SYNERGISTIC EFFECTS OF AGRICULTURAL INTENSIFICATION OF BIOECONOMIC SECURITY: EXPERIENCE OF POLAND, UKRAINE AND AZERBAIJAN

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Abstract.

The paper is devoted to bioeconomic security on the European continent in the context of international innovation system creation. The aim of the paper is to study a new direction of bioeconomics - the formation of conditions for strengthening economic security the contextin to define the elements of national innovation system.

We define the category "bioeconomic security" and main elements of the national innovation system: synergistic knowledge and innovation creating; shift to innovative advanced technologies; implementation of effective organizational and administrative solutions for creation of agro-biotechnology clusters; promotion of complex resource preservation and transition to renewable energy; implementation of large-scale research.

To strengthen economic security of the European countries, it is necessary to organize a comprehensive monitoring of all necessary indicators (using the integrated index) and begin to form bioenergetic clusters. The calculated index bioeconomic security clearly shows that four different countries (Poland, Ukraine, Azerbaijan and the Netherlands) that have individual advantages will be able to create a positive synergetic effect if they join a single bioenergetic cluster.

Thus, it can be argued that bioeconomic security on the European continent is possible only if all European innovation systems are integrated into one complex system, which will ensure a high probability of energy independence.

Key words: bioeconomic security, knowledge-intensive activities, management, national innovation system, innovation creating, synergistic effects.

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The paper is devoted to research bioeconomic security on the European continent in the context of international innovation system creation. The aim of the paper is to study of a new direction of bioeconomics - the formation of conditions for strengthening economic security in the contextin to define the elements of national innovation system.

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Formulation of the problem generally. By the beginning of the 21th century humanity has faced with the problems which have a global character because of consumer attitude to the environment. Climate changes, air pollution, decrease of suitable for consumption water, agricultural land, exhaustion of fossils, population growth are the challenges people must answer today.

These problems have an overall character and need efforts of specialists of economic security of state (science ecosestate). Problems must be solved systematically what caused by their deep and global character.

World scientific community is working actively on the problems solution. One of the results is the appearance of such phenomenon as a bioeconomy which is interdisciplinary and combines the synergistic effects of agricultural and economic sectors, sustainable development as well.

Analysis of recent researches and publications. During our investigation we were studying papers devoted to the bioeconomy development both foreign and Ukrainian scientists. It is necessary to distinguish works of such investigators: Davide V., Francesco M., Mario M., Daniel M., Gianluca S. [1], Carrez D. [2], McCormic K. [3], Calrson R. [4], Maciejczak M. [5], Fedulova L. [6], Celinnyi M. [7], Dulska I. [8].

In addition, it was analyzed papers devoted to the national innovation system creation. We have studied papers of Freeman C. [9], Lundval B-A. [10], Nelson R. [11], because they are the founders of the innovation system theory. Besides Metcafe S. [12] and Sharko M. [13] have made a significant contribution to the development of this theory. We've paid significant attention to the studies of Urmetzer S., Pyka A. [14] and Esposti R. [15] because these investigations devoted to the innovation system for bioeconomy creation.

Unsolved issues as part of the problem. In spite of a huge quantity of papers devoted to the bioeconomy development and management and national innovation systems there is the absence of investigations which try to find and study relations between these two problems. Precisely this courses the purpose of our paper.

The purpose of present research. The purpose of the paper is to analyze bioeconomy potential in Ukraine in order to define the elements of national innovation system which will stimulate the bioeconomy development.

Basic material. It was studied more than forty definitions of the bioeconomy although in this investigation we base on experts of German Bioeconomy Council who argue that "bioeconomy combines highly research- and knowledge-intensive economic activities in agriculture, forestry and the food sector with the innovative use of renewable raw materials for material and energy use" [16, p. 6].

Interest in this definition is not random. In this investigation we propose to focus on innovation and knowledge components of the bioeconomy. There is an interest in innovation ways of biomass and raw materials processing for getting products which not only satisfy consumers demand but are useful and have a minimal negative impact on the environment.

