimed at producing higher quality agricultural products with minimal consumption of fuel and energy resources. At the same time, energy conservation implies a decrease in the need for energy capacities, a decrease in the energy intensity of production in general, and the introduction of energy-saving technologies. The aim of the study is to assess the state of energy efficiency in agricultural production and substantiate the need for the introduction of energy-saving technologies by agribusiness entities to ensure sustainable development and a high level of competitiveness of agricultural products. The study made it possible to identify the specific features of the energy supply of the agricultural sector and the main reasons for the high energy intensity and low energy efficiency of agricultural production. As a result of the study of promising developments in the field of energy conservation and existing energy-saving technologies, organizational and economic measures aimed at increasing energy efficiency and reducing the energy intensity of agricultural production were determined.

## 1 Introduction

Issues of energy saving and energy efficiency in the agricultural sector of the economy are among the priorities and will become increasingly important in the future. Reliable and efficient energy supply to agribusiness entities is the basis for sustainable development of the agrarian economy. The observed growth in energy consumption should be accompanied by an increase in the energy efficiency of agricultural production, since the energy intensity of manufactured products is one of the factors of its competitiveness. In addition, the increase in prices and tariffs for fuel and energy resources at a higher rate in comparison with prices for agricultural products leads to an increase in energy consumption in the cost structure. Optimal structure of the fuel and energy balance, the use of local energy resources, the transition to renewable energy sources, the processing of agricultural waste, the introduction of innovative energy and resource-saving technologies will reduce the cost of energy supply to agricultural producers, increase production volumes and ensure an increase in the efficiency of the agricultural sector of the economy in the whole. Saving

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\* Corresponding author: [akhmetshinalg@mail.ru](mailto:akhmetshinalg@mail.ru)

energy and improving energy efficiency also make it possible to reduce negative impact on the environment, reduce emissions of harmful substances and thermal pollution.

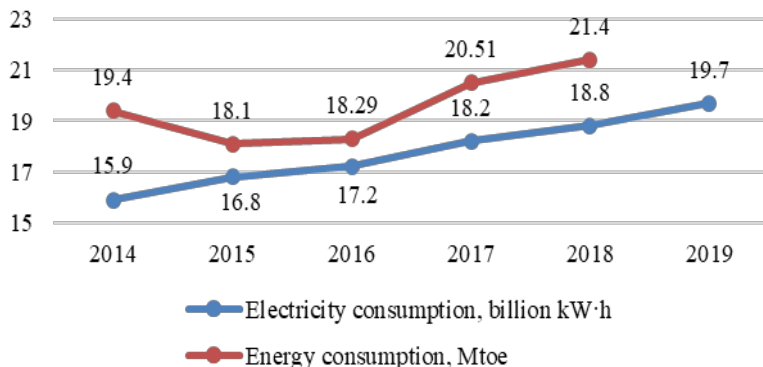
The peculiarities of the functioning of the agricultural sector of the economy associated with the use of biological factors of production (soil fertility, solar energy, precipitation, etc.) and energy resources of technogenic origin affect the system of energy consumption and distribution. Among the specific features of the energy supply of the agricultural sector are the territorial dispersion of consumers; large length of electrical, heating, gas networks; lack of centralized power supply in remote agricultural areas; low unit power. The main reasons for the high energy intensity of agricultural production and low energy efficiency are morally and physically obsolete technological equipment used in agricultural production; high costs of heat and electricity in animal husbandry; boiler houses with low efficiency and long heating networks; ineffective loading of operating technological units; uneconomical electric lighting systems, etc.

Existing studies reflect various aspects related to the provision and conservation of energy resources in agriculture [1, 2, 3]. However, the problems of rational use of fuel and energy resources by agribusiness entities, taking into account the increasing processes of mechanization and automation, require further study and development of applied aspects of the introduction of energy-saving technologies aimed at increasing the energy efficiency of agricultural production. The circumstances noted above determined the relevance of the study.

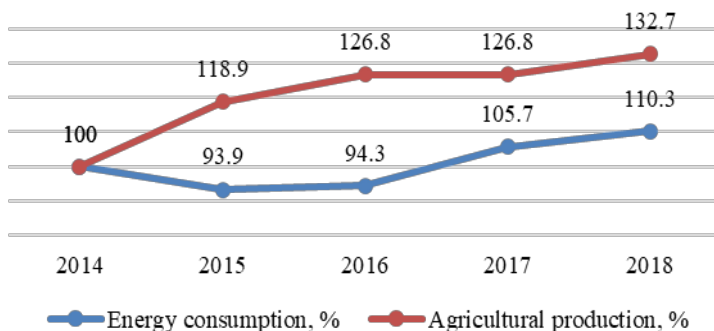
## **2 Materials and Methods**

The study was carried out on the basis of statistical data on energy and research materials on energy conservation and energy efficiency of agricultural production. As research methods, the study of various sources of information with the subsequent generalization of data, analytical and comparative methods were used.

