

Інноваційно-інвестиційні чинники економічного зростання

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BIO-FUELS AS AN INNOVATIVE PERSPECTIVE OF ENERGY DEVELOPMENT

Shudlarski Jacek, Zaika S. Bio-fuels as an innovative prospect of Energy.

An important feature of the modern world is the increased attention of the scientific community to the problems of rational and efficient use of energy resources, introduction of energy-saving technologies and alternative sources of energy.

Now global development of renewable energy has an accelerated nature. Perhaps in the next years the current trend will increase, due, primarily, to the growing global energy crisis.

Consequently, the task of meeting the needs of the world's energy, along with ensuring environmental safety necessitates the development of alternative energy, where bio-fuels occupy a special place.

The most effective scenario growth of bio-fuel production both in the world and in Ukraine as innovative perspectives of energy development is to create conditions in which the state regulation of this process will play a crucial role.

To ensure the rapid development of the bio-fuel market it is necessary to create a favorable investment climate and stable environment of enterprises that produce bio-fuels and their interaction with the government on scientific activities and introduction of innovative technologies.

Keywords: *alternative energy, innovative development, bio-fuel.*

The actuality of the subject. One of the most important features of the development of the modern world is the increased attention of the world community to the problems of the rationality and efficiency of energy resources use, the introduction of energy conservation technologies and the search for renewable energy sources.

In modern conditions of the world economy deepening problems the development of renewable energy in the world has accelerated. Most likely, over the next decade, the inherent tendency will not only remain, but will also have an upward trend, which is primarily due to the multifactorial crisis phenomena of a global nature that are growing in power.

On the one hand, global scale processes are caused by the limited and exhausted geological reserves of the main types of fuel resources – oil and gas, which leads to an inevitable rise in prices for them. On the other hand, the negative impact of environmental factors caused by the consequences of human life increase.

Today, the impact of the growing environmental crisis is increasingly felt. The main environmental damage associated with global climate change of the Earth, the greenhouse effect, is mainly caused by the extraction, processing and burning of fossil fuels – coal, oil and gas.

In this regard, the task of meeting the growing needs of the world's population in fuel, electricity and heat, along with ensuring environmental safety, necessitates the development of renewable energy.

Bio-fuel holds a special place in the structure of renewable energy sources (RES). As one of the few alternative fuels in the transport sector, bio-fuels are seen as an important resource for diversifying energy sources and ensuring energy security, agricultural and rural development, and for mitigating the effects of climate change by reducing greenhouse gas emissions.

In this regard, the beginning of the XXI century was a period of active development and development of the biofuel market, in the process of which the future model of the world

energy system is set.

However, the formation of modern trends in the world bio-fuels market is accompanied by the development of contradictions of actors at all levels – from groups of states to individual economic structures and consumers. At the same time, economic, environmental and social effects from the introduction of bio-fuels remain the subject of extensive disputes. These factors can become a significant obstacle to the development of the bio-fuel market, as an innovative perspective for the development of energy, as well as all aspects of the impact of production of this product, both on the economy of individual states and the world as a whole.

The analysis of the land research and publications. In recent years, under the influence of increasing integration in the development of renewable energy sources, various aspects of the problems of using biomass as a source of energy have become the object of a number of scientific studies. At the same time, the domestic and foreign economic literature focuses on technical and environmental-technological problems of the development, production and use of bio-fuels, assessment of the global potential of bio-energy, analysis of the state of the bio-fuel market of individual countries. However, many significant issues of the formation and features of the development of bio-fuel production as a source of innovative prospects for energy development remain unexplored. The issues of the prospects for the development of the bio-fuel market and world bio-energy as a whole under the influence of a complex of factors in interconnection and interdependence have not yet become a separate subject of scientific analysis. In this connection, the insufficient degree of scientific elaboration of the problem of the formation and development of the world bio-fuels market and the practical importance of studying these issues for the economy predetermined the authors' interest in this subject.

The aim of the article is to study the features of the formation and prospects for the development of the world bio-fuels market as an innovative perspective for the development of energy in the current conditions of deepening the global problems of the world economy.

The presentation of the basic material.

The development of the bio-fuel industry is becoming more urgent. The depletion of traditional energy sources and the growing demand and prices of hydrocarbon energy resources are of concern to the entire international community. World energy consumption over the past 20 years, according to estimates of the International Energy Agency (IEA), has increased by one and a half times, and the world demand for energy resources will increase by 65-70% by 2030, [12]. In order to ensure global energy and environmental security, the world community is actively trying to reduce the dependence of energy on fossil fuels. One of the directions of modern energy development is the use of bio-fuel.