Above mentioned task causes the necessity of innovation system for the bioeconomy creating because an innovation activity in this sphere may not give positive results if doesn't have systematic and consistent character.

Before studying a possibility of creation of such system we suggest to focus on what the national innovation system is in general.

National innovation system (NIS) concept was forming during 1980th under pressure of three main theories: general systems theory, Schumpeter's innovation theory, North's institutional changes theory.

For the first time the NIS concept was used by C. Freeman [9] in his investigation of Japan's technological policy. Nevertheless simultaneously related investigations have being provided by Lundvall B-A.[10] and Nelson R. [11] who are considered as founders of the NIS theory. They focus on the national aspect of innovation activity (Table 1).

Table 1 - **Scientific approaches to national innovation system definition**

Source	**Definition**
Freeman C. [9]	The network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies
Lundvall B-A. [10]	The elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge ... and are either located within or rooted inside the borders of a nation state
Nelson R. [11]	A set of institutions whose interactions determine the innovative performance ... of national firms
Patel P., K. Pavitt [17]	The national institutions, their incentive structures and their competencies, that determine the rate and direction of technological learning (or the volume and composition of change generating activities) in a country

Metcalfe S. [12]	The set of distinct institutions which jointly and individually contribute to the development and diffusion of new technologies and which provides the framework within which governments form and implement policies to influence the innovation process. As such it is a system of interconnected institutions to create, store and transfer the knowledge, skills and artefacts which define new technologies
Australian Innovation System Report [18]	An open network of organizations that interact with each other and operate within framework conditions that regulate their activities and interactions. The three components of the innovation system: -networks, innovation activities and framework conditions -collectively function to produce and diffuse innovations that have, in aggregate, economic, social and/or environmental value
Decree of CMU № 680-p dated from 17.06.2009 [19]	Complex of legislative, structural and functional components (institutions) which take part in in the process of scientific knowledge and technology creating and applying and define legal, organizational and social conditions for innovation process providing
Sharko M. [13]	Economic mechanism based on new knowledge creation and application, entrepreneurial approach, integration into external markets and accelerated development of a country and its region competitiveness
Fedulova L. [6]	Complex of interrelated organizations (structures) involved in creation and commercialization of scientific knowledge and technologies within national boundaries, small and large companies, universities, laboratories, industrial parks and incubators as the complex of institutes of legal, financial and social character which provide innovation processes and have powerful national roots, traditions, political and cultural features

Overview of definitions allows concluding that national innovation system (NIS):

is the subsystem of the national economy;

consists of institutes and relations between them;

the main function of it is the improvement of creation, dissemination and exploitation of new knowledge and technologies.

Experts of the OECD define the following flows of knowledge within national innovation system (Fig. 1).

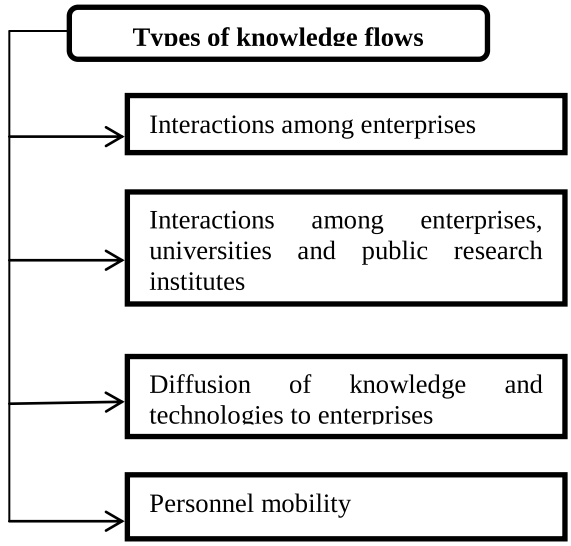

Figure 1 - **Knowledge flows according to the OECD** [20]

A lot of scientists consider that NIS is characterized by three main features:

it is identified with innovation infrastructure;

it is a separate integrated structure the main function of which is innovation activity;

it is based on the mechanism of interconnection between system's elements [21, p. 55].

