Dudin, Michail; Zas′ko, Vadim Nikolaevič; Doncova, Olesja et al.

**Article**

# Renewable energy sources as an instrument to support the competitiveness of agro-industrial enterprises and reduce their costs

International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2018, 8(2), 162-167.

# Renewable Energy Sources as An Instrument to Support the Competitiveness of Agro-industrial Enterprises and Reduce their Costs

**Mihail Nikolaevich Dudin[1]*, Vadim Nikolaevich Zasko[2], Olesya Igorevna Dontsova[3], Irina Valentinovna Osokina[4], Alisa Mikhailovna Berman[5]**

[1]Russian Presidential Academy of National Economy and Public Administration, 119571, Moscow, Vernadsky Av., 82, Russian Federation, [2]Russian Presidential Academy of National Economy and Public Administration, 119571, Moscow, Vernadsky Av., 82, Russian Federation, [3]Financial University under the Government of the Russian Federation, 125993, Moscow, Leningradsky Prospekt, 49, Russian Federation, [4]Financial University under the Government of the Russian Federation, 125993, Moscow, Leningradsky Prospekt, 49, Russian Federation,[5]Institute of State and Law of the Russian Academy of Sciences, 119019, Moscow, Znamenka str.,10, Russian Federation. *Email: dudinmn@mail.ru

**ABSTRACT**

The intensive development of the Russian agro-industrial complex is accompanied by high energy consumption, which ultimately may result in environmental pollution and ecological imbalance. The dependence of the agricultural production on organic fuels (i.e., traditional hydrocarbon energy sources) may limit the ability of this sector to meet the demand for agricultural products and ensure the food security of the country. Moreover, the high dependence of the agricultural production on traditional energy sources affects the business profitability and competitiveness. Based on the materials outlined in this article, the authors come to the following main conclusions: (i) The adoption of innovative energy saving models is required for the reliable energy supply and improvement of the efficiency of agricultural production. Moreover, the damage to the environment caused by the utilization of fossil fuels can be mitigated by using renewable energy sources; (ii) Russia has the climatic conditions required for the use of solar energy, small hydropower, and wind energy. At the same time, in the part of ensuring the energy needs of agro-industrial and agricultural production in Russia, traditional hydrocarbon energy sources are mainly used.

**Keywords:** Agriculture, Energy Supply, Renewable Energy, Hydrocarbon Energy, Costs, Competitiveness, Food Security
**JEL Classifications:** Q10, Q40, Q49

## 1. INTRODUCTION

Farley and Daley in their study cited Charles Elton, who first noticed that energy is the natural currency of the economy (Farley and Daly, 2003). The utilization of new, energy-intensive technologies has dramatically increased the production of food products. The increasingly interrelated food systems have been further transformed by the globalization (Dudin et al., 2016).

The total food production is projected to increase substantially by 2050 to meet the needs of the world's growing population. Given the limited energy resources underlying all food supply chains – both renewable and nonrenewable sources – along with the limited ability of the host ecosystems to assimilate the waste into energy production, the possibility of application of the innovative energy conservation models in Russia's agro-industrial production deserves close attention from experts and researchers (Fotourehchi, 2017; Pelletier et al., 2008; Harris, 2017). Moreover, since the utilization of energy is often an indicator of environmental friendliness (Huijbregts et al., 2010), the estimate of the energy intensity of agricultural production can be useful for general improvement of the environmental management system in the agro-industrial complex. Thus, the monitoring of the efficiency and scale of energy use is likely to be of great importance for consummation of the sustainable development goals in this sector.

Moreover, it should be noted that since agro-industrial and agricultural production in Russia is energy-consuming (in terms of valuation), respectively, the adoption of renewable energy is not only the cost-reducing means (including the environmental one), but also a way to increase the business competitiveness, since the balance of the price and quality of food products, as well as agricultural raw materials, has not been formed by now (Bezzubtseva et al., 2015; Karpov et al., 2014). Therefore, within the framework of this article, the general assessment aspects of the energy intensity of agro-industrial and agricultural production will be considered by the authors, and, in particular, the issues related to the possibility of using the potential of renewable energy in the agro-industrial sector of the Russian Federation are explored.

