



Bioenergy Potential of Russia: Method of Evaluating Costs

Jaehyung An¹, Alexey Mikhaylov², Evgeny Lopatin^{3*}, Nikita Moiseev⁴, Ulf H. Richter⁵, Igor Varyash⁶, Uyeh Daniel Dooyum⁷, Artem Oganov^{8,9,10}, Rasmus Gjedssø Bertelsen¹¹

¹Hankuk University of Foreign Studies, College of Business, Seoul, Korea, ²Department of Financial Markets and Banks, Financial University Under the Government of the Russian Federation, Moscow, Russia, ³British College of Banking and Finance, London, United Kingdom, ⁴Department of Mathematical Methods in Economics, Plekhanov Russian University of Economics, Moscow, Russia, ⁵Richterion Limited, Hong Kong, ⁶Analytical Center of Financial Research, Financial Research Institute of the Ministry of Finance of the Russian Federation, Moscow, Russia, ⁷Department of Bio Industrial Machinery Engineering, Kyungpook National University, Daegu, Korea, ⁸Skolkovo Institute of Science and Technology, Skolkovo Innovation Center, Moscow, Russia, ⁹Moscow Institute of Physics and Technology, Dolgoprudny, Russia, ¹⁰International Center for Materials Discovery, Northwestern Polytechnical University, Xi'an, China, ¹¹The Arctic University of Norway (UiT), Tromsø, Norway. *Email: evgeniy.lopatin97@gmail.com

Received: 14 May 2019

Accepted: 15 July 2019

DOI: <https://doi.org/10.32479/ijeeep.8133>

ABSTRACT

Paper proposes the method of evaluating costs for bioenergy supply in Russia based on energy analysis. The main deterrent factor is not as much limited resources as the marginal cost of production biofuels and the possibility of using cost-effective ways reducing greenhouse gas emissions, including capturing and carbon storage, alternative forms of renewable energy and energy efficiency and energy savings. In this situation, the possibility of progressive development of the global market for biofuels can only be achieved by fundamental changes in the industry determined by the peculiarities of development scientific and technological progress. The authors also identifies a number of factors of technological, economic financial nature constraining the large-scale implementation of scientific technical advances in bioenergy. Comparing the innovation policy of various countries of the world, paper notes that industrialized countries have a high level of investment in R and D in the field of biofuel technologies.

Keywords: Bioenergy, Alternative Energy Sources, Biofuel, Energy Cost Analysis, Bioenergy Factors

JEL Classifications: C30, D12, Q41, Q48

1. INTRODUCTION

In this regard, in many countries it has become noticeable intensified use of alternative energy sources, and in particular biological resources for energy purposes, capable of further at least partially supplement or replace drying out hydrocarbon sources, thereby making the transition from the current crisis to the future sustainable energy smoother and more manageable.

At the same time, a significant place in renewable energy occupies the traditional untreated plant biomass (up to 13%), mainly including waste agricultural and forestry production. While

biofuels - product of deep processing of plant biomass - takes a very modest place in world primary energy consumption.

Its share is accounted for only 0.6% of total energy consumption, and the total contribution biomass in the production of heat and electricity (along with solar, geothermal and wind energy) amounted to 2.1%.

The biomass is currently the most common international trade in renewables: from all other alternative energy sources are distinguished by their versatility: Applications (in heat supply, power generation and in the transport sector), the ability to replace

any element of the traditional energy balance (coal, oil, gas), and recently also act as a chemical and biotechnological raw materials.

In addition biomass can be stored, transported and sold directly as primary raw materials, and in the form of their derivatives. Biomass application in the world for the period 2009-2019 years. It increased by more than 4 times. The USA is the leader in bioenergy production (Figures 1 and 2).

However, when evaluating the quantitative indicators underlying current fuel and energy balance, the author proceeds from the fact that despite the rapid growth in the importance of global bioenergy, coming years biomass is unlikely to be able to act as a significant source of meeting the growing energy needs of the world.