The history of the global bio-fuel market counts several decades since the first oil crisis 1970s. The modern bio-fuel market began to be formed in the 21st century. Its development is conditioned by the following factors:

- the desire to reduce the dependence of individual states on the import of fossil fuels and ensure energy security;
- adherence to the requirements of the Kyoto Protocol, which provides the reduction of greenhouse gas emissions into the atmosphere (including methane);
- the need to develop the agricultural sector of the economy, processing agricultural waste, create new jobs, etc. [16, 17].

Modern bio-fuels are divided into two types: of the first and second generation. Bio-fuels of the first generation include bio-ethanol, produced from sugar cane, corn, wheat and other cereals, and biodiesel derived from oil crops – soybean, rape, palm, sunflower. The use of quality arable land, a lot of agricultural machinery, as well as fertilizers and pesticides are required for their cultivation. Of course, in this scenario, bio-fuel production directly competes with the food sector of the economy. This leads to its consequences in the social sphere and gives a negative color to all bioenergetics.

Fuel bio-ethanol is obtained by fermenting sugars using ethanol production technology without additional purification steps. Biodiesel is produced by the chemical reaction of fats of vegetable oils and lower alcohols (primarily methanol).

Second generation bio-fuels are made from non-food raw materials. It can include waste fats and vegetable oils, biomass of trees and grasses. The advantage of this fuel is that these plants can be grown on less improved lands with the minimum amount of machinery, fertilizers and pesticides. The downside is that wood lignocellulose is a complex polymer carbohydrate; it requires much more chemical transformations and, accordingly, energy to produce liquid fuels from it than in the production of first-generation bio-fuels. But the efficiency of energy production from biomass bio-fuel of both generations is the same, about 50%.

Biodiesel from non-food raw materials is also bio-fuel of the second generation. It is obtained from technical oilseeds and microalgae. Due to the rapid growth and reproduction of microalgae, it is possible to obtain fuels from 15 to 200 times more than from the best agricultural oilseeds.

Bio-fuels of the second generation are also

classified as bio-fuels of the first generation, obtained by new technologies, which lead to a decrease in the consumption of fossil fuels during their production, as well as to a reduce of the harmful impact on the environment.

There is another classification of bio-fuels - by the methods of their production. There are chemical, thermochemical and biological methods.

A relatively new type of bio-fuel stands out: green diesel (supercetane). In simpler terms, this is a mixture of hydrocarbons of the diesel fraction. Green diesel has a high cetane number (flammability characteristic) - 70-85, this is a very good level. Green diesel is positioned as an improving additive to traditional diesel fuels. Presently, concepts and technologies are being developed for the production of third generation bio-fuels, which will be more cost-effective and environmentally friendly (with a minimum aggregate emission of CO₂ в into the atmosphere). Figure 1 shows a simplified classification of bio-fuels.