## 2. LITERATURE REVIEW

Thus far, the research has accumulated sufficiently large scientific potential, necessary for assessment of the energy intensity of production (in the agro-industrial sector as well). In particular, the general methodological aspects of conducting energy analysis are disclosed in the works of Pardo et al. (2013), Sharma (2015), Rajaniemi et al. (2015), Guillen et al. (2016), as well as many other scientists and researchers (Bezzubtseva et al., 2015; Karpov et al., 2014).

Energy analysis is a quantitative evaluation method for the energy costs required to obtain a specific product or service. Recently, the use of energy analysis has increased due to the relevance of the issues of energy intensity reduction and improvement of the competitiveness of Russian agricultural production.

The earliest study of energy efficiency in food production is the scientific work of the American specialist Pimentel et al. (2008). The later studies in the field of energy system include a lot of works on the energy intensity analysis of the production of certain agricultural products (Khosruzzaman et al., 2010).

According to some studies (Canning et al., 2010), the use of energy in the agro-industrial complex averages to 15–20% of the total energy consumption in the US food system. As it will be shown further, this figure is much higher in the agro-industrial sector of Russia, since it accounts for about 3% of the total consumption of energy resources in the country. Therefore, the issues of adoption of renewable energy are relevant not only for Russia, but for a number of highly developed countries.

The high importance of the renewable energy development for agriculture was repeatedly noted by the experts of international organizations. Thus, it was emphasized in the review of the Food and Agriculture Organization of the United Nations (2012) that the widespread adoption of renewable energy sources in the global agro-industrial sector was a promising way to reduce the cost of food, as the potential of renewable energy sources was huge and they could meet the world's energy demand. The transition to energy systems based on renewable energy sources is becoming increasingly probable, as the costs of their production decline, and the prices of oil and gas continue to fluctuate.

The issues of development of resource-saving technologies and improvement of the energy efficiency of the agricultural production are set out in various contexts in the previously mentioned studies (Dudin et al., 2017; Pardo et al., 2013; Sharma, 2015; Rajaniemi et al., 2015; Guillen et al., 2016). At the same time, the specifics of the agricultural production development in the Russian Federation require further study of energy conservation and the identification of the feasibility and expediency of use of the renewable energy sources in order to increase the competitiveness of agricultural production.

## 3. METHODS

To achieve this objective, the following problems are solved by the author:

- To analyze the energy intensity of agricultural production in the Russian Federation;
- To study the current state of renewable energy sources in the agricultural sector of the Russian Federation;
- To identify the main directions for the development of renewable energy sources in agricultural production of the Russian Federation.

In the framework of this study, a comprehensive analysis of statistical data and analytical indicators is carried out. The tabular and graphical methods are used to visualize the results obtained. The indicator of the specific consumption of fuel and energy resources for agricultural production, the electric and heat capacity of certain types of products (EI) are used to assess the energy efficiency of agricultural production of the Russian federation. This indicator is defined as the total amount of energy consumed (electricity, heat and fuel) per unit of manufactured production or work:

$$EI = \frac{EC}{Vp_i} \qquad (1)$$

EI is the energy intensity;
EC is the total amount of energy consumed by a certain type;
$Vp_i$ is the volume of production of a particular type of agricultural products.

## 4. RESULTS

Russia is a country with huge agricultural potential: The total area of farmland is more than 2,017.7 million hectares, which is 13.3% of the country's land resources (Uzun et al., 2012); moreover, about 26% of the total population of the country lives in rural areas. Over ten years (2002–2012), the share of agriculture in the GDP structure has been declining, which is a natural tendency for the developing and developed countries of the world. At the same time, this indicator began growing in 2013, and by the end of 2016, the share of the industry in the country's GDP had reached 4.5%. This emphasizes the sustainability of agriculture in times of crisis (Uzun and Shagaida, 2015), which is not to a small extent promoted by state government support for agricultural producers. The state targeted programs, concessional lending, and agricultural insurance have become a powerful impetus for the development of agriculture. In total, currently there are about 30 options of state support for this industry, including the subsidizing of the part of the interest rate in case of a long-term credit, and the provision of subsidies, depending on the yield of each hectare available to the producer. In recent years, the volume of agricultural production in the Russian agro-industrial sector has been growing. So, by the end of 2016, the gross grain harvest has increased by 15.6% compared to the previous year, the production of meat of livestock and poultry has increased by 4.7%, the catch of aquatic biological resources has increased by 5% (Federal State Statistics Service, 2017).