The situation is explained by the fact that the development of bioenergy at the global level proceeds very contradictory, primarily

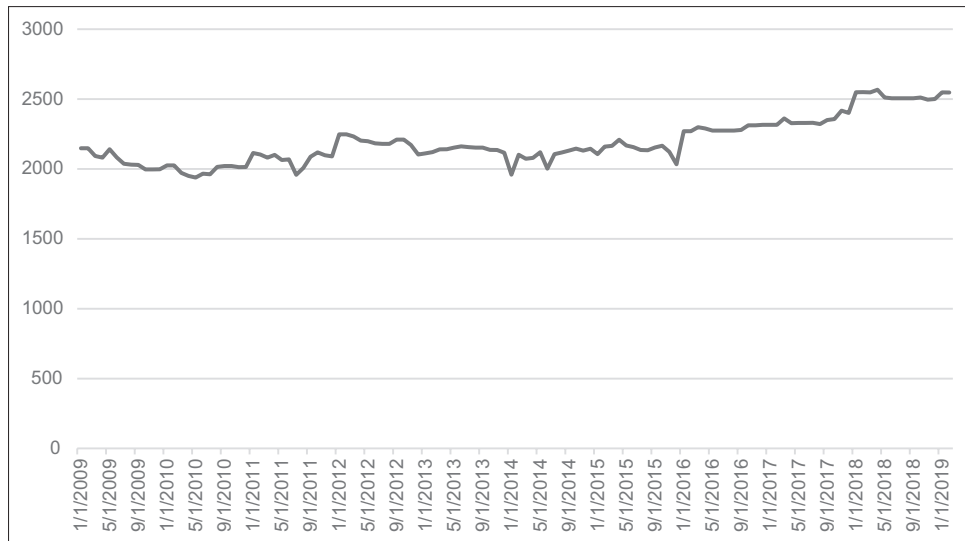
affecting the food, ecological and social aspects of functioning new energy market.

As a result of changing priorities of environmental and energy modern bioenergy policy is a new source of demand for agricultural products capable in the long term perspective to promote the revitalization of agriculture in developing countries. At the same time, the development of bioethanol and biodiesel, requiring large amounts of food raw materials, leads in the medium term to higher prices for all types of food, and this process affects all countries of the world.

Moreover, they participate in the cultivation of biofuel feedstock at the production of biofuels can certainly be considered a factor destabilizing the world food system.

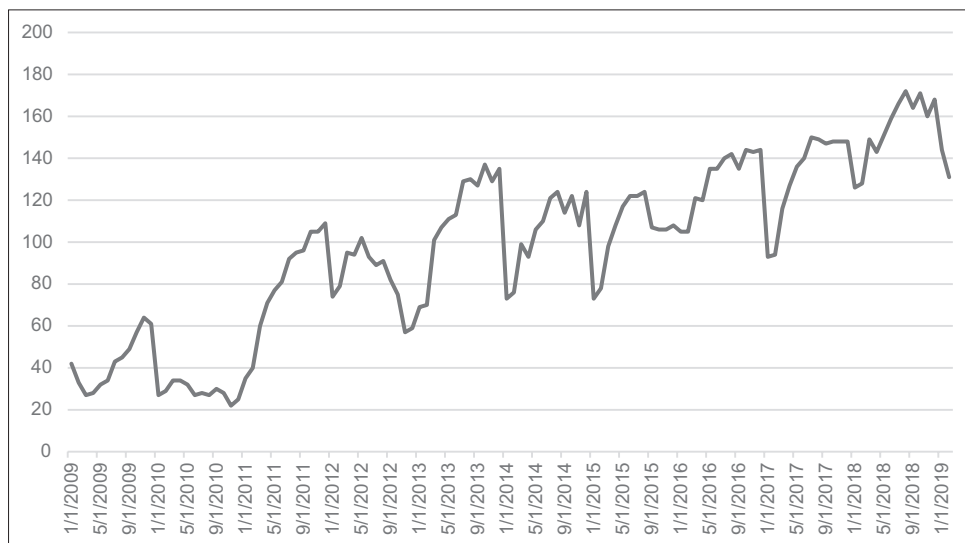
The environmental aspect also seems highly controversial functioning biofuel market.

Figure 1: Capacity of biodiesel in USA, mln. gallons



Source: Thomson Reuters

Figure 2: Supply of biodiesel in USA, mln. gallons



Source: Thomson Reuters

Research analysis allows us to state that performance indicators biofuels in the fight to reduce “greenhouse” emissions strongly vary depending on the type of raw materials used in the production, conditions of its cultivation and the degree of perfection of its processing technology.

