

Artículo de investigación

Innovative Approaches to Energy Resource Saving and Use of Renewable Energy Sources to Reduce the Cost of Agro-Industrial Enterprises

Инновационные Подходы к Энергоресурсосбережению и Применению Возобновляемых Источников Энергии с Целью Сокращения Издержек Агропромышленных Предприятий
Enfoques innovadores para el ahorro de recursos energéticos y el uso de fuentes de energía renovables para reducir los costos de las empresas agroindustriales

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Abstract

This article is devoted to the relevant problem of development of innovative approaches to energy saving and the use of renewable energy sources in order to reduce the costs of agro-industrial enterprises. It is concluded that promising directions for achieving sustainable development of agro-industrial enterprises include minimizing costs, synergistic approach to the combination of natural and economic resources, maintaining balance among economic, ecological and social factors, innovative competitiveness, and long-term focus. On the basis of the materials described in the article, it is considered necessary to formulate the main conclusions:

Resumen

Este artículo está dedicado al problema relevante del desarrollo de enfoques innovadores para el ahorro de energía y el uso de fuentes de energía renovables con el fin de reducir los costos de las empresas agroindustriales. Se concluye que las direcciones prometedoras para lograr el desarrollo sostenible de las empresas agroindustriales incluyen minimizar los costos, un enfoque sinérgico de la combinación de recursos naturales y económicos, mantener el equilibrio entre los factores económicos, ecológicos y sociales, la competitividad innovadora y el enfoque a largo plazo. Sobre la base de los materiales descritos en el artículo, se considera necesario formular las principales conclusiones:

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- the efficiency of the activity of economic entities (including agro-industrial and agricultural producers) depends on the presence of innovative approaches to their management. At present, innovative technologies should be considered not only as a source of competitive advantages, but also as a tool to reduce costs in production, logistics, marketing, and other business processes;
 - renewable energy, which is based on modern high-tech technologies of the transformation of primary energy into energy sources, can become one of the key directions of costs optimization of agro-industrial and agricultural producers; this is confirmed by the practice and statistics obtained in the studies of the agro-industrial sector of the European Union, Asia, Eurasia, and Latin America;
 - for the Russian agro-industrial sector, the task of reducing costs is particularly acute, as the level of expenditures on energy supply is steadily increasing, which affects not only the profitability of business, but also its competitiveness. A sectoral energy model based on a combination of conventional and renewable energy sources has been developed to tackle this problem;
- La eficiencia de la actividad de las entidades económicas (incluidos los productores agroindustriales y agrícolas) depende de la presencia de enfoques innovadores para su gestión. En la actualidad, las tecnologías innovadoras deben considerarse no solo como una fuente de ventajas competitivas, sino también como una herramienta para reducir los costos en producción, logística, mercadeo y otros procesos comerciales;
 - La energía renovable, que se basa en tecnologías modernas de alta tecnología para la transformación de la energía primaria en fuentes de energía, puede convertirse en una de las direcciones clave de la optimización de costos de los productores agroindustriales y agrícolas; Esto se confirma por la práctica y las estadísticas obtenidas en los estudios del sector agroindustrial de la Unión Europea, Asia, Eurasia y América Latina;
 - Para el sector agroindustrial ruso, la tarea de reducir costos es particularmente aguda, ya que el nivel de gastos en suministro de energía aumenta constantemente, lo que afecta no solo la rentabilidad de las empresas, sino también su competitividad. Se ha desarrollado un modelo de energía sectorial basado en una combinación de fuentes de energía convencionales y renovables para abordar este problema;

the transition to renewable energy in the agro-industrial sector should be accompanied by energy audit and implementation of power management systems. This will determine the rational combination of energy resources used to ensure the normal functioning and sustainable development of agro-industrial and agricultural producers.

Keywords: Energy saving, agro-industrial enterprises, energy efficiency, renewable energy sources, energy-saving technologies, energy management, energy audit, innovations, bio-based economy

Аннотация.