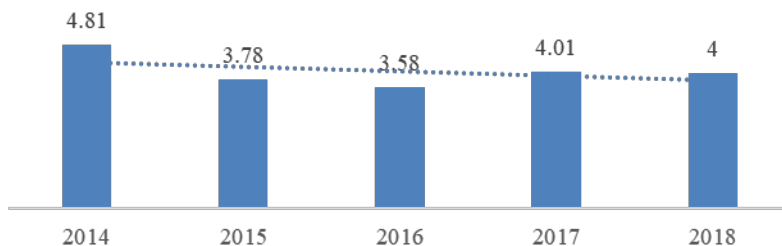
The agricultural sector is a consumer of various types of energy resources and has a significant energy potential. The main sources of energy are electricity, fuel processing products, heat energy. Electricity consumption for the period from 2014 to 2019 increased by 24% and amounted to 19.7 billion kWh (Fig. 1). Growth in agricultural production by 32.7% in 2014-2018 was accompanied by an increase in energy consumption by 10.3% (Fig. 2) [4]. The energy intensity of agricultural products decreased by 16.8% and amounted to 4 kg of oil equivalent/1000 rubles (Fig. 3). It should be noted that the energy intensity indicator is underestimated, since agricultural statistics do not take into account the consumption of energy resources by small forms of husbandry (micro-enterprises, peasant (farmer) households, household farms). In the structure of agricultural production, their share in 2019 accounted for 41.8% of agricultural production.



**Fig. 1.** Indicators of energy and electricity consumption in agriculture, hunting, forestry, fishing and fish farming in 2014-2019.



**Fig. 2.** Dynamics of indicators of agricultural production and energy consumption in 2014-2018.



**Fig. 3.** Energy intensity of agricultural products in 2014-2018, kg of o.e./1000 rubles.

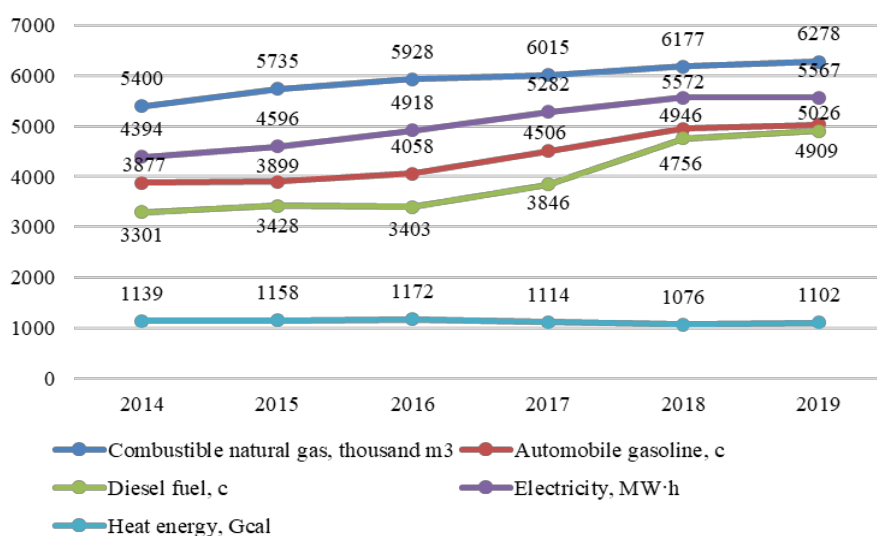
Fluctuations in the energy intensity of agricultural products are associated with such factors as weather conditions, an increase in tariffs for energy resources, which leads to their more economical use, the closure of more energy-intensive industries, changes in the productivity of agricultural production, a slow but existing process of introducing energy-efficient technologies. In peasant farms and household farms, there is a large share of manual labor, which also affects the energy intensity of products. The low level of mechanization of agricultural work leads to a decrease in crop yields and animal productivity, deterioration in the quality of agricultural products and, accordingly, a decrease in its competitiveness [5].

Despite the downward trend in the energy intensity of agricultural products, Russian agribusiness lags behind the leading countries in this indicator. Low energy efficiency of agricultural production is caused by more severe climatic conditions, low agricultural productivity, insufficient technical and organizational level of energy supply systems, lag in the introduction of innovative energy-saving technologies [3].

Table 1 shows the actual consumption of electricity, heat energy and fuel per unit of certain types of agricultural products in 2017-2019 [4]. For the types of agricultural products under consideration, the actual consumption of electricity is reduced for all types of products, with the exception of milk and dairy products, butter; thermal energy consumption is subject to fluctuations, but tends to decrease. Fuel consumption in kg of oil equivalent increases by 1 ton for all types of products, except for sugar, which with rising energy prices (Fig. 4) leads to an increase in energy consumption in the structure of the cost of agricultural products [4].