At the same time, the study of the balance of greenhouse gases based on the analysis of the total product life cycle suggests that most biofuels can actually increase harmful emissions (compared to fossil fuels, as well as other negative environmental impact).

2. LITERATURE REVIEW

Assessing the potential impact of expansion biofuel production for emissions, it is necessary to consider the extent to which production will be ensured by increasing the productivity of land, and in which - due to the expansion of the cultivated areas (in the latter case the category of land is also relevant). Both of these factors are largely other types of environmental impacts associated with biofuels are also identified with land and water resources and with biological diversity (Morris and Barlaz, 2011). The cost of biofuels compared to traditional energy resources are quite high (Ong et al., 2013; Wustenhagen and Bilharz, 2006).

Many times more cost-effective in the fight to reduce global climate warming are such methods as reducing energy-intensive modes of transport, increasing the efficiency of consumption of traditional energy resources, as well as the protection and restoration of forests (Jaramillo and Matthews, 2005; Kroh, 2013).

The market for a number of countries is complex, controversial and to some extent controversial. In this regard, the most acute is the question of determining efficient and competitive types of biofuels to ensure positive contribution to the preservation of the environment and at the same time to a minimum of negative energy, environmental and social consequences (Milbrabdt et al., 2014, Morgan and Yang, 2001).

A clear understanding of the specifics of new biofuel products industries, economic characteristics and the formation of conditions, factors growth production and international trade, patterns pricing and government regulation will allow to find the most effective criteria for providing economically, environmentally and socially sustainable biofuel production and promote a solution global problems of the world economy (Mikhaylov, 2018a; Mikhaylov, 2019).

The current demand for biofuels many times the sentence that is most effective market incentive for the development of the industry, despite the food component of the development of bioenergy (Chiemchaisri et al., 2012; Gardner et al., 1993).

At the heart of the continuous growth of aggregate demand for biofuels there are mainly factors such as population growth, continuous increase in global energy needs, as in power industry, and in the transport sector the limitations and depletion of traditional energy resources, as well as high prices for them (Amini and Reinhart, 2011; Bansal et al., 2013).

At this situation biofuel is seen as a source of savings in general balance of consumers. The supply of energy to local facilities and consumers as well as to competitive replacement traditional sources in selected sectors (Ahmed et al., 2014; Mikhaylov, 2018b; Nyangarika et al., 2018).

Exploring the dynamics of the global biofuel market, the researchers note that before the period of sharp increase in energy prices production, consumption and trade in biofuels were predominantly local character, however nowadays world turnover is taking shape this product (Bove and Lunghi, 2006; Cai et al., 2011).

The main reasons for the growth of biofuel product turnover are increasing import in a number of industrialized countries (mainly in the US and the EU), which are most intensively implement the objectives of environmental greenhouse gas emissions, but do not have enough bioenergy sources to organize production inside the country (Nyangarika et al., 2019b; Nyangarika et al., 2019a).

3. METHODS

The rapid development of bioenergy targets countries, on the one hand, into trade catalysts, and on the other parties - in some of the largest consumers in this market.

An important impact on the dynamics of world trade biofuel has a steady expansion of consumer demand in this group of countries due to the significant diversification of the range biofuel products as a result of rapid penetration the results of scientific and technological progress in the woodworking and biochemical industry.

In this regard, the main feature of the geographical structure global biofuels trade is the dominant industrial participation developed countries, many of which act simultaneously as exporters and importers.

$$\text{Bioenergy cost} = \sum A + B + C + D \quad (1)$$

Where A - the costs incurred by the infrastructure dependent on the annuity factor and related CAPEX cost; B – the operational costs of plant technology; C – the supply chain costs of the biomass in the harvesting, collection, and treatment; D - the biomass transport cost.

This feature determines the commodity structure of trade developed countries where a significant place is occupied by deeply processed technological biofuels (wood pellets, pellets, bioethanol and biodiesel).

The developing countries are dominated as supplies raw biomass.

However, recently the export potential increased in the world supply of liquid biofuels.