Данная статья посвящена актуальной проблеме разработки инновационных подходов к энергоресурсосбережению и применению возобновляемых источников энергии с целью сокращения издержек агропромышленных предприятий. Сделан вывод, что перспективные направления достижения устойчивого развития агропромышленных предприятий включают в себя минимизацию издержек, синергический подход к сочетанию природных и экономических ресурсов, поддержание баланса между экономическими, экологическими и социальными факторами, инновационную конкурентоспособность и ориентированность на долгосрочную перспективу. На

La transición a la energía renovable en el sector agroindustrial debe ir acompañada de una auditoría energética y la implementación de sistemas de administración de energía. Esto determinará la combinación racional de los recursos energéticos utilizados para garantizar el funcionamiento normal y el desarrollo sostenible de los productores agroindustriales y agrícolas.

Palabras claves: ahorro de energía, empresas agroindustriales, eficiencia energética, fuentes de energía renovables, tecnologías de ahorro de energía, gestión de la energía, auditoría de energía, innovaciones, economía de base biológica.

основании изложенных в статье материалов авторы считают необходимым сформулировать основные выводы:

- эффективность деятельности хозяйствующих субъектов (в том числе агропромышленных и сельскохозяйственных производителей) зависит от наличия инновационных подходов к управлению ими. В настоящее время инновационные технологии следует считать не только источником получения конкурентных преимуществ, но и инструментом, позволяющим снизить уровень издержек в производственных, логистических, маркетинговых и прочих бизнес-процессах;
- возобновляемая энергетика, которая основана на современных наукоемких технологиях преобразования первичной энергии в энергоресурсы, может стать одним из ключевых направлений оптимизации издержек агропромышленных и сельскохозяйственных производителей, это подтверждает практика и статистика, полученная в ходе исследований агропромышленного сектора стран Европейского Союза, Азии, Евразии, Латинской Америки;
- для российского агропромышленного сектора задача снижения издержек стоит особенно остро, поскольку уровень расходов на энергоснабжение неуклонно возрастает, что влияет не только на доходность бизнеса, но и на его конкурентоспособность. Для решения этой проблемы разработана отраслевая энергетическая модель, основанная на сочетании традиционных и возобновляемых источников энергии;
- переход на возобновляемую энергетику в агропромышленном секторе должен сопровождаться энергетическим аудитом и внедрением систем энергоменеджмента. Это позволит определить рациональное сочетание энергоносителей, используемых для обеспечения нормального функционирования и устойчивого развития агропромышленных и сельскохозяйственных производителей.

Ключевые слова: энергосбережение, агропромышленные предприятия, энергоэффективность, возобновляемые источники энергии, энергосберегающие технологии, энергетический менеджмент, энергетический аудит, инновации, биоэкономика

Introduction

The effective development of the agro-industrial sector is one of the most important components of the national food security policy (Balabanov, Dudin, Lyasnikov, 2014). The conception of food security comes down to "securing the country's population with safe agricultural, fish, and food products in the volumes necessary for active and healthy life", and the basis for achieving food security goals is stable domestic production (Komov, 2008). In turn, while ensuring sustainable development of agro-industrial enterprises, it is necessary to take into account and neutralize the negative manifestations of objective by nature and specific groups of factors (Balabanov, Dudin, Lyasnikov, 2014; Chapple, 2008; Demirbas, 2005; Komov, 2008; Krasnoshchyokov et al., 1995):

- the first group of factors relates to the conditions of markets operation in agriculture, which are closer to pure competition and provide for the presence of a large number of producers selling their products. Such products are standardized or homogeneous, which complicates the possibility of non-price

competition, as well as free entry and exit from the market;

- the second group of factors concerns current problems, the essence of which is to ensure the stability of agricultural producers' incomes and is manifested in the fluctuation of prices for agricultural products and, accordingly, income by year. These fluctuations are related to the peculiarities of production in this industry, which depends to a large extent on weather and climatic conditions;
- the third group of factors is related to the macroeconomic problem of obtaining low incomes of agricultural producers in comparison with enterprises of other branches. The main reasons for the existence of this problem are price inelasticity of demand for agricultural products, imbalance of supply and demand, high production capacity, as well as low mobility of agricultural resources.