**Table 1.** Actual consumption of electricity, heat and fuel per unit of certain types of agricultural products in 2017-2019.

Product type	Electricity, kW·h/t			Heat energy, kcal / t			Fuel - all kg of o.e./t		
	2017	2018	2019	2017	2018	2019	2017	2018	2019
Meat and offal	224.8	198.2	183.1	151.5	101.6	107.1	8.2	7.9	11.1
Milk and dairy products	148.0	162.3	164.2	326.0	340.7	323.6	8.5	10.0	9.6
Butter	482.3	501.3	581.9	1424.7	1284.4	1257.3	41.6	51.0	58.3
Flour from cereals and other crops	111.8	90.9	94.6	38.8	29.3	26.4	1.3	1.8	0.9
Unrefined vegetable oils	118.2	116.0	118	393.9	379.3	354.1	5.2	7.4	10
Refined vegetable oils	106.0	102.8	96.7	256.6	253.4	250.4	3.0	3.1	3.4
Sugar	190.8	176.3	164.6	1568.9	1553.6	1447.3	25.1	23.8	22.4



**Fig. 4.** Average prices for certain types of energy resources purchased by agricultural companies in 2014-2019, rubles.

Thus, the most important task is to increase the efficiency of energy use, optimize energy consumption, and introduce energy-saving technologies.

### 3 Results

Energy supply to agribusiness entities can be centralized and decentralized. Decentralized energy supply is possible from various low-power generators: a local power plant, thermal energy from local boilers, power plants using local renewable energy sources (solar power plants, wind farms, etc.). The power supply system can have a different combination of power generation subsystems. However, the presence of a large number of small energy consumption objects: farms, complexes, greenhouses, storage facilities, warehouses, office buildings, etc., their dispersal, remoteness from power supply sources, uneven consumption during the day lead to large energy losses [6]. Low utilization rates of technological and power plants, outdated and worn out equipment and communications, the state of maintenance and repair, a reduction in the fleet of agricultural machinery, and a shortage of qualified personnel also lead to an increase in energy consumption.

The provision of agribusiness entities with energy capacities is characterized by such indicators as energy supply - energy capacities in hp per 100 hectares of sown area, and the power-to-labor ratio - power capacity in hp per 1 worker employed in agricultural production. The level of energy supply of agricultural companies during the period under study (2014-2019) almost unchanged and is about 200 hp per 100 hectares of sown area, the power-to-labor ratio increased by 11% to 83 hp per employee (Table 2).

**Table 2.** The level of provision of agricultural organizations with energy capacities in 2014-2019.

	2014	2015	2016	2017	2018	2019
Power supply, hp	201	197	200	198	200	199
Power-to-labor ratio, hp	74.7	74.3	77.1	74.5	80.2	83

Significant energy savings can be achieved through the introduction of energy-saving technologies. Certain activities are provided for each of the resources (tab. 3) [7,8].

**Table 3.** Energy saving technologies in agriculture.

Electricity	Fuel	Thermal energy
introduction of energy-saving lamps, the correct choice and rational placement of lamps, compliance with the electrical equipment work schedule	use of combined equipment in soil cultivation that allows reducing the number of passes of agricultural machines across the field	use of liquid boiler fuel from agricultural waste for heating
organization of effective lighting control and automation	timely maintenance and repair	heat recovery from livestock farms for water heating and space heating
rational construction of lighting networks	zero tillage technology	precise automatic regulation of temperature and humidity conditions
systematic and high-quality operation of lighting installations	use of mobile gas stations	introduction of heat pumps and ventilation control devices
maintenance of electrical equipment in good condition	use of biofuels - rapeseed oil - a cheaper alternative to diesel fuel, increasing the life of the engines	use of solar collectors and heat accumulators

Energy audit, improvement of energy consumption control and accounting, use of energy-saving machines instead of outdated and worn-out equipment are also effective

measures to reduce energy consumption. This should take into account the comprehensive nature of the relevant measures, the need to change the traditional approach to energy consumption. However, even partial implementation will lead to significant energy savings.

It is possible to significantly reduce energy costs through the use of digital technologies of precision farming and precision animal husbandry, which include geographic information systems (GIS), global positioning technologies (GPS), monitoring systems for agricultural machinery, continuous monitoring of the state of animals, robotization of the milking process, etc. to obtain the maximum volume of high-quality agricultural products, taking into account environmental safety standards [9].

The organization of a precision farming system will allow avoiding to use fields with depleted soil, exclude idle runs of equipment, re-processing of plots. Precision animal husbandry is aimed at ensuring the quality of livestock products, the readiness of animals for productivity.