The relative redundancy of cheap labor and the presence of the rich natural resources along with favorable climatic conditions for

biomass production form the basis of the current competitiveness of most countries of this group.

Among the main exporters should be noted Brazil, China, India, Thailand, the Philippines, Malaysia, as well as a number of countries in sub-Saharan Africa.

However, an analysis of international biofuel trade shows that the prevailing share of import supplies at the present stage of market development to a decisive extent it relies not yet on competitive, technical economic benefits of the goods, and on the versatile support of the state.

The weakest competitive side of modern technical base bioenergy remains production costs due to still imperfect biomass conversion technologies, resulting in cost and efficiency production of biofuels with modern technologies, in many respects, depend on high cost of raw materials, the share of which reaches 50-80% of the total cost of the final product.

In this regard, the factors of supply in the biofuel market determined by the choice of raw materials and the availability of land resources in production of liquid biofuels, as well as the availability of organic and wood waste in the production of wood biofuels - which creates a number of problems and bottlenecks in the further development of bioenergy sources.

Often, in his the current form of bioenergy sources are effective only for local, decentralized power supply and unconnected to common networks of use.

At the same time, despite the fact that, in general, biofuel remains more expensive than traditional energy resources.

Comparative competitiveness with respect to traditional energy carriers also have liquid biofuels, produced based on sugar-containing crops of the tropical belt (in Brazil, for example, characterized by a high yield of hectare of land).

In most cases, the development of the biofuel market is largely determined by wide set of tools state stimulate and support the market, especially at the national level. At present state support is taking the form of development programs biofuels, creating a stimulating economic mechanism and application of administrative measures for its implementation in the energy sector.

Virtually all developed countries and some developing countries use advanced bioenergy development programs that imply preferential rules for calculating tariffs for the connection of renewable energy sources to networks, tax benefits and benefits for consumers and manufacturers of "green" electricity, reservation for bioenergy cultures of acreage and land, supporting R and D and reducing administrative barriers.

Programs are crucially conducive to the fact that they rely on expanded economic mechanism, which, in turn, implies budget financing, economic benefits and administrative measures in bioenergy benefits.

In the public sector, the state assumes expenses for R and D, especially on fundamental developments.

In terms of tax and other benefits practiced by the reduction of duties; tax exemption for biofuel producers; preferential rates for indirect taxes on the sale of cars working on a mixture traditional motor fuels with biofuels or their complete release from tax payment; tax rebates on environmental program revenues private enterprises and others.

Important role in the bioenergy promotion system administrative measures that imply standardization and biofuels certification.

As the experience of foreign countries shows, the most effective national level is an integrated regulatory approach, combining administrative and economic instruments aimed to maintain guaranteed demand for biofuel products and stimulating innovation.

Far from the last role in the development of efficient trade in biofuels the development and adoption of unified international product quality standards played.

The market effect of government regulation is manifested in some smoothing of price fluctuations and stabilization of supply and demand, which directly affects the competitiveness of biofuel products.

Changes occurring in the dynamics and structure of demand and offers for biofuels, are manifested in prices. Important the impact on the prices of biofuel products has an average level cost per unit of output and its dynamics, largely dependent on technology of cultivation of agricultural raw materials, crop yields, regional climatic and financial-economic conditions.

The movement of actual biofuel prices has a significant effect the state of the monetary and financial system of countries: market fluctuations key currencies (US dollar and Euro).

Prices for biofuel products determined by the ratio of the above factors, as well as technological changes and long-term price trends on traditional energy.

Thus, the peculiarities of the development of the global biofuel market in the medium and long term it is largely determined by its intermediate, borderline position in the world energy and food systems.

On the one hand, the production process biofuels due to the influence of specific food cycles in raw materials sector and a combination of climatic factors that forms the specifics of market trends.

The most important factors are the continuous growth of global energy needs, resulting in general economic trends in the biofuel market.

The interaction of these factors is manifested through the mismatch market mechanisms with multiple excess of demand over the disproportion in the provision of energy needs of the population of the planet.

Under these conditions, it is obvious objective need to optimize the functioning of the world market biofuels.