Accordingly, prospective directions of achievement of sustainable development of agro-industrial enterprises include: minimizing costs, combining different scientifically based

approaches to the exploitation of natural and economic resources, maintaining balance among economic, environmental and social factors of impact, ensuring strategic competitiveness in the domestic and foreign markets and long-term focus. This article will examine key issues related to the efficient use of energy and other resources in the organization of agro-industrial enterprises, which will help reduce the costs/turnover ratio of production, and, consequently, this in turn will provide the solution of the problems related to the price competition of agricultural (and agro-industrial) producers.

Review of Literature and Sources

The aspects of improving the efficiency of agro-industrial and agricultural producers are very much discussed in both scientific and business literature. So, the scientific view of the problem has evolved considerably over the last few decades. So, for example, the last quarter of the twentieth century was dominated by the idea that improving the performance of economic entities (including the agricultural sector) could be achieved by reducing costs and increasing access to various resources (such as natural, energy, human, financial, other tangible and intangible), but the scientific paradigm has changed in the first two decades of the 21st century (Balabanov, Dudin, Lysanikov, 2014; Komov, 2008; Krasnoshchyokov et al., 1995). At present, improving the performance of producers including agricultural producers is impossible without the use of high-tech (innovative) technologies which will ensure transition from extensive to intensive use of resources, which means that the cost per unit of production will be reduced (Chapple, 2008; Demirbas, 2005; Farmer, Trancik, 2012). This scientific approach is the most optimal and requires its active use in the management practices of agricultural producers, taking into account that innovations (hi-tech technologies) can be used not only for production, but also in solving the issues related to supply of production, sales of products, and interaction with consumers and contractors. However, as the market reviews (Ernst & Young, 2017; KPMG, 2017), as well as statistical data (see the "Results" section), show the largest share of the costs of agricultural producers falls on energy and material supply. Given that in recent years the issues of transferring of the agricultural industry to renewable energy have been actively discussed, we believe it is appropriate to consider this context of reducing costs in the activities of

agro-industrial enterprises. First and foremost, this is very important for the agricultural sector in transition economies and developing countries.

Methods

The given article is based on the combination of scientific research methods. In particular, in the context of the literature review on the cost reduction problems in the activities of agro-industrial enterprises, the methods of content analysis of scientific works were used. In addition, the article uses the methods of macroeconomic statistical industry analysis, which has confirmed the hypothesis that the use of renewable energy potential allows reducing the level of expenses of agricultural and agro-industrial producers. The authors of the article also used the methods of scientific synthesis, which allowed developing a number of key provisions concerning:

- a) the construction of the macroeconomic (sectoral) energy model of the agro-industrial sector; the model was based on the optimal combination of conventional and renewable energies that could be involved in the power supply of agricultural and agro-industrial production;
- b) the introduction of energy audit and power management systems in agro-industrial enterprises, providing the formation and effective use of resource potential of these economic entities.

Results

According to the data of independent consulting agencies and according to the data of the Food and Agriculture Organization of the United Nations, economic activities in the field of agro-industrial and agricultural production are the most intensive from the perspective of the needs in material, energy and natural resources. But the level of production profitability in the agro-industrial sector and agricultural sphere varies considerably across the world regions and countries. So, for instance, in some countries of the European Union (particularly in Denmark and Finland, where the agro-industrial sector is the most developed), the average profitability of production is about 45%, while in Brazil, China and Russia, the average profitability of agricultural production does not exceed 23% (see Fig. 1).