The increase in the volume of production of agricultural and food products resulted in the increase in energy costs. According to Rosstat, over 4 years the rate of growth of expenses for payment of energy resources in agriculture exceeds the similar indicator for the Russian Federation. The specific share of energy intensity of the agricultural production in the total amount of energy intensity in the whole of the Russian Federation has increased from 2.3% in 2012 to 2.7% in 2015 (Figure 1).

In order to increase the energy efficiency of the production processes, the State Program has been developed, within the framework of which the activities aimed at reduction of the energy intensity of agricultural products are introduced (Uzun and Shagaida, 2015). As a result of the introduction of these measures, the dynamics of decrease in the energy intensity of the agricultural and food production are observed in the Russian Federation. In this vein, over 2012-2015 the actual electricity consumption for the production of a unit of product decreased practically for all types of products of the agro-industrial sector of Russia. The most energy-intensive production is the greenhouse business. Over 2012–2016, the specific consumption of fuel and energy resources for heating greenhouses decreased by 63%. A marked decrease in this indicator occurred in 2016.

This dynamics can be caused by the high rates of commissioning of new capacities simultaneously with the decommissioning of old less energy-efficient greenhouses. Over the period of 2012–2016, about 600 hectares of greenhouse facilities were commissioned, which was about 30% of the total area of greenhouse facilities in 2013 (Figure 2). The specific consumption of fuel and energy resources for the operation of the agricultural tractors and combines in the Russian Federation in 2016 decreased by 8% and amounted to 16.4 kgoe/ha. The reduction in 2016 was largely due to the refinement of the conversion of acreage into conditionally standard hectares, which characterized the number of shifts completed by agricultural machinery (Ministry of Energy of the Russian Federation, 2017).

The specific consumption of fuel and energy resources for the production of poultry for slaughter (in live weight) decreased over 2016 by 15% and amounted to 20.1 and 23.7 kgoe/c. There is the dynamics of decreasing consumption of both electric and thermal energy in the agriculture and food production. So, over 2012–2015 the electricity and energy intensity of meat production decreased by almost a third and amounted to 1,987.1 kWh/t. The growth of electricity intensity per unit of product is observed only in the production of sausage products (Table 1).

Over four years, the thermal and energy efficiency of meat production decreased by 62.6%; of bread and bakery products – by32.2%, of whole milk production – by 31% (Table 2).

It should be noted that in order to reduce the specific material and energy costs, as well as to reduce the losses of agricultural products during harvesting, it is necessary to use energy-saturated, high-performance equipment and introduce resource-saving technologies using combined soil cultivating and sowing units.

## 5. DISCUSSION

To date, the use of renewable energy in Russia is <1% in the total power generation. And, for example, the US shows a

**Figure 1:** Dynamics of energy intensity by the type of activity "agriculture, hunting and forestry" for 2012–2015 (Federal State Statistics Service, 2017)

