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MODERN VISION OF THE BIOECONOMY DASHBOARD

The paper is devoted to studying modern vision of the bioeconomy dashboard. Last twenty years bioeconomy was in the focus of scientists of different fields of science. This phenomenon is interdisciplinary and combines knowledge and ideas of biology, chemistry, mathematics, economics and agronomy. Some of its sectors, for instance, agriculture and food & feed sectors have a long history and developed not like a part of the bioeconomy but separate sectors. As to forestry, aquaculture, biofuel production and biotechnology, these sectors are rather new and got their development in the second part of the twentieth century. The EU countries has the biggest experience in studying bioeconomy concept. Experts of the EC provided in 2012 Bioeconomy Strategy and Action Plan "Innovating for Sustainable Growth: A Bioeconomy for Europe". We found out that the bioeconomy sectors revenue have grown on average more than 10% every year over the past decade - much faster than the other sectors of economy. Bioeconomy has the great potential for development that allows presuming the economic growth of its sectors in coming decades.

Key words: bioeconomy, agriculture, food & feed, sustainable growth, biobased products, biotechnologies, renewable resources.

Лимар В.В.

СУЧАСНЕ БАЧЕННЯ ІНОФРМАЦІЙНОЇ ПАНЕЛІ БІОЕКОНОМІКИ

Стаття присвячена аналізу сучасного бачення інформаційної панелі біоекономіки. Останні двадцять років біоекономіка була в центрі уваги науковців різних галузей науки. Дане поняття є міждисциплінарним та поєднує знання та ідеї біології, хімії, математики, економіки та агрономії. Деякі її сектори, наприклад, сільське господарство та виробництво продуктів харчування та кормів мають довгу історію та розвивалися не як частина біоекономіки, а як окремі сектори. Стосовно лісівництва, аквакультури, виробництва біопалива та біотехнологій, дані сектори відносно нові та отримали свого розвитку в другій половині двадцятого століття. Країни Європейського Союзу мають найбільший досвід у вивченні концепції біоекономіки. Експерти Європейської Комісії у 2012 році розробили Стратегію розвитку біоекономіки та План дій "Інновації для стабільного зростання: біоекономіка для Європи". Було визначено, що дохід секторів біоекономіки щорічно зростає більш ніж на 10% останні 10 років – набагато швидше ніж інші сектори економіки. Біоекономіка має значний потенціал для розвитку, що дозволяє припустити економічне зростання її секторів у найближчі десятиліття.

***Ключові слова**:* біоекономіка, сільське господарство, продукти харчування та корми, біопродукція, біотехнології, відновлювані ресурси.

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СОВРЕМЕННОЕ ВИДЕНИЕ ИНФОРМАЦИОННОЙ ПАНЕЛИ БИОЭКОНОМИКИ

Статья посвящена анализу современного видения информационной панели биоэкономики. Последние двадцать лет биоэкономика была в центре внимания ученых разных областей науки. Данное понятие является междисциплинарным и сочетает знания и идеи биологии, химии, математики, экономики и агрономии. Некоторые ее

секторы, например, сельское хозяйство и производство продуктов питания и кормов имеют длинную историю и развивались не как часть биоэкономики, а как отдельные секторы. Относительно лесоводства, аквакультуры, производства биотоплива и биотехнологий, данные секторы являются относительно новыми и получили свое развитие во второй половине двадцатого века. Страны Европейського Союза имеют наибольший опыт в изучении концепции биоэкономики. Эксперты Европейской Комиссии в 2012 году разработали Стратегию развития биоэкономики и План действий "Инновации для стабильного роста: биоэкономика для Европы". Было определено, что доход секторов биоэкономики ежегодно возрастает более чем на 10% последние 10 лет - намного быстрее, чем другие секторы экономики. Биоэкономика имеет значительный потенциал для развития, что позволяет допустить экономический рост ее секторов в ближайшие десятилетия.

Ключевые слова: биоэкономика, сельское хозяйство, продукты питания и кормы, биопродукция, биотехнологии, возобновляемые ресурсы.