The special challenge of examining the national systems regarding their capability to move towards the knowledge-based bioeconomy is emerging from the overarching and yet quite specific nature of the bioeconomy [14, p. 4].

Interconnection between concepts of NIS and the bioeconomy was developed by R. Eposti [15]. He suggests the creation of Agricultural Knowledge and Innovation System (AKIS). AKIS is "the set of agricultural organizations and/or persons, and the links and interactions between them, engaged in the generation, transformation, transmission, storage, retrieval, integration, diffusion and utilization of knowledge and information, with the purpose of working synergistically to support decision making, problem solving and innovation in agriculture" [22; 23].

According to work groups of the Standing Committee on Agricultural Research (SCAR) there are three possible scenarios of the bioeconomy development within the AKIS.

Table 2 - **Bioeconomy development within AKIS** [24, p. 79].

Scenarios	Description
High Tech	Represents a world dominated by large multinationals and advanced technology (ICT, robotics, genetics). It is characterized by globalization, widespread use of unmanned vehicles, contract farming and outsourcing, with a large urban population. European institutions are strong, national governments are weak. In general it is a wealthy society, but inequality creates concern. Sustainability problems are largely solved through technical solutions such as precision farming and genetic modification (GMO)
Self-organization	A world of regions where new ICT technologies with disruptive business models to self-organization, bottom-up democracy, short supply chains and multi-forms of agriculture. European institutions are week, regions and cities rule and follow quite different pathways for agriculture. Products are traded between regions. There is inequality between regions, depending on endowments
Collapse	A world where climate change, mass-migration and political turbulence leads to a collapse of institutions and European integration. Regional and local communities look for self-sufficiency. Bio-scarcity and labor-intensive agriculture, including permaculture and urban farming arise out of necessity. Technology development becomes dependent on science in China, India and Brazil

AKIS is the theoretical concept which is related with national and regional innovation systems. There are different AKIS in different countries. There is no an ideal AKIS. The elements of AKIS may defer from each other, in addition incentives for these elements are different. As to management of AKIS, it varies from public to national level.

AKIS are dynamic and may change over time. They must be changed in accordance with modern challenges and tendencies. For the analysis of the AKIS components different indicators are used. R&D analysis is based on the number of publications, citation, while education – on the number of students. Such differences don't encourage an interdisciplinary approach for systematic problems solving in agriculture.

It is necessary to add that agriculture, education and R&D are managed by different ministries and there are different incentives for different sectors of AKIS. It is difficult to propose the policy which will take into account all aspects and element of AKIS. And there is no confidence that in the future AKIS could answer the challenges it will face.

Despite on difficulties and uncertainties the experience of European colleagues in agrarian knowledge and innovation systems (AKIS) creating is very useful for our investigation. Taking into account their lessons we propose the possible frame of innovation system for bioeconomy in Ukraine.

It is offered following components of national innovation system for the bioeconomy in Ukraine) (Fig. 2).