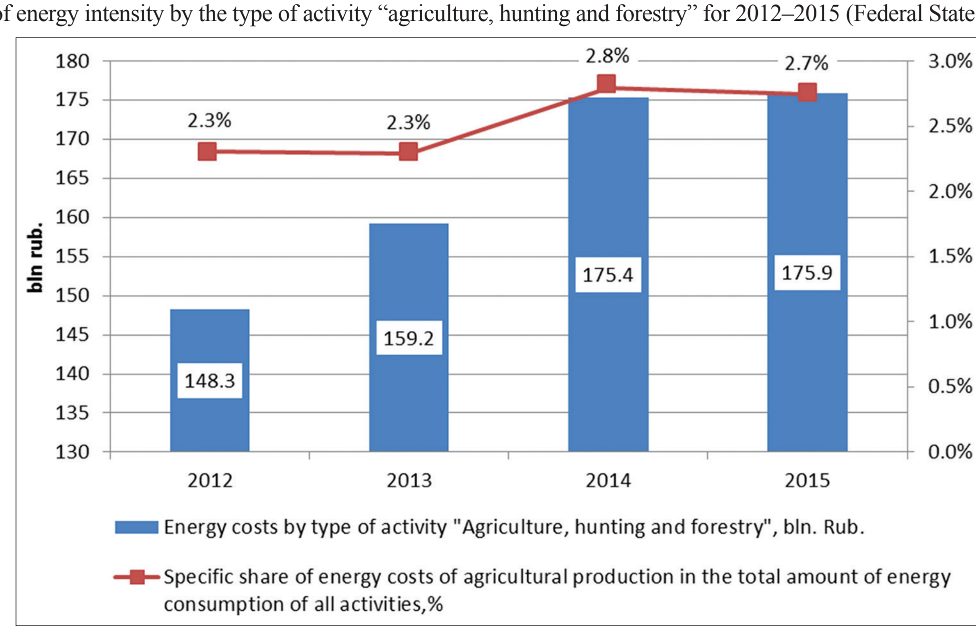

**Figure 2:** Dynamics of specific consumption of fuel and energy resources in agriculture of the Russian Federation in 2012–2016 (Federal State Statistics Service, 2017)

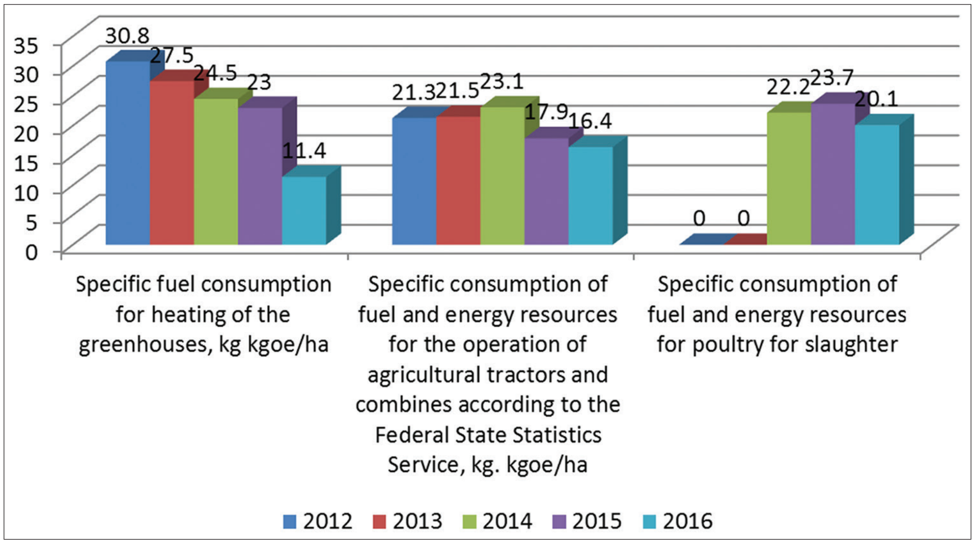


**Table 1: Actual electricity consumption for the production of a unit of agricultural product in the Russian Federation (Federal State Statistics Service 2017; Ministry of Energy of the Russian Federation, 2017)**

| Indicator | 2012 | 2013 | 2014 | 2015 | Changes | |
|---|---|---|---|---|---|---|
| | | | | | +/− | % |
| Electricity and energy intensity of meat production, kWh/t | 2,990.1 | 3,233.4 | 2,523.5 | 1,987.1 | −1,003 | −33.5 |
| Electricity and energy intensity of production of whole milk products (in terms of milk), kWh/t | 934.5 | 909.5 | 826.9 | 873.6 | −60.9 | −6.5 |
| Electricity and energy intensity of sugar beet processing | 371.5 | 355.4 | 338.1 | 317.6 | −53.9 | −14.5 |
| Electricity and energy intensity of bread and bakery products production | 1,537.4 | 1,645.7 | 1,517 | 1,420.9 | −116.5 | −7.6 |
| Electricity and energy intensity of production of sausage products | 1,001.1 | 1,047.9 | 1,085.6 | 1,090.8 | 89.7 | 9.0 |