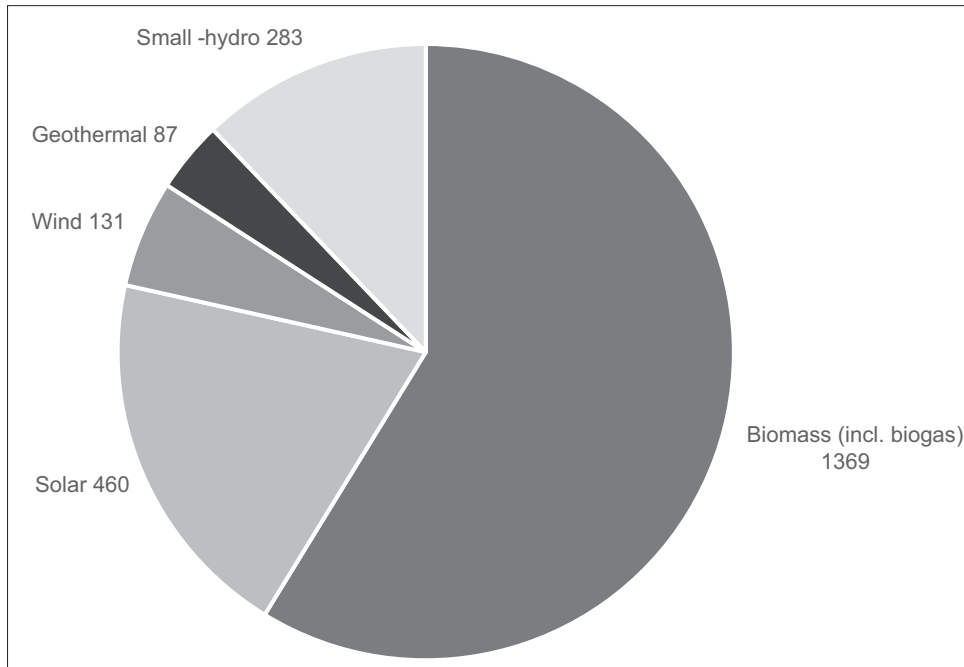
4. RESULTS

The problem of determining the prospects for development the global biofuels market is that it is necessary to take into account the complex interrelated factors that have a direct impact on the state

of bioenergy potential and the development of trade in products biofuel industries. Russia has great capacities in bioenergy production (Figure 3 and 4).

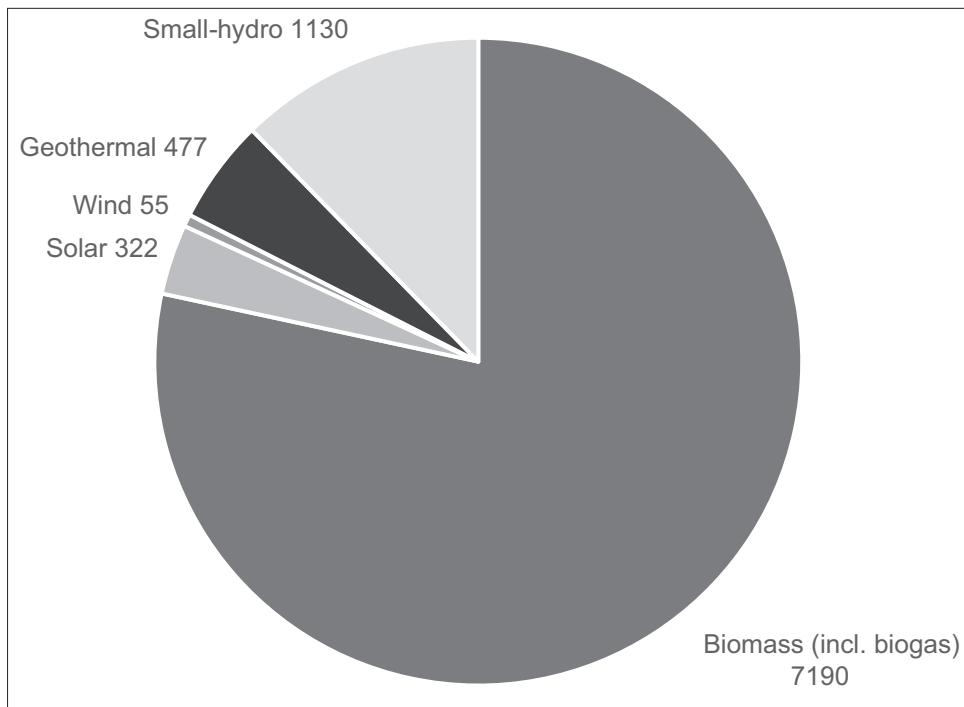
The analysis showed that most currently existing expert assessments of the global potential bioenergy does not sufficiently fully reflect the impact of environmental problems on the prospects for the production and use of biofuels (Table 1).