Introduction. Bioeconomy is an important topic for scientists and politicians. Modern advances in biology combined with artificial intellect have resulted in big jumps in our vision of living organisms, including the biomass made by plants and animals.

That has gone very close to technologies that permit scientists and production to manipulate, very easily, everything from enzymes to plants and animals.

Nowadays production can make bio-plastics from plant oils rather than fossil-based sources. Those bio-based plastics can be made biodegradable, even in oceans, or they can be made solid, to replace glass.

So rapid are the changes in science and production, and so profound are its implications, that some refer to the new phenomenon, like bio-economy, that uses bio-based sources for pretty much anything in our economy, as the 4th industrial revolution [1].

The biotech sector revenue is assessed to have grown on average more than 10% every year over the past 10 years - much faster than the other economy sectors. A more detailed assessment of bioeconomy contribution, nevertheless, will need improved data collecting, classification and analysis [2].

Literature review. The bioeconomy is a concept that have been studied about two last decades. These are scientists who made the significant contribution into studying this problem: Carlson R. [3], Ronson T. [5], Gurria P. [6], Kaeb H. [13], Carees M. [14], Reddy P.S. [20], Bogner J. [21] and others. Besides, information base of this paper includes reports of the EC, Eurostat, IEA, EEA and other organizations.

Unsolved problem. Inspite of the significant contribution of the authors above there are some aspects that must be studied in detail what causes the aim of this paper.

The aim of the paper is to analyse modern vision of the bioeconomy dashboard and to study annual revenues of its subsectors.

Results. The traditional bioeconomy is not new phenomenon; it is agriculture, forestry and the agro-food system. Nonetheless, exactly the current agro-food system is not stable. It produces approximately a quarter of greenhouse gas emissions causing climate change, has led to degraded soils in a very large share of cultivated land, is responsible for about 70 % of all water used by people and thus is a key factor in water scarcity. It overuses fertilizers that causes pollution in rivers and lakes, and is responsible for the biggest share of deforestation and biodiversity [1].

The scintific community defines the bioeconomy as the production of renewable biological resources and their conversion into food, feed, bio-based products and bioenergy. It

includes agriculture, forestry, fisheries, food, and pulp and paper production, as well as parts of chemical, biotechnological and energy industries. Its sectors have a strong innovative potential thanks to their use of a wide range of sciences (life sciences, mathematics, agronomy, ecology, food science and social sciences), including industrial technologies [4].

The EU bioeconomy represented approximately 9 % of the total economy in terms of employment and revenues in 2017 [5], whereas biomass accounted for more than 25 % of total material resources. Therefore, the potential of modern bioeconomy is larger compared with its economic output.

In economic indicators, the production of food is the biggest contributor, followed by the production of biomaterials, particularly textiles, wooden products, pulp and paper, plastics and chemicals. Of those employed in the bioeconomy, only about 50% work in agriculture, another 24 % in food production, and 20 % in the production of biomaterials. Bioenergy plays not significant role, both in indicators of revenues and in terms of employment.

In physical indicators, agriculture makes up about 63 % of the total biomass supply in the EU, forestry 36 % and fisheries less than 1 % [6]. Food and feed account for about 60 % of the EU's biomass use, with materials and energy each representing around 20 %. Biomass for materials is sourced from forests, with less than 0.1 % of agricultural biomass used for production. Biofuel production uses around 2 % of agricultural biomass, or 18 times more than the amount used in biomaterial production [6].

As for food, the EU is the biggest manufacturer and net exporter of wine, olive oil, tomatoes, dairy products and meat. As for livestock production, poultry and pig production are increasing, as opposed to beef, sheep and goat production. Major imports are tropical fruits, coffee, tea, soy products and palm oil, as well as fish products. Apart from the impact on global fish stocks, European consumption has a significant effect through the dependency on feed imports for its intensive livestock and aquaculture. About 11 million hectares were needed in 2011 for the production of imported soybeans [7].

As to biomaterials and natural fibers or wood fibers mixed with polymers in composite materials are the four main biomaterials used in the European countries.