**Table 2: Actual thermal energy consumption for the production of a unit of agro-industrial product in the Russian Federation (Federal State Statistics Service, 2017; Ministry of Energy of the Russian Federation, 2017)**

| Indicator | 2012 | 2013 | 2014 | 2015 | Change | |
|---|---|---|---|---|---|---|
| | | | | | +/− | % |
| Thermal and energy intensity of meat production, kWh/t | 1,162.7 | 874 | 536.8 | 434.6 | −728.1 | −62.6 |
| Thermal and energy intensity of production of whole milk products (in terms of milk), kWh/t | 847.8 | 528 | 875.7 | 585.1 | −262.7 | −31.0 |
| Thermal and energy intensity of sugar beet processing | 3,515.7 | 3,320.8 | 3,055.9 | 2,752.1 | −763.6 | −21.7 |
| Thermal and energy intensity of bread and bakery products production | 1,221.9 | 825.1 | 1,393 | 828.3 | −393.6 | −32.2 |
| Thermal and energy intensity of production of sausage products | 1,103.7 | 1,050.9 | 989 | 934.2 | −169.5 | −15.4 |

similar figure - about 7%. On average, the world's actual share of renewable energy in electricity production exceeds 10% (Dudin et al., 2017; ENERDATA, 2017).

According to the plans for the introduction of renewable energy sources, Russia is also lagging behind the West. According to the energy development strategy, the share of renewable energy sources in the country will amount to 4.5% by 2020 against 20% in Europe (Strebkov and Shogenov, 2017). The main sources of renewable energy used in agriculture are solar, wind and bioenergy.

### 5.1. Solar Energy

In the Russian Federation, there are a fairly large number of areas, energy-deficient and isolated from the general network, but with a high level of insolation, where the development of solar energy is not only efficient, but also capable of saving the budgetary funds, which are now holding back the growth of tariffs for electricity. Russia has a fairly high level of insolation – there are quite a few areas where the average annual solar radiation intake is 4-5 kWh per square meter per day (this indicator is commensurate with the south of Germany and the north of Spain, the leading countries in the introduction of solar systems). At the same time, a high level of insolation in Russia is not only in the south – the Krasnodar Territory, the Rostov Region, the Caucasus, – but also in the Altai, and, in general, in the south of Siberia, the Far East and the Transbaikalia – in these regions, the number of sunny days per year amounts to 300. Currently, Russia produces solar modules, large network and small autonomous solar power stations; it has developed and patented its own highly efficient technology for the production of heterostructural modules.

The rated capacity of solar power plants in Russia is about 500 MW, and it is planned to increase this indicator up to 1.5 GW by 2024. The retail market is also being developed – currently, the companies, offering solar solutions, are established almost in every region of the Russian Federation. Since the second quarter of 2017, the group of companies "Hevel" has started the production of solar modules of a new generation using the heterostructural technology – this is the most promising of existing technologies today. One of the most promising new segments, successfully mastered by Russia, is the hybrid generation using renewable energy sources. In 2013, the first in the world autonomous hybrid power plant running on solar and diesel generation was launched in the Altai Republic.

### 5.2. Wind Power

Russia has the world's largest wind power potential. The country's economic potential is estimated at more than 100 tWh/year, and its development requires production capacity. In Russia, only a few wind farms with a rated capacity of more than 1 MW have been built: According to the report, the rated capacity of a wind farm in the territory of Russia as of mid-2016 was 11 MW (the capacity of wind farms in the Crimea constructed under the administration of Ukraine is 87.8 MW). The wind energy industry in Russia received the necessary impetus for active growth: In the summer of 2016, the results of the first competitive selection of 700 MW of wind power projects in the wholesale electricity market were announced, which are planned to be introduced within the next three years. In Russia, the objective is set legislatively to achieve 3.35 GW of rated capacity of a wind farm by 2024, and 4.5 GW by 2030 (Ministry of Energy of the Russian Federation, 2017; Strebkov and Shogenov, 2017).