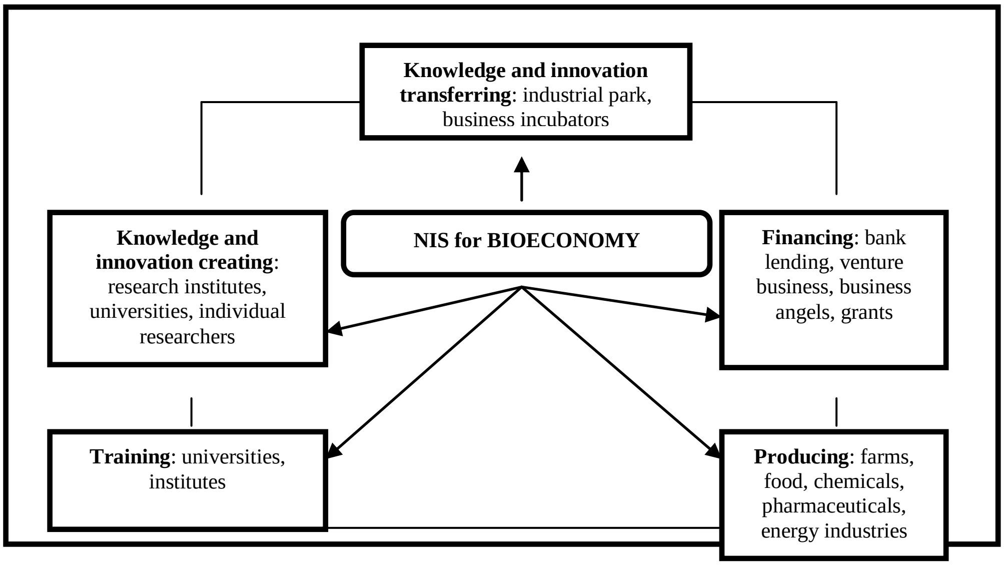

Figure 2 - **NIS for bioeconomy in Ukraine vision**

It is defined five main elements of the national innovation system (NIS) for the bioeconomy in Ukraine: knowledge and innovation creating; knowledge and innovation transferring; financing; producing; training.

All of the given elements are important and required. In addition they are interconnected. NIS for the bioeconomy functioning may be sterling and effective just in the presence and coordinated work of the defined elements.

In our paper we are not going to define what element is the most important. The aim of their synchronous and harmonious functioning is biomass and renewable materials processing into high quality products which meet the needs of consumers and make minimal negative impact on the environment.

Empirical results.

In determining the ability of national economies to move toward the bioeconomy based on knowledge, a special challenge is the comprehensive nature of bioeconomy. For example, analyses of innovation in a particular sector of bioeconomy, such as in the agricultural or biotechnological ones, will not give a complete picture about the state of bioeconomy in the whole country; meanwhile, the analysis of the entire national economic system will not meet the specific requirements for the development of bioeconomy.

The aggregate of parameters of national innovation systems in relation to their ability to evolve towards bioeconomy is still the subject of scientific debate. An interesting from a scientific point of view approach, in our view, is offered by Sophie Urmetzer and Andrea, forming six categories, grouping the corresponding indexes:

1. The environmental and resource productivity of production and consumption: Indicating an economy's ability to minimize non-renewable resource consumption per unit of output (i.e. decoupling production from non-renewable resources).

2. The base of relevant scientific, applied and public knowledge: Indicating a nation's potential to tackle future challenges in the field of the bioeconomy with the help of education on different levels. The European Commission (2012) states that innovation in bioeconomic sectors requires a workforce that has the right mix of skills including experienced workers with new qualifications and professionals for interdisciplinary tasks who understand "the economic and societal impact of their activities, fostering cross-talk between sectors" and across society. At the same time, public understanding about the ethical, environmental, health and safety implications of the bioeconomy affects the acceptance and the economic success of new products and processes [25].

3. Policy responses and bio-economic opportunities: Indicating a nation's potential and will to innovate and proceed in technological and institutional terms. This becomes evident by assessing activities that foster innovation in general and specifically in environmental science and technology (Global Innovation Index, R&D expenditures, research personnel etc.). In addition, these indicators shall measure political efforts and social acceptance to support a move towards a resource-efficient and environmentally-friendly economy.

4. The natural asset base: Indicating an economy's capability to maintain the quantity of their natural assets. This measure takes account of the fact that naturally regrowing resources are not infinite and must be sustainably managed.

5. The environmental dimension of quality of life: Indicating the social well-being in terms of access to an intact environment (including clean air, intact nature etc.). The desired increase in utilisation of biological resources must not be achieved at the expense of a loss in environmental quality – an asset hardly measurable in economic terms and to be kept separate from the natural asset base measured quantitatively (indicator group no. 4).

6. General socio-economic structure: Indicating the socio-economic context in which the different economies act. Even among the EU member states, structural and socioeconomic

differences exist that may influence their overall performance of their development towards the bioeconomy, including differing attitudes of the population. [14].

Based on the specified categorization of indicators, the authors of the article conducted a comparative analysis of their empirical values in in Europe and Central Asia. The results are shown in Table 3.