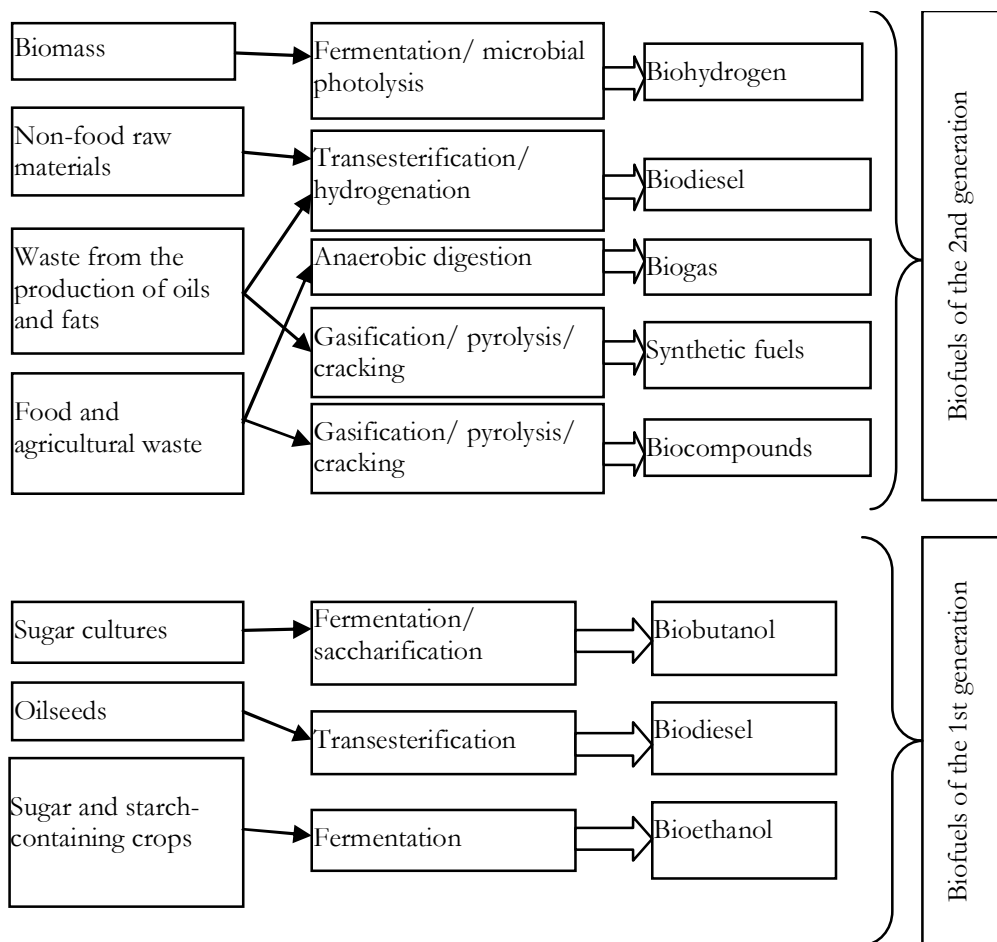


Fig. 1. Classification of bio-fuels
 (A source: R.C. Saxena, D. Seal, S. Kumar, H.B. Goyal, *Renewable and Sustainable Energy Reviews*, 12, 2015)

Now bio-fuel occupies an insignificant share of the world energy market, although the UN plans to increase the share of renewable energy sources in energy production to 30% by 2030 from the current 17% [4]. More than 80% of the energy consumed in the world is produced from traditional sources (oil, gas, coal) [10]. In

2016, the share of renewable energy sources (RES) in the world consumption of primary energy sources was about 20%. From the point of view of the dynamics and volumes of consumption, the main segments of the world market for alternative energy are bio-fuels, solar and wind power (Fig. 2).

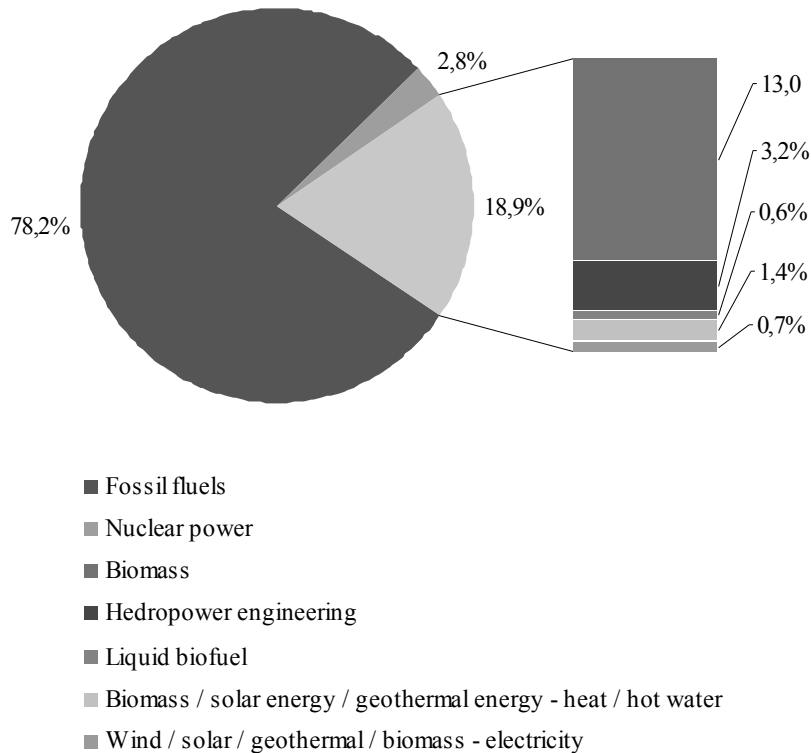


Fig. 2. World primary energy consumption by source

(Source: *Renewables 2015 Global Status Report / Renewable Energy Policy Network for the 25 st century Secretariat. – Paris, 2015. – P. 23.*)

In most economically developed countries, the share of biomass in total primary energy production, as a rule, does not exceed 3%. Today, most of the biomass consumption falls on developing countries (up to 20% of the country's fuel and energy balance), in which it is used mainly by households when burning firewood in furnaces for heating and cooking. The use of biomass for generating heat is widely used, both in the private sector and in the district heating system. Most of the heat produced from RES in the world is produced with the help of biomass. This area of biomass is actively developing in Europe, in particular, in Sweden, Finland, Denmark, Austria, Germany and the Netherlands. For example, in Sweden biomass is the main raw material used in heat supply, and is also used to produce fuel for transport. In 2015 in Sweden, the volume of

energy production from biomass was 31.7%, ahead of oil (30.8%) [8]. In many countries, both developed and developing, including China and India, the use of biomass for electricity generation is increasing. By the end of 2015, there had been more than 60 GW of installed units in the world working on biomass.