### 5.3. Small Hydropower

In the territory of the Russian Federation, there are a huge number of watercourses and energy reservoirs that can be used for distributed generation, with the help of equipment for small hydropower. And this direction can be considered as one of the most promising in terms of using renewable energy for production needs in the agro-industrial sector and agriculture.

Given that the current state of the agro-industrial sector in Russia can be described as an energy-intensive industry (since each stage of production requires additional energy resources), the relevance of issues related to the adoption of renewable energy is correspondingly increasing. The use of traditional energy sources (hydrocarbon raw materials) only does not seem to be a rational solution to the problem, because, firstly, it increases the cost of the final product, secondly, it negatively affects the environmental situation, and thirdly, it deprives the agricultural producers of the ability to adapt their enterprises to the changing trends in the context of energy supply sources.

## 6. CONCLUSION

Within the framework of this article, the energy intensity of agricultural and agro-industrial production in the Russian Federation was reviewed, and the possibilities of use of the renewable energy in the agro-industrial sector (in particular, solar, wind and small hydropower) were briefly explored by the authors. The analysis showed that the physical volume of consumption of traditional energy sources decreased (in total for all types of production) from 6% to 11% in 2012–2016; in value terms, the energy intensity in the agro-industrial sector increased by almost 20% over the same period. The state programs for promotion of the introduction of renewable energy in many respects do not ensure reaching the European level, since it is expected in the short term that by 2020 renewable energy sources in the energy supply of the economic and social sector of Russia will amount to no more than 5% of the total volume of demand. Thus, the Russian economy as a whole and the agro-industrial sector in particular require structural and institutional reforms that will contribute to:

- First, reduction of the energy intensity of production, including the energy intensity of agro-industrial production, which will also reduce the costs of food production;
- Second, the transition to the use of environmentally friendly fuel and energy resources;
- Third, the increase in the competitiveness of Russian food products, including through the achievement of the balance of price and quality.

In this paper, the authors did not consider the aspects related to the risks of transition to renewable energy in the agro-industrial sector; these issues will be studied in the following articles on similar subject matter.

## REFERENCES

Bezzubtseva, M.M., Volkov, V.S., Obukhov, K.N. (2015), Inzhiniring Energotekhnologicheskikh Protsessov v APK [Engineering of Energy Technological Processes in the Agroindustrial Complex]. Mezhdunarodnyi Zhurnal Eksperimentalnogo Obrazovaniya, 5(2), 220-220.

Canning, P., Charles, A., Huang, S., Polenske, K., Waters, A. (2010), Energy Use in the U.S. Food System. Economic Research Report No. 94. United States Department of Agriculture, Economic Research Service.

Dudin, M.N., Frolova, E.E., Kucherenko, P.A., Vernikov, V.A., Voykova, N.A. (2016), China in innovative development of alternative energy advanced industrial technologies. International Journal of Energy Economics and Policy, 6(3), 537-541.

ENERDATA. (2017), Statisticheskii Ezhegodnik Mirovoi Energetiki [Annual Statement of World Energy]. Available from: https://www.yearbook.enerdata.ru. [Last retrieved on 2017 Dec 21].

Farley, J., Daly, H.E. (2003), Ecological Economics: Principles and Applications (Ecological Economics Textbook). Washington, DC: Island Press, p540.

Federal State Statistics Service. (2017), Ofitsialnaya Statistika [Official Statistics]. (Federal State Statistics Service.Available from: http://www.gks.ru. [Last retrieved on 2017 Dec 21].

Food and Agriculture Organization of the United Nations. (2012), Energy-Smart Food at FAO. Available from: http://www.fao.org/docrep/015/an913e/an913e.pdf. [Last retrieved on 2017 Dec 21].