The system of precision farming is based on the collection and analysis of information about the state of fields, equipping equipment with sensors, and the use of satellite navigation. Based on accurate maps of fields with all characteristics, starting from the boundaries of the terrain, the relief of each site, ending with the chemical composition of the soil, the level of moisture, the amount of radiation received, etc., which were compiled with the help of sensors, a map of the yield of each site is drawn up, the required amount of fertilizers, seeds, water, precise instructions for agricultural machinery going into the field are created. The plots are processed with minimal human intervention. Geographic information systems (GIS) are used to analyze the collected information about the state of the fields and develop practical recommendations for each plot.

The parallel driving system allows carrying out field work with maximum accuracy at any time of the day in conditions of poor visibility and strong dustiness, eliminating untreated or re-processed areas. It is based on satellite positioning (GPS), does not require high costs, is technologically simpler and more affordable, the effect is immediately noticeable. Satellite positioning also makes it possible to continuously monitor and analyze the operation of agricultural machinery. Remote control over the operation of equipment, the consumption of seeds and fuel is one of the energy-saving technologies in agriculture.

The system of precision animal husbandry involves electronic identification and monitoring of individual animals and herds, registration of data on processes (feeding ration, body temperature, activity, milk yield, weight gain), satisfaction of individual needs, automatic regulation of indoor climate, constant monitoring of animal health, quality of livestock products, robotization of production processes, etc.

A significant part of the demand for energy resources will be covered by the creation of decentralized autonomous energy supply systems based on local and renewable energy resources [10]. Small-scale energy systems can reduce dependence on centralized power supply, reduce the number of power outages, and provide power to remote areas. When choosing technology and equipment, one proceeds from the needs in volumes and types of energy, existing conditions and the availability of its own energy resources and renewable sources, the distance to centralized energy supply. The most effective technologies for agribusiness entities can be technologies for the processing of biomass and agricultural waste into high-quality energy carriers - gaseous, liquid, solid fuels for use in electric and heating plants, as well as bioconversion of manure into biogas and fertilizers, conversion and use of renewable energy.

The development of biogas technologies is promising from the point of view of resource and energy conservation. Biogas is used to produce various types of energy (heat, electricity and fuel). Waste from crop and livestock production in biogas plants provide organic fertilizer, protein and vitamin feed additives. The heat of the fermented mass is utilized using heat pumps.

The use of renewable energy sources is of particular relevance for agricultural production. Photovoltaic stations of modular type, wind power plants with a capacity of 0.1 to 100.0 kW, micro and mini hydroelectric power stations, etc. contribute to solving the problem of energy saving. Uninterrupted power supply and economy of diesel fuel guarantees the creation of combined solar-wind-diesel units (or a combination of them with traditional ones).

A lower energy intensity of agricultural products is observed in areas where organic farming methods are used, compared to traditional cultivation methods. This is mainly caused by savings in indirect energy costs, including feed production, heat production, steam, etc. The most significant savings in energy costs are provided by the use of soil-saving technologies in organic farms. However, the level of development of organic agribusiness in Russia [11] does not allow considering organic agriculture as a significant energy-saving factor of agricultural production.

## 4 Conclusions

Energy saving and improving energy efficiency of the Russian agribusiness will ensure its sustainable development and increase the competitiveness of agricultural products. The main tasks in this case are: meeting the growing needs for energy resources; uninterrupted, reliable power supply to production facilities; rationalization of the structure of the fuel and energy balance; self-sufficiency in energy in accordance with the available energy resources. The transition from traditional energy consumption to energy conservation requires a constant search and development of innovations, special knowledge and skills, and largely depends on the level of scientific support and staffing, consistency and complexity in solving energy supply problems. These circumstances imply carrying out fundamental and applied research in the field of agricultural energy, the development of rational energy supply systems, targeted government programs for the development of agricultural energy.

Promising areas of energy conservation and energy efficiency in Russian agribusiness are the following:

- constant monitoring and accounting of energy consumption;
- replacement of obsolete and introduction of energy-saving equipment;
- using cheaper plant-based fuels;
- energy-saving technologies for the production of crop and livestock products;
- energy-saving systems for providing microclimate in livestock buildings with utilization and recirculation of air heat;
- use of agricultural waste in biogas plants;
- cogeneration of energy based on renewable sources.

The most important energy and resource-saving area is smart agriculture technologies (precision farming and animal husbandry).

Solving the problem of energy conservation requires an integrated and systematic approach. It is necessary to increase the level of coordination of actions in a number of areas: regulatory support [12], organization and management, scientific support, technical and technological measures, tariff regulation, production of energy-saving equipment, economic incentives for energy conservation, training of personnel. In this regard, the proper coordination of the executive bodies of state power and non-governmental organizations, the creation of legal, economic and organizational prerequisites, the harmonization of the interests of the main participants in energy-saving activities becomes an indispensable condition for solving the problem of energy conservation and increasing energy efficiency.

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