At the same time, traditional untreated plant biomass (about 13%), which mainly includes agricultural and forestry waste, occupies a significant place among renewable sources of fuel and energy. While bio-fuel, a product of deep processing of plant biomass, occupies a very modest place in the world consumption of primary energy: it accounts for only 0.6% of total energy consumption, and the total contribution of biomass to heat and power generation (along with solar, geothermal and Wind energy) is 2.1%.

It is biomass that is currently the most common commodity for RES of international trade: from all other alternative sources of energy, it is distinguished by the versatility of use (in heating, power generation and transport), the ability to replace any element of the traditional energy balance (coal, oil, gas), and recently, it has also acted as a chemical and biotechnological raw material. In addition, unlike other RES, whose energy, as a rule, remains local and consumed at the time of generation, biomass can be stored, transported and sold directly as primary raw materials, and in the form of its derivatives. The use of biomass in the world in comparison with the twentieth century increased more than 4 times.

However, in assessing the quantitative indicators underlying the current fuel and energy balance, despite the rapid growth of the importance of world bio-energy, in the coming years biomass is unlikely to be an important source of meeting the growing energy needs in the world. This situation is explained by the fact that the development of bio-energy at the world level is very contradictory, first of all, affecting

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

As a result of changes in the priorities of environmental and energy policy, modern bio-energy represents a new source of demand for agricultural products that can, in the long run, promote the revitalization of agriculture in developing countries. At the same time, the development of industries for the production of bio-ethanol and biodiesel, which require a large amount of food raw materials, leads in the medium term to an increase in prices for almost all types of food products, and this process affects all countries of the world, regardless of whether they participate in the cultivation of bio-fuel raw materials or not. In this regard, the production of bio-fuels, of course, can be considered as a factor destabilizing the world food system.

Fig. 3 shows the technical potential of world biomass supplies for energy production in 2020 in comparison with the mandatory level of consumption specified for the purpose of the RES Development Strategy for 2020.