Fotourehchi, Z. (2017), Renewable energy consumption and economic growth: A case study for developing countries. International Journal of Energy Economics and Policy, 7(2), 61-64.

Guillen, J., Cheilari, A., Damalas, D., Barbas, T. (2016), Oil for fish: An energy return on investment analysis of selected European Union fishing fleets. Journal of Industrial Ecology, 20(1), 145-153.

Harris, T.R. (2017), Incorporating risk in analysis of tax policies for solar power investments. International Journal of Energy Economics and Policy, 7(6), 112-118.

Huijbregts, M., Hellweg, S., Frischnecht, R., Hungerbuhler, K., Hendriks, A. (2010), Cumulative energy demand as predictor for the environmental burden of commodity production. Environmental Science and Technology, 44(6), 2189-2196.

Karpov, V.N., Yuldashev, Z.S., Nemtsev, A.A., Nemtsev, I.A. (2014), Kontseptsiya otsenki toplivno-energeticheskoi effektivnosti proizvodstva v APK [The Concept of the Estimation of Fuel and Energy Efficiency of Production in the Agroindustrial Complex]. Izvestiya Mezhdunarodnoi Akademii Agrarnogo Obrazovaniya, 20, 35-41.

Khosruzzaman, S., Asgar, M., Rahman, K., Akbar, S. (2010), Energy intensity and productivity in relation to agriculture-Bangladesh perspective. Journal of Bangladesh Academy of Sciences, 34(1), 59-70.

Ministry of Energy of the Russian Federation. (2017), Gosudarstvennyi doklad o sostoyanii energosberezheniya i povyshenii energeticheskoi effektivnosti v Rossiiskoi Federatsii v 2016 g. [State Report on the State of Energy Conservation and Energy Efficiency in the Russian Federation in 2016]. Available from: https://www.minenergo.gov.ru/node/5197. [Last retrieved on 2017 Dec 19].

Pardo, M.A., Manzano, J., Cabrera, E., García-Serra, J. (2013), Energy audit of irrigation networks. Biosystems Engineering, 115(1), 89-101.

Pelletier, N., Arsenault, N., Tyedmers, P. (2008), Scenario-modeling potential eco-efficiency gains from a transition to organic agriculture: Life cycle perspectives on canadian canola, corn, soy and wheat production. Environmental Management, 42, 989-1001.

Pimentel, D., Doughty, R., Carothers, C., Lamberson, S., Bora, N., Lee, K. (2008), Energy inputs in crop production in developing and developed countries. In: Food, Energy, and Society. 3rd ed. New York: CRC Press. p137-159.

Rajaniemi, M., Turunen, M., Ahokas, J. (2015), Direct energy consumption and saving possibilities in milk production. Agronomy Research, 13(1), 261-268.

Sharma, A. (2015), Energy Audit of Frozen Vegetable and Fruit Processing Industry (Doctoral Dissertation). JNKVV.

Strebkov, D.S., Shogenov, Y.H. (2017), Razvitie sistem energoobespecheniya, energoresursosberezheniya i vozobnovlyaemoi energetiki v agropromyshlennom komplekse [Development of Energy Supply Systems, Energy Saving and Renewable Energy in the Agro-Industrial Complex]. Tekhnika i Oborudovaniye Dlya Sela, 8, 10-13.

Uzun, V.Y., Shagaida, N.I. (2015), Agrarnaya Reforma v Postsovetskoi Rossii: Mekhanizmy i Rezultaty [Agrarian Reform in Post-Soviet Russia: Mechanisms and Results]. Moscow: Delo.

Uzun, V.Y., Shagaida, N.I., Saraykin, V.A. (2012), Agrokholdingi Rossii i ikh rol v proizvodstve zerna. Issledovaniya po politike perekhoda selskogo khozyaistva No. 2012-2 [Agroholdings of Russia and Their Role in Grain Production. Research on the Policy for Transition of Agriculture No. 2012-2]. FAO Regional Office for Europe and Central Asia.