Table 3 - **Matrix of indicators of bioeconomic security** [26]

Cate-gory	Indicator	Year	Azerbaijan	Ukraine	Poland	Netherlands	Europe&Central Asia
1.	CO_2 emissions (metric tons per capita)	2014	3,93	6,26	7,50	9,90	7,54
	CO_2 intensity (kg per kg oil equivalent energy use)	2014	1,9	2,20	3,00	2,30	2,31
	Energy use (kg of oil equivalent) per $1,000 GDP (constant 2011 PPP)	2014	89, 86	306	98,40	91,00	116
	Share of renewable energy in gross final energy consumption (%)	2015	2,31	4,14	11,91	5,89	11,30
	Artificial fertilizer consumption (kilograms per hectare of arable land)	2015	24,2	43,5	175,5	258,10	76,90
	Index of aquaculture development	2015	0,4	0,4	0,6	0,9	-
	Index water productivity	2015	0,7	0,4	0,7	0,8	0,75
2.	Researchers in R&D (per million people)	2015	1	1,006	2,139	4,548	2,92
	Scientific and technical journal articles (per thousand capita)	2016	-	7,375	32,978	29,949	758,303
	Total public expenditure on education, all levels (% of GDP)	2013	2,44	6,5	4,94	5,95	5,34 EU 28
3.	Global Innovation Index	2017	30,6	37,62	41,99	63,36	-
4.	Renewable internal freshwater resources (m^3 per inhabitant)	2014	851,7	1,217	1,41	652	7,85
	Share of agricultural land cover (% of total land area)	2015	23,4	71,3	46,9	54,5	44,2

	Share of forest land cover (% of total land area)	2015	13,7	16,7	30,8	11,2	38
	Terrestrial and marine protected areas (% of total territorial area)	2017	5,5	3,93	38,1	21,2	9,4
	Total natural resources (oil, gas, coal, mineral, forest) rents (% of GDP)	2016	20,47	3,8	0,8	0,4	1,3
5.	PM2.5 air pollution, population exposed to levels exceeding WHO guideline value (% of total)	2016	100	100	100	100	93,3
	People using safely managed drinking water services (% of population)	2015	87	92	94	100	91
6.	GDP per capita, PPP (constant 2011 current international $)	2016	16,001	7,894	27,216	48,473	20,562
	GINI coefficient of equivalised disposable income (0-100)	2017	33,7	28,5	29,2	27,3	24,6
	Urban population (%)	2016	54,8	69,7	61,0	92,0	70,9
	Employment rate (% of age 20-64)	2017	-	64,7	70,9	78,0	69,2
	Value added from agricultural sector (% of GDP)	2017	6	14	1,7	1,9	2,2
	Share of total organic crop area (% of total agricultural area)	2017	-	0,9	3,72	2,91	6,2

It should be noted that a number of countries do not fall into the field of vision of the world's statistical organizations. For example, one can not unambiguously talk about the state of Azerbaijan's economic security, since some indicators are not available.

Being aware of the shortcomings of the basic measurements, including limited access to the data and the degree of relevancy, statistical imperfection of the analysis method and the general uncertainty of the chosen strategy of sustainable and efficient mode of production and consumption, we ventured to give an interval estimate of economic security using the algorithm presented by (Zalizko 2016).

Table 4 - **Integral index of bioeconomic security** [27]

Integral index	Year	Azerbaijan	Ukraine	Poland	Netherlands
	2015	0,3854	0,3336	0,5004	0,5332
Rank		3	4	2	1

The rating of countries listed in Table 4 for the level of the integral index of economic security shows that its is at the initial level of development. Most countries are engaged in local development of bioeconomics and even in scientific space the issue of creating a system of optimal indicators that will identify the level of country's security in the context of biotechnology development has not been investigated.

As we see, the calculated index for Ukraine and Azerbaijan has a rather low value, but if we hypothetically write that these countries will create a bioenergy cluster, the corresponding index of bioeconomic security of the cluster will be in the interval (0,55-0.78), which is necessary and sufficient condition for the sustainable development of each country.