Figure 3: Renewable energy sources capacity in Russia in 2017, GWh/year



Source: Thomson Reuters, Minenergo

Figure 4: Renewable energy supply in Russia in 2017, GWh/year



Source: Thomson Reuters, Minenergo

As a result, a general assessment of the potential of bioenergy on the present stage of development of science and technology may be significantly lower indicators that are found in studies of an earlier period, if take into account the negative affect of expanded biofuel production on soil, water and biodiversity.

The world market will be carried out mainly by developing second-generation technologies, involving a significantly wider scope and diversity of raw materials for the production of biofuels compared to currently used technologies of the first generation.

The price of bioenergy has grown for in recent years (Figure 5 and 6).

Table 1: Share of factors in bio energy supply, %

Parameter	Share, %
A	51
B	21
D	20
C	8
Total	100

The main forecast direction of technical progress in the industry advocating the transfer of biofuel production to non-food raw materials and expansion recyclable waste.

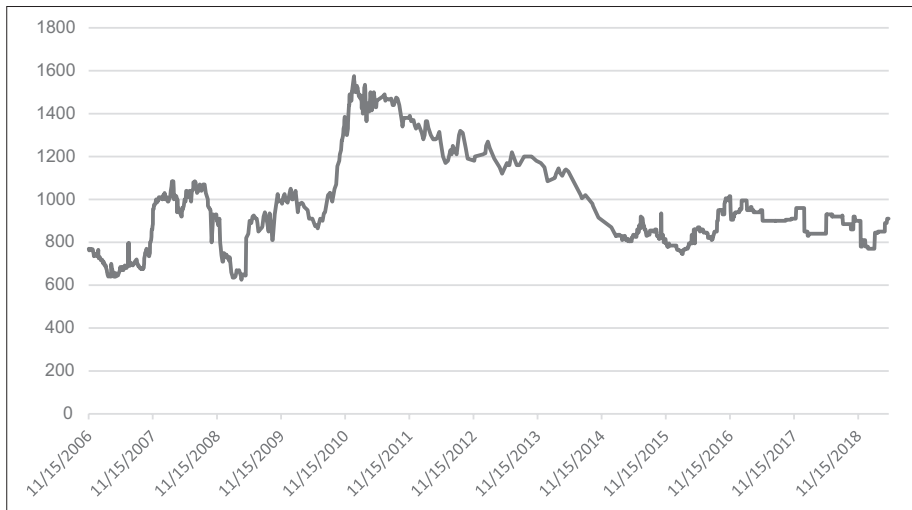
Paper notes the high competitive advantages of Russian companies on global market for wood biofuels, due to the presence in Russia significant part of the world’s forest reserves, efficient technologies wood processing and conversion of wood biomass to fuel.

In addition to the woody sector, an important priority bioenergy in Russia is the field of technology development and application of biomass gasification, involving the processing of wood waste, and also agricultural waste and municipal solid waste.

Agriculture could become an important element in shaping the biofuel market in Russia through creating new chains of production of raw materials for renewable energy.

Paper offers a number of recommendations for the development bioenergy in Russia and emphasizes that to realize the potential

Figure 5: Price of biodiesel, USD



Source: Thomson Reuters

Figure 6: Price of bioethanol, USD



Source: Thomson Reuters

renewable energy is fully needed consistent state policy in the field of energy saving and renewable energy.

5. CONCLUSION AND DISCUSSION

Despite the dynamic development of the biofuel industry in the world, at the production technologies used today characteristic features and disadvantages of biofuels represent it only in as a tool for the transitional phase in overcoming the energy deficit in world, very slightly increasing the energy security of individual countries.