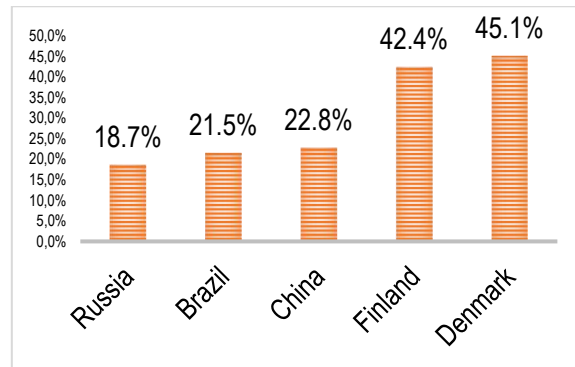


Figure 1. Average annual profitability of agricultural production (for the period from 2014 to 2016) (Ernst & Young, 2017; European Commission, 2015; Food and Agriculture Organization of the United Nations, 2017; KPMG, 2017).

If we consider the structure of the costs of agricultural production in these countries, we will see that in 2000 European agricultural producers in roughly equal terms bore the costs associated with wages and energy. But in 2015

the situation has already drastically changed, and the main expenses of European agro-industrial enterprises now relate to marketing and logistics, as well as the remuneration of employees of agro-industrial enterprises in Europe (Fig. 2).

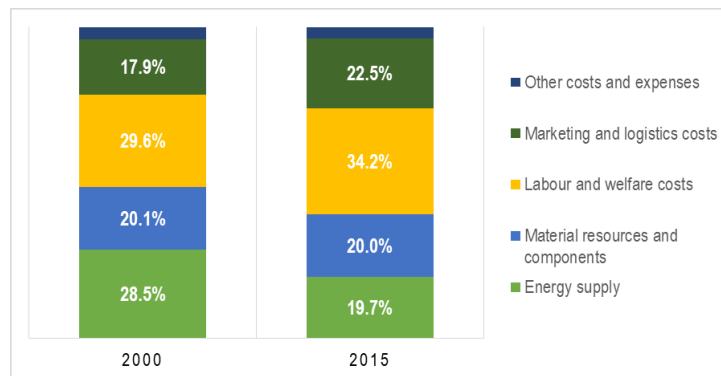


Figure 2. Average cost structure of agro-industrial enterprises operating in the territory of the European Union (Ernst & Young, 2017; European Commission, 2015; Food and Agriculture Organization of the United Nations, 2017; KPMG, 2017).

On the contrary, in Russia over the last 15 years, the cost of energy supply to agro-industrial enterprises showed an increase in the specific

weight, and the costs of staff salaries decreased in their share (Fig. 3).

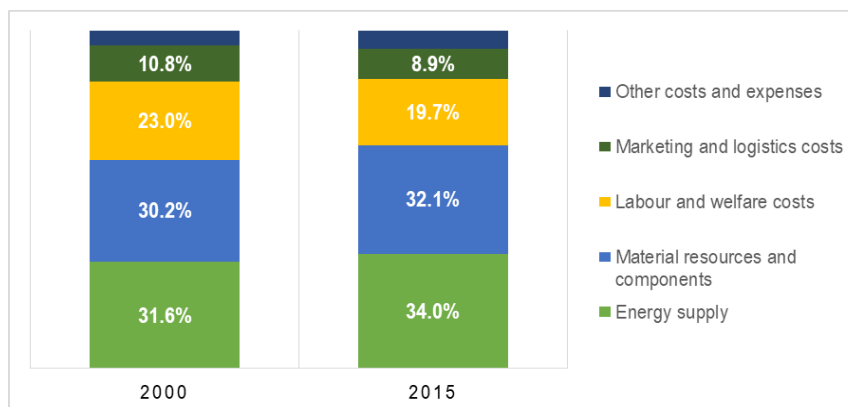


Figure 3. Average cost structure of agro-industrial enterprises operating in the territory of the Russian Federation (Ernst & Young, 2017; Food and Agriculture Organization of the United Nations, 2017; KPMG, 2017).

Russia, which has significant global reserves of energy resources, can consider the situation as paradoxical, but it is important to note that the reduction in the level of expenditures of agro-industrial enterprises for energy supply in European Union countries occurred not at the expense of cheaper hydrocarbons, but at the expense of transition (partial or complete) to renewable energy.