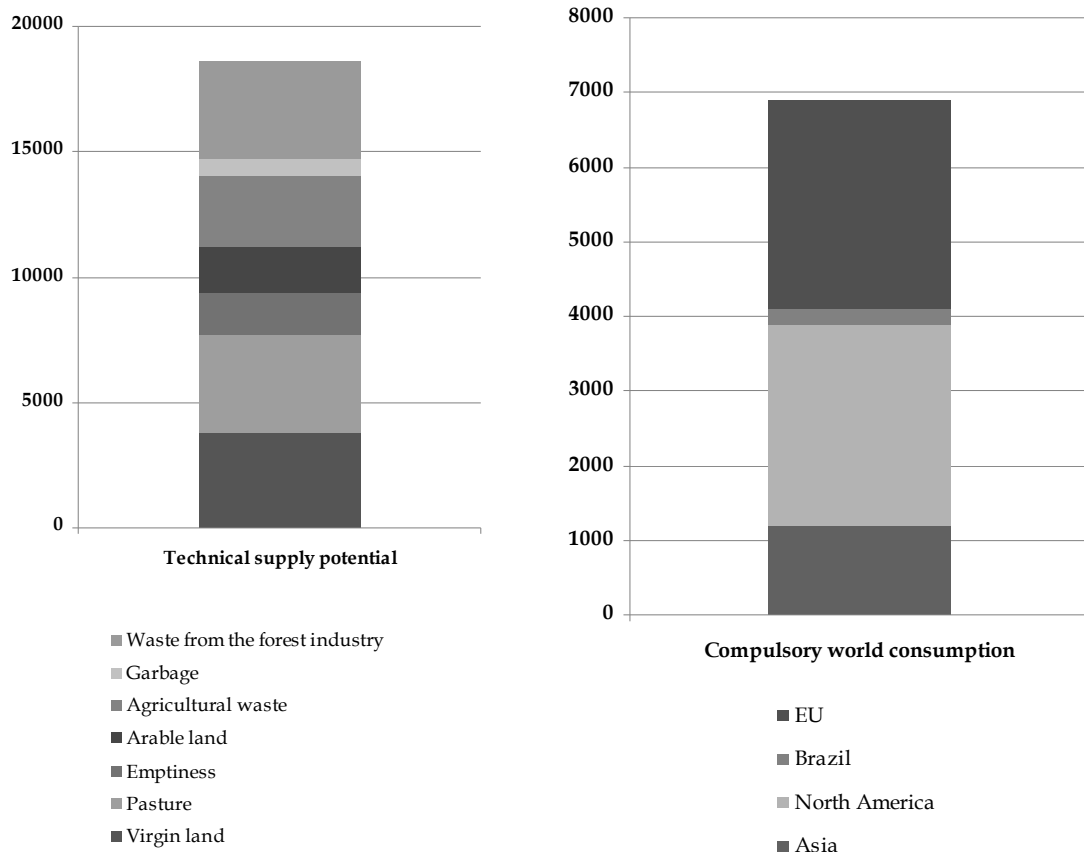


Fig. 3. Technical potential of world biomass supplies for energy production in 2020 in comparison with the mandatory level of consumption, designated for the purpose of the Strategy for Development of Renewable Energy for 2020. (worked out from the data given by the International Organization of FAO)

The trends in the development of the bio-fuel industry in the European Union are of particular interest. In April 2009, the European Union Renewable Energy Directive (RenewableEnergyDirective 2009/28 / EC) was adopted, covering all 27 member countries. The directive sets out the following goals by 2020:

- Achievement of a 20% share of RES (biomass, bio-fuels, biogas) in the total final energy consumption of the EU;
- Achieving a 10% share of used bio-fuels in the transport sector;
- Reduction of greenhouse gas emissions

when using bio-fuel by 6% [3].

The mandatory level of 10% for motor fuels is included in the increase in the share of renewable energy. The new Directive replaced the previous commitment to achieve a 5.75% share of bio-fuels, which was achieved individually by each member of the European Union through various strategies. According to the forecasts of the European Commission, the production of heat and electricity from biomass in the EU will increase to 1,250 TWh by 2020 (Fig. 4).