The forestry produces materials for different spheres including furniture, paper and cardboard. It is the oldest of the biomaterial sectors in the EU. The sector has also developed different ways to reuse waste [8]. The recycling of wood fibers has evolved into a cascading industrial system, in which fibers are cycled from high-to lower-grade applications with energy recovery as the ultimate step.

About one third of primary biomass sourced from forests is used to produce energy. From the other side, approximately 47 % of the EU's need for wood products and pulp and paper are met by secondary resources from industrial and post-consumer recycling — 26 % and 21 %, respectively.

Paper producing is already highly circular, but the recycling rate of wood products is low. This can be explained by the long life of furniture or construction wood, effectively sequestering carbon by taking resources out of economic flows. Another important factor is the lack of collection systems.

Anyway, a greater proportion of such products is used for energy recovery than for recycling.

The production and use of bio-based polymers in the EU is new, except for traditional natural polymers, such as natural rubber. A main technological innovation within the chemical industry is the refining of biomass into feedstock chemicals in search of renewable alternatives to fossil-based materials.

In that context, bio-based polymers have been the most relevant drivers for the development of the EU research and policy agenda related to bioeconomy.

Current production and consumption levels of bio-products are low compared with other bioeconomy sectors and the fossil fuel sector. In 2016, 13 % of the global fossil fuel consumption (coal, natural gas and oil) was used for non-energy purposes [9], mainly as a feedstock for the chemical industry. The global production of plastics is assessed to account for around 7 % of the global fossil fuel consumption [10], while the production capacity for bio-based plastics, of which Europe holds 27 %, accounts for approximately 1 % (about 4 million tons) of global plastics production [11, 10].

Bioplastics are sourced from agricultural biomass, primarily maize and wheat (WEF et al., 2016). A shift is, nonetheless, occurring towards biomass from plants that are not suitable for food & feed production, for example crop residues such as maize stalks, cobs, waste vegetable oils, pulp and paper. Additionally, biomass produced from algae is being investigated, as it does not rely on agricultural land and has a higher growth yield than land-based feedstock.

Bio-based polymers are low compared with other bioeconomy sectors and the fossil fuel sector. In 2016, 13 % of the world's fossil fuel consumption was used for non-energy purposes [12], mainly as a feedstock for the chemical production. The global production of plastics is assessed to account for round 7 % of the world's fossil fuel consumption [10], while the production capacity for bio-based plastics, of which Europe holds about 27 %, accounts for nearly 1 % (about 4. million tons) of global plastics production [11, 10].

The term bioplastics covers both biodegradable and bio-based plastics. According to the OECD definition, biodegradable plastics are materials that can be decomposed by microorganisms into water, naturally occurring gases and biomass. This process depends on the environmental conditions. Bio-based plastics are made from renewable resources such as starch, sugar and vegetable oils. Some bio-based polymers are biodegradable but many are not.

The last polymers are called drop-in bio-based polymers, as they have the same structure as their fossil counterparts and can thus be substituted into existing plastics production systems. Fossil-based biodegradable polymers exist as well, for example polybutylene adipate-co-terephthalate, which is used for food packaging, compostable plastic bags for gardening and agricultural use, and as a water-resistant coating for certain products.

Within the broad vision of biodegradability, industrially compostable materials are a category of biomaterials defined by different standards. These standards include criteria for whether or not a material is compostable, that is, if it biodegrades by at least 90 % by weight during six months under controlled composting conditions, it fragments into parts smaller than two mm diameter under controlled composting conditions during 12 weeks and the compost obtained at the end of the process has no negative effects on plant growth. Additionally, to industrially compostable materials, home compostable materials are defined as well. These are industrially compostable, but can be treated at ambient temperatures and the timeframes for biodegradation and disintegration can be longer.

Besides, indicators such as moisture content, aeration, acidity and the carbon-to nitrogen ratio do not need to be controlled.

With 30% bio-based material, the most famous bioplastic manufactured is bio-PET, used for bottles, followed by cellulose acetate (CA), used for cellophane film, and PBAT and PLA, used for various kinds of package.

The main use of bioplastics is in packaging – about 39 % or 1.6 million tons. Uptake within other sectors, for example, consumer, automotive and construction goods is rising [11].