Requirements for land resources and crops for the production of food raw materials are too large to replace fossil fuels on a larger scale. At medium term hydrocarbon fuels will remain most important source of energy in the world, with biofuels will be able to provide only a small share in the global fuel energy balance and even less in transport energy.

The aggregate demand for biofuels will constantly increase, mainly due to extensive factors. Significant impact on changing the demand for biofuels is having a state by creating mechanisms to support the production and consumption of biofuels, as well as promoting the development of market infrastructure. Demand is also determined by the design of the markets for substitute products, especially oil.

With modern production technologies, the main resources determining the specifics of the production and supply of biofuels are original agricultural raw materials and land.

To ensure economic efficiency of some crops for the production of liquid biofuels high quality agricultural land is required, significant amount of fertilizer and water resources.

As a consequence, the issue of ensuring energy security through increased use of biofuels should be considered in the context of increasing pressures on rural economy and the rapid growth in demand for food in the world that leads to a significant reduction in technical and economic bioenergy potentials.

One of the factors constraining large-scale development bioenergy, stands the rather high cost of most species biofuels compared to the cost of traditional energy.

However, the competitiveness of biofuels varies considerably depending on the specific type of product, raw materials and location production, and profitability may change as you change conjuncture of world markets for raw materials and due to technological advances in the industry itself.

Direct impact on the competitiveness of biofuels in the markets of individual countries has a policy to promote bit fuel for state level while providing financial support and managing relevant tax policy.

However, for many measures government regulation of the biofuels market, taken as in developed and developing countries, characterized by high economic, social and environmental costs.

Despite the fact that liquid biofuel provides only a small fraction of the global energy requirements, it is nonetheless has a significant impact on world agriculture and agricultural markets through land use and food raw materials for its production.

In the long run expansion of demand and rising prices for agricultural products can create favorable opportunities for the development of agriculture and rural areas.

But, on the other hand, the increasing demand for agricultural raw materials for biofuels increase food prices, most endangering the food security of the poor net food buyers in urban and rural areas.

The impact of biofuels on condition environment varies widely by country, type biofuels, type of raw materials and production practices.

The contribution of biofuels to reducing greenhouse gas emissions is not necessarily positive for all types of biofuels.

Moreover, the analysis of the situation shows that today the direct or indirect involvement of new land in the economy associated with the rapid progress of biofuels, can only increase the amount of greenhouse gases in the atmosphere.

Complexity and the multi-factor nature of the tasks of reducing greenhouse gas emissions, different conditions for their solution and unequal consequences for different countries make it difficult to make general decisions regarding the assessment of the contribution of biofuels to solving environmental problems. In this regard, the most appropriate considering biofuels as just one of components of a range of alternatives aimed at addressing global environmental issues.

Determining the potential of bioenergy and evaluating future of the prospects for the development of the biofuel market require consideration of a wide range of factors that have a deterrent effect on technical and economic opportunities of the biofuel industry.

Given the criteria limited land use, overall capacity assessment bioenergy is significantly lower, where the influence of environmental factors underestimated.

The introduction of new technologies, as well as the creation and development qualitatively new methods for converting lignocellulosic biomass from non-food raw materials, waste and highly efficient energy crops under the influence of scientific and technological progress provides increased efficiency production and cost reduction per unit of product that plays a crucial role in determining the future prospects of bioenergy.

But, a prerequisite for improving the competitiveness of new species fuels are the launch of large-scale production and commercialization technologies, along with ensuring the availability of bioenergy sources and raw materials.

Products of the bioenergy industry in Russia are not used widely, although in the domestic market certain types of biofuels have competitive advantages.

This situation is due mainly due to limited state participation in solving problems of this important industry. To strengthen the position of the industry it is necessary to carry out constant search for ways to reduce costs, increase productivity labor at the enterprises of the forest complex and the agro-industrial complex and increasing the share of solid biofuels and biogas in the total output of the range, because they are more in demand by the market.

One of the directions to optimize the structure of foreign trade of Russia should recognize the expansion of the export structure due to the proposal in the competitive domestic biofuel market production.

For the development of high-tech biofuel production, it is necessary to continue investing in economically and organizationally appropriate basis as well combine efforts to increase competitiveness.

6. ACKNOWLEDGEMENTS

This work was supported by Hankuk University of Foreign Studies Research Fund.