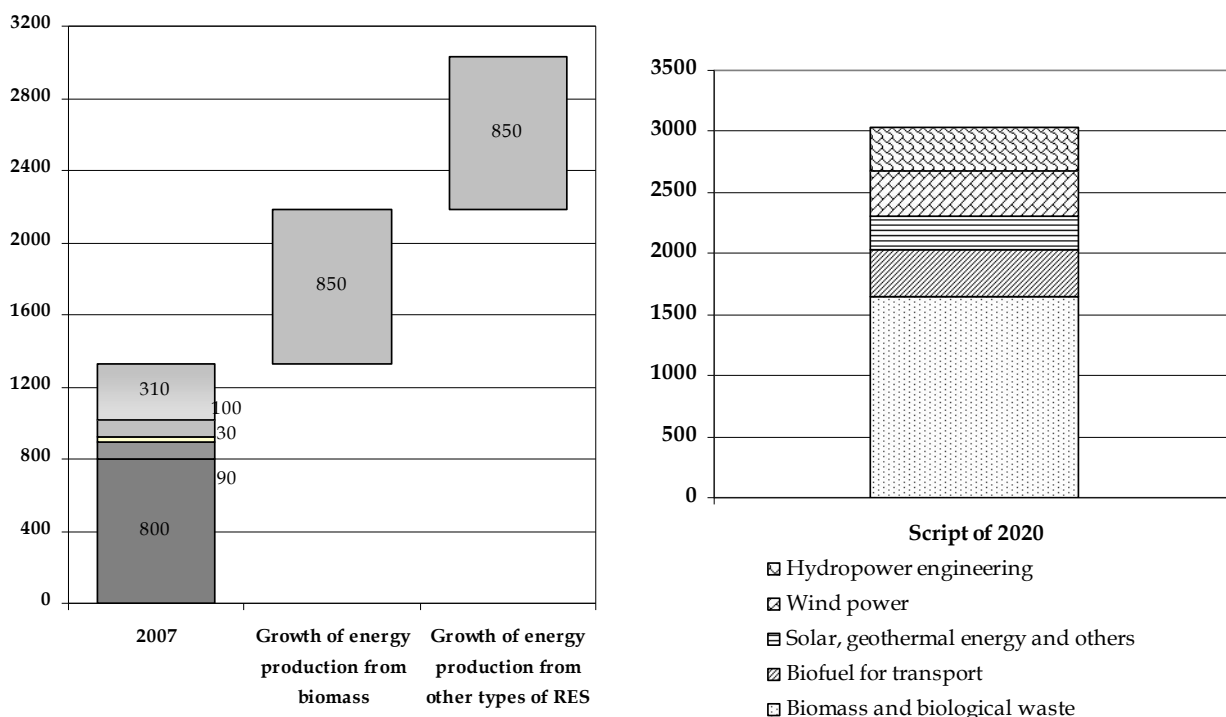


Fig. 4. The role of biomass in the achievement of EU objectives for the development of renewable energy, – the scenario of the European Commission (total energy consumption in the EU-27, TWh).

A source: Biomass for heat and power. Opportunities and economics. European Climate Foundation, Sveaskog, Södra, Vattenfall, 2016

This growth will be about half of all current energy consumption from coal. The current EU bio-fuel policy requires a number of restrictions on greenhouse gas emissions in production that directly affect land use due to the increasing use of bio-fuels.

In June 2010, the EU adopted regulations that provide strict control so that the production of bio-fuels based on rapeseed, wheat, corn and sugar not to be associated with deforestation, use of wetlands and protected areas, which can lead to an increase of greenhouse gas emissions.

EU member states, aiming to achieve a 20 % share of renewable energy (10 % in the transport sector), can only consider those bio-fuels that comply with all established criteria. The main problem of the bio-fuel industry in the EU is the shortage of industrial raw materials, which resulted in rising prices, both of the raw materials and the final product. The introduction of a 10% mandate for bio-fuels contributed to the expansion of European companies to commodity markets, both within the EU and beyond [1, 5].

Now about 90 % of the world consumption of bio-fuel falls within bio-ethanol and biodiesel. The use of bio-fuels in transport is an important way to reduce emissions of harmful substances into the atmosphere, along with increasing its effectiveness. The total production of liquid bio-fuels in the world exceeds 100 billion liters. Today, liquid bio-fuels take about 3% of total fuel for transport, and also reach a significant share in some countries

that are most actively developing this sector. For example, in Brazil, the share of bio-fuel use in the transport sector is about 21%, in the USA – 4 %, in the EU – 3 %. The IEA estimates that by the year 2050 the share of bio-fuel in the transport sector could increase to 750 million tons and make up 27 % of the total transport fuel, reducing transport emissions by 20 % and reducing world dependence on fossil fuels (Fig. 5).