These points indicate that, for almost all countries and regardless of the level of development achieved, the use of renewable energy can increase the efficiency of agro-industrial and agricultural production.

Discussion

With increasing competition in the world market and acceleration of scientific and technological

progress, optimization of production is a decisive condition for sustainable development of modern agro-industrial enterprises. The imperative of market economy is the introduction of innovations and resources' reallocation from less efficient to more efficient management areas under the influence of competition in the market of goods, labor, and capital. Since innovation is a systemic process that ensures continuous improvement of production as a result of new learning experience and is carried out to implement the achievements of scientific and technological progress in production and social sphere, its implementation requires flexible approach to the use of already established resource potential and continuous updating of the energy resource capacity of agrarian enterprises taking into account new technological requirements (Fig. 4).

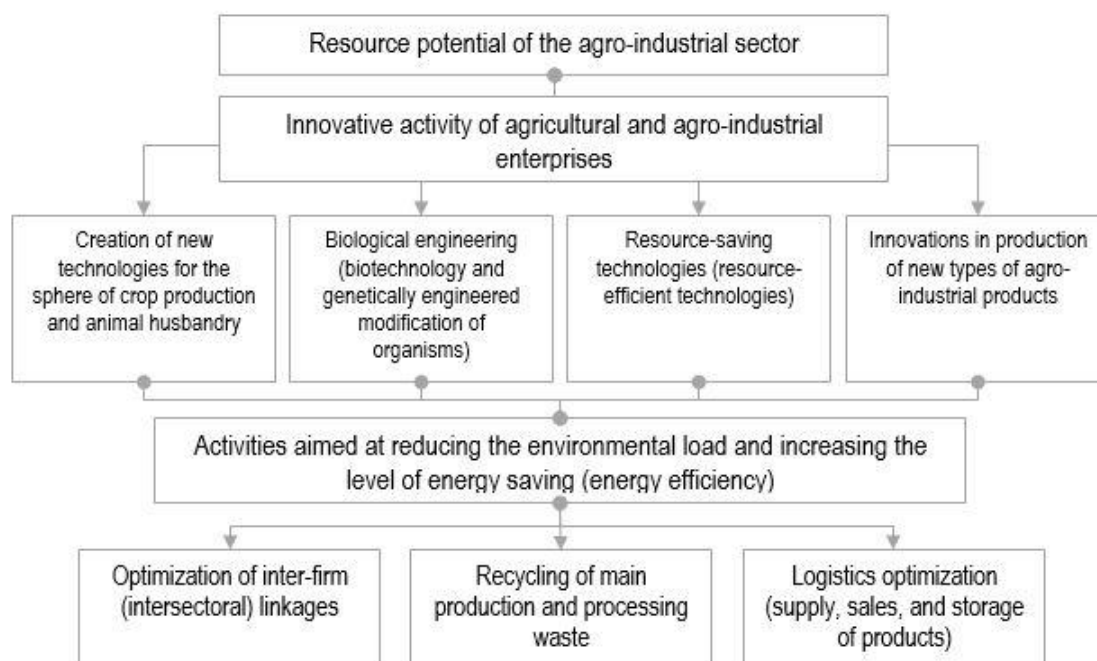


Figure 4. Influence of innovative activity on the development of resource potential of agrarian enterprises (compiled by the authors on the materials by Komov, (2008); Krasnoshchyokov et al., (1995); Kalogirou, (2013), Fernandes et al., (2012)

In this regard, the use of energy- and resource-saving technologies, as well as renewable energy sources, the increase in the efficiency of energy saving, the use of non-conventional sources of power, the development of bio-based economy and organic production are of particular relevance (International Energy Agency, 2017; World Energy Council, 2017). According to experts' forecasts, by 2030 all over the world "the energy received from the sun, wind, water, heat

of the earth, as well as from biomass, will increase twice in comparison with 2010 and will make 16% of all production" (ENERDATA, 2017; IRENA, 2017). In turn, the optimistic forecast made by the European Industry Union of Renewable Energy Sources assumes that "by 2030, the share of alternative energy will increase to 35%, and in 2020 in Europe the fifth part of energy will be produced from environmentally safe sources" (European