In 2016, about 100 000 tons of biodegradable plastics, mainly starch based and PLA co-polymers were manufactured, mainly for compostable shopping and waste collection bags [13].

Issues with the right collection and sorting of plastics cause problems for closing bioplastic material loops.

Wrong classification at the point of removal, for instance, of PLA and PET9, can pollute biowaste streams unintentionally.

Composite materials are those made from different materials with special properties, compliant materials with new conjunctions of properties. In the context of the bioeconomy, relevant biocomposites are WPCs and NFCs. In 2014, biocomposites accounted for 15 % of the total European compound market, with approximately two thirds being WPCs and one-third being NFCs.

The main use is in construction, for decking panels and fences, furniture, and fixtures and fittings. Cotton, flax and hemp are among the main sources of natural fibers used in NFCs in the automobile industry [14]. In general, biocomposites are very difficult to recycle because separating the fibers from the polymer material is virtually impossible without destroying the fiber structure and/or the polymer integrity.

Fibers for textile use have been bio-based, sourced from crops such as hemp and jute; animals in the case of silk and leather; or processed from natural polymers for the production of viscose. With the advent of the chemical industry, although, synthetic fibers such as polyester, acrylic and polypropylene have become common materials in the production of clothing, floor coverings and furnishings, as well as in industrial textiles.

In 2012-2016, more than 30 % of fibers used in the EU countries came from cotton and wool, 36 % from jute and fibers, and 31 % were artificial fibers. Over the same period, 77 % of spun fibers came from cotton or wool, when 23 % were artificial fibers [15]. This information shows only the use of fibers in European manufacturing, rather than the final consumption of textiles, which is supplied by imports from outside the European Union.

The European Commission defines biowaste as biodegradable park and garden waste, food and kitchen waste from households, offices, cafes, wholesale, canteens and retail premises and comparable waste from food processing plants [16]. Across the European Union, about138 million tons of biowaste are generated every year [17], of which an estimated 100 million tons are food and household waste [18].

Today, only approximately 30 million tons (25 %) of this biowaste are collected and recycled into compost [19]. However, the biggest part of biowaste still ends up in municipal waste, and goes to landfill or is incinerated.

Unmanaged biowaste causes a threat to public health, as it can attract insects or other disease vectors, and can generate leachate, which can pollute water and groundwater [20]. Besides, when biowaste is disposed of in an uncontrolled way, it becomes a large source of methane emissions that contribute to climate change [21]. It was assessed that gas emissions from uncontrolled biowaste decomposition on fields or in landfill accounted for some 3 % of total EU greenhouse gas emissions [22].

The experts of bioeconomy were recognized specialists in technical and economic analysis. There were experienced scientists, strategists, and entrepreneurs. And we identified the best new enterprises and to help them succeed in a rapidly developing market space. The figures bellow are technical and economic metrics that were developed and used in making investment decisions.

Based on different goods development costs and timelines, including regulatory approval, revenues from biotechnology naturally produced into three different sectors: biologics (drugs), crops, and industrial products (including tools).