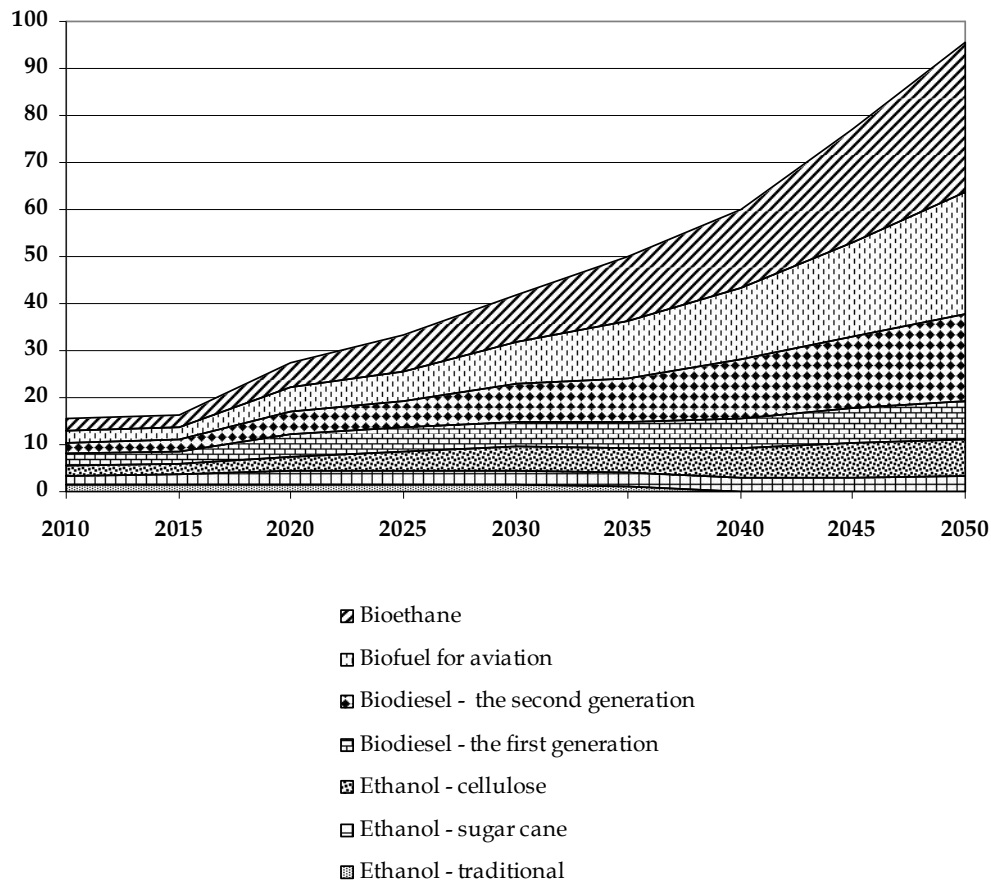


Fig. 5. Forecast of liquid bio-fuel production in the world, 2010-2050.
(A source: *Technology Roadmap Bio-fuels for Transport*, МЭА, 2017)

According to the IEA study, the costs of transporting bio-fuel production in the above-mentioned volume will take 11 to 13 billion US dollars between 2010 and 2050, which, however, will not have a significant impact on the total cost of transport fuel in the world. In March 2011, the European Commission introduced the Transport-2050 (Transport-2050) single transport space strategy, aimed at exempting oil dependence on reducing emissions by 60% by 2050. The strategy provides significant changes in the transport sphere of the EU:

– 50% of cars on low-carbon fuel by 2030, refusal to use cars on conventional fuels

in cities by 2050;

– 40% share of low-carbon fuel use in aviation, at least 40% reduction in emissions from shipping by 2050;

– 50% transition in the sphere of passenger and freight traffic at medium distances to the use of rail and water transport by 2050 [11].

At present, China is the world's third largest producer of bio-fuels (after the US and Brazil). Ethanol, as a rule, is added in volume of 10% to traditional fuel. Ethanol was originally produced from grain, but new plants now predominantly use cassava, sweet potatoes or sorghum. Demand for biodiesel in China is also

increasing, but domestic production lags far behind in scale. There is a growing interest in the production and use of second generation bio-fuels: energy consumption from renewable sources in 2015 reached 11.4 %. The expansion of bio-fuel production of the second generation allows providing jobs for up to 3 million people. We consider algae as one of the promising sources of raw materials for the production of new bio-fuels in China. According to experts, China can produce up to 12 million tons of aviation bio-fuel a year (30% of the total volume of jet fuel consumption in the country) by 2020 [10].

The production of liquid bio-fuel in our country is still rather poorly developed. The use of motor fuel oil by Ukrainian transport is insignificant. However, the possibility of exporting bio-fuels and bio-raw materials to Europe looks promising enough for Ukraine [7].

Ukraine has favorable conditions for the production of bio-fuel from agricultural raw materials. According to experts, the total volume of potentially produced "green" diesel and motor ethanol can reach 500 thousand tons per year, which will provide up to 60 % of the total demand of the country in diesel fuel and up to 10% in petrol [6, 14]. In Ukraine, from 2013, there is a phased increase in the regulatory impurity of bio-ethanol in motor petrol, in particular, in 2013-2015. – 5%, and from 2016 – no less than 7 % [2].

The growth of the bio-fuel market promotes the creation of new jobs and incomes throughout the entire production and distribution chain: from farmers and biotechnologists to distributors. New jobs, early economic recovery, production growth, new investment opportunities are the positive effects noted by research into the potential consequences of the development of the biofuel industry in the world. The US expect the creation of 800,000 new jobs with a total

economic effect of \$ 148700 billion, as a result of the development of the bio-fuel industry, by the year 2022, which will save \$ 350 billion over 12 years (2010-2022) of oil imports reduction [13, 15].

Output. Despite the fact that liquid bio-fuels provide only a small fraction of the world's energy needs, it nevertheless has a significant impact on global agriculture and agricultural markets through the use of land resources and food raw materials for its production. In the long term, increasing demand and rising prices for agricultural products can create favorable opportunities for the development of agriculture and rural areas.

In the future, the total demand for bio-fuels will continue to increase, mainly due to extensive factors. These include: the overall growth in the world population and the continuous increase in energy needs in various sectors of the economy.

The main impact on changing demand for bio-fuels belongs to the state through the creation of mechanisms to support the production and consumption of bio-fuels, as well as to encourage the development of market infrastructure.

The most effective scenario for increasing bio-fuel production in Ukraine as an innovative perspective for energy development is to create conditions under which the state regulation of this process will play a leading role.