Commission, 2015). According to the estimates of the International Energy Agency, "in order to preserve the ecological parameters of the planet by the value of the average annual temperature, 45% of the world's electrical energy should come from alternative sources, and 17% of them should be based on the sources with renewable resource feature" (International Energy Agency, 2017). The attractiveness of renewable energy is caused by the inexhaustibility of resources, independence from the price conditions in the world energy-carriers markets, and last but not least, environmental soundness. The mentioned advantages of renewable energy are the reason of dynamic development of renewable energy abroad and rather optimistic forecasts about its prospects in the coming years.

In the long term, the world will not be able to avoid changes in the fuel and energy market associated with the desire of energy importers to seek for new energies and attention to the development of new power-saving technologies. And this, in turn, will increase the consumption of energy-efficient services, in particular, energy audit and information support, including those in the agro-industrial sector. Taking into account all the points made above, the key strategic guidelines for the energy policy of agro-industrial enterprises, aimed at reducing costs, in modern conditions are: energy security, energy efficiency of production, budgetary efficiency of energy, ecological safety of agricultural production and energy resource saving, which can be expressed as macroenergy models of the agro-industrial sector (Fig. 5).

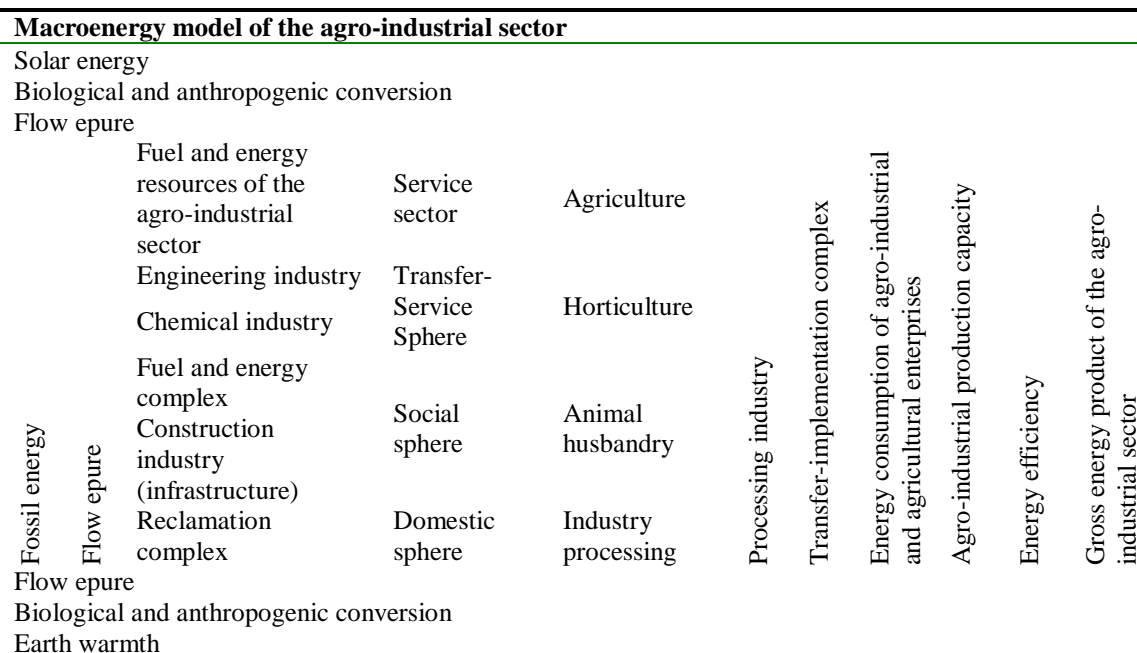


Figure 5. Macroenergy model of the agro-industrial sector (Krasnoshchyokov et al., 1995)