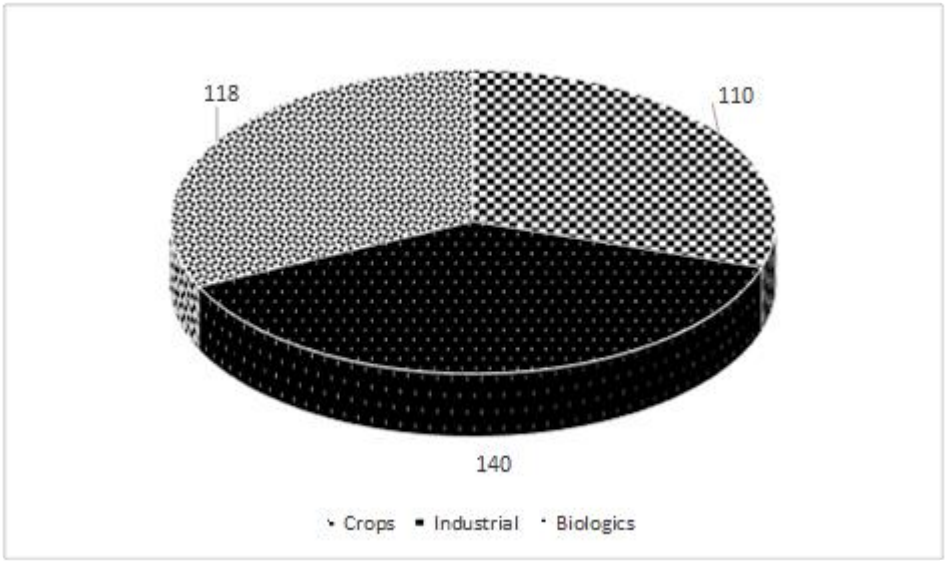

Figure 1 - Biotechnology revenues in 2018, bln. US doll.
Developed by the author according to [23].

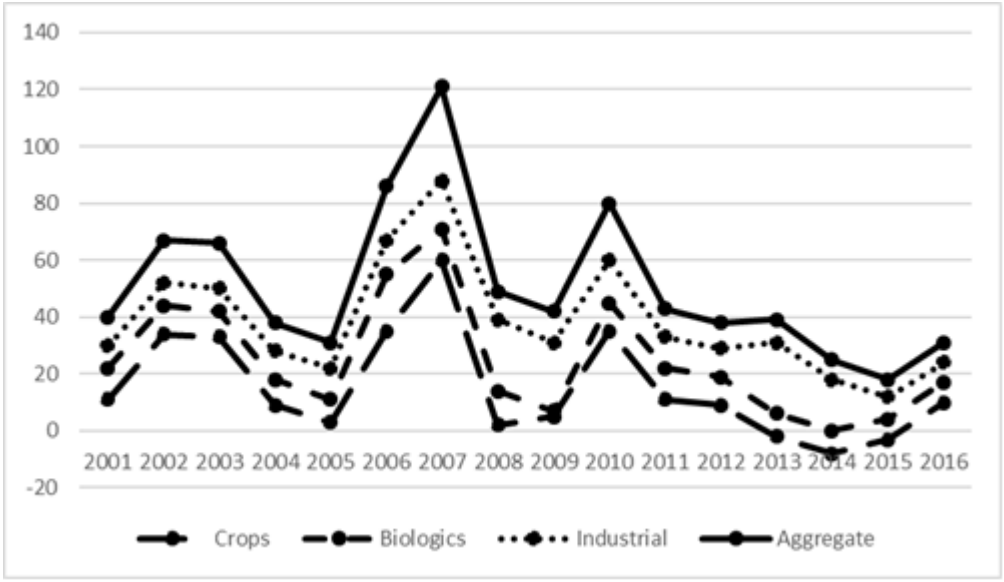

Figure 2 - Dynamics of biotechnology revenues in 2001-2016, %
Developed by the author according to [23].

On the figure above, we can see the dynamics of biotechnology revenues by sectors in 2001 – 2016. The highest indicators industrial sector demonstrates: the highest percent is seen in 2007 (approximately 85%). Further, it is seen the dramatic fall of the indicator (40% in 2008).

Conclusions. Literature review and made analysis of revenues of the bioeconomy sectors allow making such conclusions. Modern bioeconomy is not a new phenomenon. Its sectors like agriculture and food & feed production have long history and evolution for development. However, only last two decades they have been analyzing as sectors of the bioeconomy. Previous papers were devoted to studying bioeconomy concept from different points of view where the author have given his own definition of this concept. For this investigation it was very important to analyze and describe modern condition of all subsectors of the bioeconomy

to understand contribution of all of them into bioeconomy in general and analyze their revenues. According to the results of the investigation the biggest revenue industrial biotechnologies demonstrate. Besides, we conclude thet revenues of all the bioeconomy sectors are characterized by high level of volatility. Thus, bioeconomy combine sectors that has big potential for further development.

Investigation prospects. There were given detailed information about modern condition and potential for development of different sectors of the bioeconomy in the EU countries. Further we are going to study the bioeconomy srctors in different regions of the world, for instance the USA experience.

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