Promising elements of the successful process of using innovations are their synthesis in the fields of energy, industry and agriculture.

To ensure the development of the bio-fuel market fully, it is necessary to create a favorable investment climate and a stable environment for the functioning of enterprises associated with the production of bio-fuels, interaction between the state and enterprises in the direction of scientific activity and the introduction of new technologies in production.

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Анотація.

Шудларські Яцек, Заїка С.О. Біопаливо як інноваційна перспектива розвитку енергетики.

Важливою особливістю розвитку сучасного світу є підвищена увага наукової спільноти до проблем раціонального та ефективного використання енергоресурсів, впровадження технологій енергозбереження та пошуку альтернативних джерел енергії.

Нині світовий розвиток альтернативної енергетики має прискорений характер. Напевно, протягом наступних років існуюча тенденція буде підвищуватися, що пов'язано, перш за все, зі зростаючими в енергетиці кризовими явищами глобального характеру.

Отже, завдання задоволення потреб населення світу в енергії поряд із забезпеченням екологічної безпеки зумовлює необхідність розвитку альтернативної енергетики, особливе місце в якій займає біопаливо.

Найбільш ефективним сценарієм зростання виробництва біопалива як в світі, так і в Україні, як інноваційної перспективи розвитку енергетики є створення умов, за яких визначальну роль буде грати державне регулювання цього процесу.

Для забезпечення стрімкого розвитку ринку біопалива потрібно створити сприятливий інвестиційний клімат і стабільне середовище діяльності підприємств, які виробляють біопаливо, та їх взаємодію з державою щодо наукової діяльності та впровадження у виробництво інноваційних технологій.

Ключові слова: альтернативна енергетика, інноваційний розвиток, біопаливо.

Аннотація.

Шудларски Яцек, Заїка С.А. Биотопливо как инновационная перспектива развития энергетики.

Важной особенностью развития современного мира является повышенное внимание научного сообщества к проблемам рационального и эффективного использования энергоресурсов, внедрения энергосберегающих технологий и поиска альтернативных источников энергии.

Сейчас мировой развитие альтернативной энергетики имеет ускоренный характер. Наверняка, в последующие годы существующая тенденция будет повышаться, что связано, прежде всего, с растущими в энергетике кризисными явлениями глобального характера.

Следовательно, задача удовлетворения потребностей населения мира в энергии наряду с обеспечением экологической безопасности предопределяет необходимость развития альтернативной энергетики, особое место в которой занимает биотопливо.

Наиболее эффективным сценарием увеличения производства биотоплива как в мире, так и в Украине, как инновационной перспективы развития энергетики является создание условий, при которых определяющую роль будет играть государственное регулирование этого процесса.

Для обеспечения стремительного развития рынка биотоплива нужно создать благоприятный инвестиционный климат и стабильную внешнюю среду деятельности предприятий, производящих биотопливо, и их взаимодействие с государством относительно научной деятельности и внедрения в производство инновационных технологий.

Ключевые слова: альтернативная энергетика, инновационное развитие, биотопливо.

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**ІННОВАЦІЙНИЙ РЕЙТИНГ УКРАЇНИ:
МІЖНАРОДНІ ОЦІНКИ ТА ПОРІВНЯННЯ**

Шарко І.О., Гуторов О.І. Інноваційний рейтинг України: міжнародні оцінки та порівняння.

Представлений зведений аналіз досягнутого рівня та чинників динаміки інноваційного рейтингу України за індексами глобальної конкурентоспроможності, глобального індексу інновацій та європейського інноваційного табло. Встановлено, що особливістю українського інноваційного середовища є, з одного боку, наявність значного інтелектуального потенціалу, а з другого боку – дефіцит умов для його повноцінної реалізації. Для підвищення рівня інноваційності національної економіки рекомендовано державним органам управління сприяти розвитку інноваційної інфраструктури, особливо в частині узгодження економічних, організаційних, політичних і правових умов з потребами суб'єктів інноваційної діяльності в межах національної інноваційної системи.

Ключові слова: інновації, рейтинг, конкурентоздатність, інноваційний статус, інноваційний потенціал.

Постановка проблеми у загальному вигляді. Особливе значення науково-технічної та інноваційної сфери в сучасному світі обумовлюється тим, що саме нові знання та нові технологічні рішення стають визначальним чинником

конкурентоздатності не лише окремих виробників, а й цілих країн. За інших однакових умов успішнішими є саме ті національні економіки, в яких сформовані найбільш сприятливі умови для створення та впровадження інновацій.