This model was intended to explain the process of energy conversion and the creation of gross energy product in the agro-industrial and agricultural sectors. Its main components were three segments of the agro-industrial sector and energy sources entering each of the spheres, in the process of their interaction creating gross energy product of the sector being considered. However, the given figure does not provide a clear idea of what kind of energy comes to each of the spheres. The model itself contains separate elements (energy costs, power consumption of

agro-industrial and agricultural production, energy efficiency), which characterize the quality of energy use, rather than the process (scheme) of its creation and movement in the agrarian sphere. In view of the above mentioned, it is better to consider the agro-industrial sector as a system of interrelated elements of transformation, consumption, transmission, supply, and creation of energy, the result of which is the creation of gross energy product (Fig. 6).

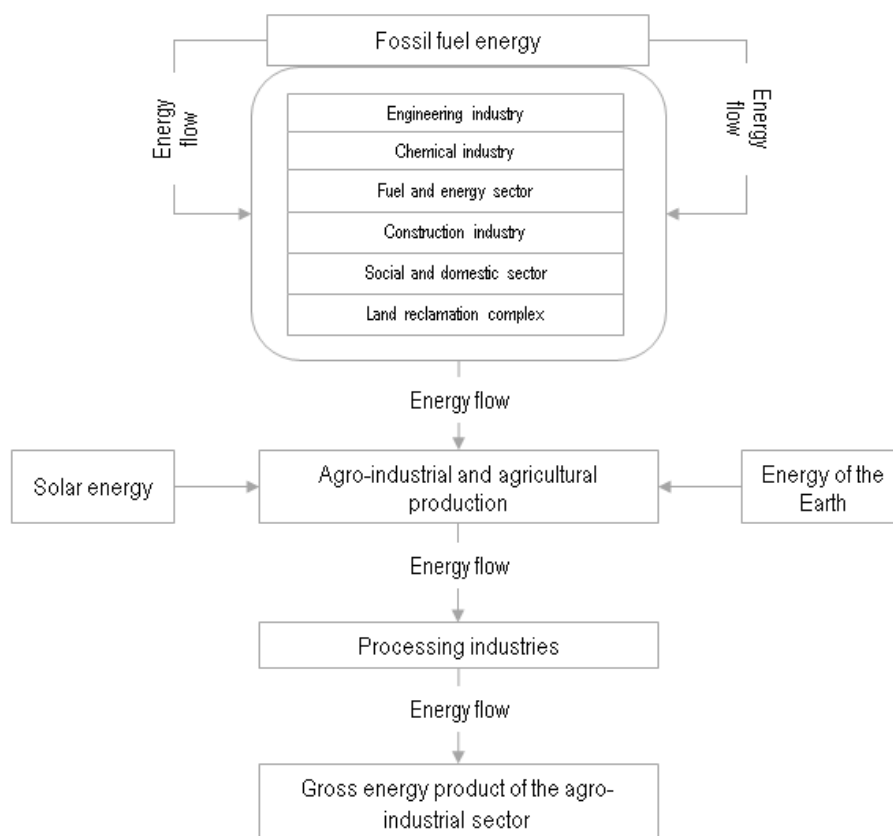


Figure 6. Energy model of the agro-industrial sector (compiled by the authors on the materials by: Komov, (2008); Krasnoshchyokov et al., (1995); Kalogirou, (2013); Fernandes et al. (2012)

The main factors determining the efficiency of energy saving policy formation in the economy in general, and agriculture in particular, are:

- presence of fuel and energy resources, their volumes and availability for use;
- cost of fuel and economic viability of the use of one or another type of energy resources;
- cost of the technologies used to generate energy;
- competition between different producers of energy resources;
- environmental requirements that the state and society pose to producers and consumers of energy resources;
- implementation of energy and resource saving policy;
- requirements for ensuring energy and food security of national economy.