REFERENCES

- Ahmed, S.I., Johari, A., Hashim, H., Mat, R., Lim, J.S., Nagadi, N., Ali, A. (2014), Optimal landfill gas utilization for renewable energy production. *Environmental Progress and Sustainable Energy*, 34(1), 289-298.
- Amini, H.R., Reinhart, D.R. (2011), Regional prediction of long-term landfill gas to energy potential. *Waste Management*, 31(9-10), 2020-2026.
- Bansal, A., Illukpitiya, P., Singh, S.P., Tegegne, F. (2013), Economic competitiveness of ethanol production from cellulosic feedstock in Tennessee. *Renewable Energy*, 59, 53-57.
- Bove, R., Lunghi, P. (2006), Electric power generation from landfill gas using traditional and innovative technologies. *Energy Conversion and Management*, 47(11-12), 1391-1401.
- Cai, X., Zhang, X., Wang, D. (2011), Land availability for biofuel production. *Environmental Sciences Technology*, 45(2), 334-339.
- Chiemchaisri, C., Chiemchaisri, W., Kumar, S., Wicramarachchi, P.N. (2012), Reduction of methane emission from landfill through microbial activities in cover soil: A brief review. *Journal Critical Reviews in Environmental Science and Technology*, 42(4), 412-434.
- Gardner, N., Manley, B.J.W., Pearson, J.M. (1993), Gas emissions from landfills and their contributions to global warming. *Applied Energy*, 44(2), 166-174.
- Jaramillo, P., Matthews, H.S. (2005), Landfill-gas-to-energy projects: Analysis of net private and social benefits. *Environmental Science and Technology*, 39, 7365-7373.
- Kroh, K. (2013), World's Largest Landfill Will Soon be NYC's Biggest Solar Plant. *Think Progress*. Available from: <http://www.thinkprogress.org/climate/2013/11/26/2994631/york-landfill-solar-plant>.
- Mikhaylov, A. (2018a), Pricing in oil market and using probit model for analysis of stock market effects. *International Journal of Energy Economics and Policy*, 8(2), 69-73.
- Mikhaylov, A. (2018b), Volatility spillover effect between stock and exchange rate in oil exporting countries. *International Journal of Energy Economics and Policy*, 8(3), 321-326.
- Mikhaylov, A. (2019), Capital and Crypto Markets: Institutional Investor Behavior and Strategies. Vienna: Premier Publishing S.R.O. p204-206. Available from: <http://www.doi.org/10.29013/MikhaylovA.CCM:IIBS.404.2019>.
- Milbrabdt, A.R., Heimiller, D.M., Perry, A.D., Field, C.B. (2014), Renewable energy potential on marginal lands in the United States. *Renewable and Sustainable Energy Review*, 29, 473-481.
- Morgan, S.M., Yang, Q. (2001), Use of landfill gas for electricity generation. *Practice Periodical of Hazardous, Toxic, and Radio Waste Management*, 5(1), 14-24.
- Morris, J.W., Barlaz, M.A. (2011), A performance-based system for the long-term management of municipal waste landfills. *Waste Management*, 31(4), 649-662.
- Nyngarika, A., Mikhaylov, A., Richter, U. (2019a), Oil price factors: Forecasting on the base of modified auto-regressive integrated moving average model. *International Journal of Energy Economics and Policy*, 9(1), 149-159.
- Nyngarika, A., Mikhaylov, A., Richter, U. (2019b), Influence oil price towards economic indicators in Russia. *International Journal of Energy Economics and Policy*, 1, 123-129.
- Nyngarika, A., Mikhaylov, A., Tang, B.J. (2018), Correlation of oil prices and gross domestic product in oil producing countries. *International Journal of Energy Economics and Policy*, 8(5), 42-48.
- Ong, S., Campbell, C., Denholm, P., Margolis, R., Heath, G. (2013), Land-Use Requirements for Solar Power Plants in the United States. NREL/TP-6A20-56290. p. 39. Available from: <http://www.nrel.gov/docs/fy13osti/56290.pdf>.
- Wustenhagen, R., Bilharz, M. (2006), Green energy market development in Germany: Effective public policy and emerging customer demand. *Energy Policy*, 34, 1681-1696.