As it is impossible for objective reasons to reduce the amount of energy of natural resources (sun and soil) in agricultural production needed to obtain the products of its main industries (horticulture and animal husbandry), and, taking into account the complexity of measuring its income in the agrosystems of a separate

enterprise during a certain time period, from the position of use to solve the problem of energy saving and rational and most effective use of available resources of the agrarian enterprise, the energy potential of the agricultural enterprise, the total amount of energy, the carriers of which are human and material resources, (the sum of the energy potential of human resources (HR energy potential) and energy potential of material resources (material and technical energy potential) of the given enterprise) is offered to be interpreted as cumulative.

The use of certain energy resources in the production of agro-industrial enterprises is the result of a choice between several options of energy consumption. Since the energy potential of agricultural enterprises is the basis for producing goods, which are also an energy carrier, in determining the volume of products that will minimize the consumption of a company's energy potential components at maximization of economic and efficiency of production, it is expedient to consider the marginal energy value of products and the limiting energy intensities for their production as the main criteria. The volume of products in which the marginal cost of energy for their production is equal to the marginal energy value

of products will be optimal in terms of energy saving and energy efficiency, and thereby, the cost-effectiveness of production for the economy. This means that in the production process the increase in energy intensities is justified until they exceed the level of the energy value of products derived from their use, which will ensure the competitiveness of a company's products.

To manage the energy potential of enterprises, including agro-industrial ones, it is reasonable to use energy management, which should be understood as a set of voluntary, initiative, and effective actions of economic entities, aimed at realization of their own programs, projects, and purposes with the maximum possible efficiency in the field of use and conservation of energy and its carriers in the production process. At the macrolevel in the sphere of energy saving and use of energy resources, it is expedient to use the term "Energy Management", which should be understood as a set of actions of state bodies and economic entities, focused on compliance with and implementation of the mandatory legislative requirements on energy resource saving and use of energy carriers, as well as the development and implementation of relevant programs, projects, and objectives.

The use of energy audit is possible as a tool to control the use of the economic system's energy potential. In addition to the monitoring function (monitoring of the actual use of the economic system's energy potential), it is also intended to perform the information function (it should be a source of information on the level of the economic system's energy potential use, which will come from different levels of management, and on the basis of which management decisions will then be taken) and the analytical function (providing a comprehensive study of the actual use of the economic system's energy potential in order to improve its further use from the position of energy saving).

The process of energy management is not a simple and single act and consists of several stages, but its introduction in enterprises, including agro-industrial ones, will have for the latter a number of positive effects, or the so-called benefits:

- improvement of technological and production processes from the standpoint of energy saving and improving the efficiency of their use (technological benefits);

- an increase in the competitiveness of an enterprise and the efficiency of its activity as a whole;
- facilitation of compliance with current legislation on energy saving (production benefits);
- an increase in the company's revenue while minimizing its costs (financial benefits).

Conclusion

So, having considered the main aspects of energy saving and increasing the efficiency of resources use by agro-industrial and agricultural enterprises, the following key conclusions can be drawn:

- firstly, the management of agro-industrial enterprises should take into account the current trends in energy and resource supply, i.e. they should be oriented to the use of innovative technologies not only in production processes, but also in the processes of supply, sales, and marketing;
- secondly, to reduce the level of the costs/turnover ratio of agro-industrial enterprises' operating activities (in particular, in countries with economies in transition, for example, in Russia), it is advisable to optimize the cost of energy supply through the use of renewable energy (e.g. solar and geothermal energy);
- thirdly, in order to achieve the efficiency of renewable energy use, agro-industrial enterprises need to implement energy audit and energy management within the framework of the strategic and operational management system.

The aspects related to the method of energy audit formation of agro-industrial enterprises aimed at optimizing production costs have not been considered in this article. The article also did not set out methodological approaches to assessing the feasibility of introducing renewable energy for the needs of agricultural and agro-industrial producers. The authors will consider these aspects in their next works which will have a similar focus.

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