In particular, Ukraine and Azerbaijan have unique natural resources that need to be properly used, rather than increase the level of arable land (Fig. 3)

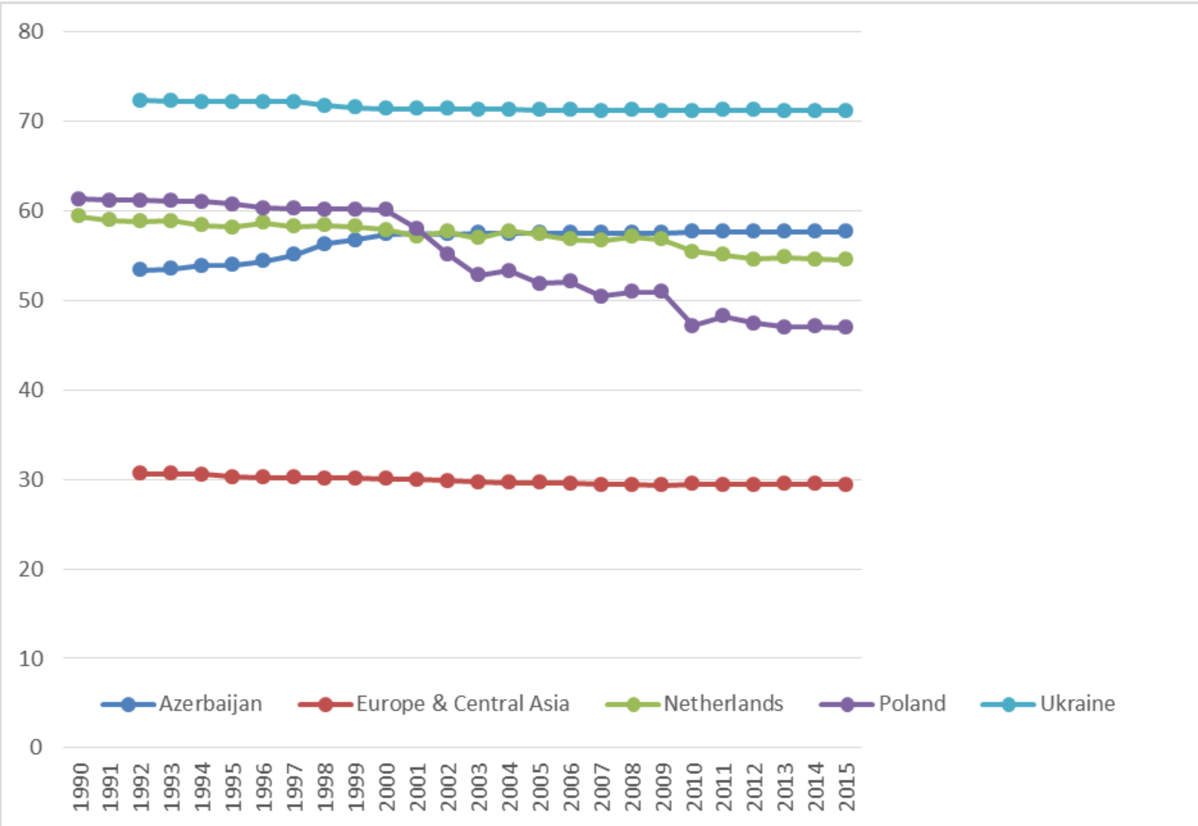

Figure 3 - **Share of agricultural land cover (% of total land area)**

National innovation system of Ukraine has significant potential for the bioeconomy development. This is evidenced by indicators such as Value added from agricultural sector (% of GDP), Share of total organic crop area (% of total agricultural area), Population with access to improved drinking water (%), Total natural resources (oil, gas, coal, mineral, forest) rents (% of GDP). But such figures as Artificial fertilizer consumption (kilograms per hectare of arable land), Share of renewable energy in gross final energy consumption (%) are significantly behind Europe & Central Asia indicators. The indicator Energy use (kg of oil equivalent) per $1,000 GDP (constant 2011 PPP) is three times higher than the European level, which indicates the acute urgency of the bioeconomy.

Conclusions and directions of further researches. Empirical research conducted at the given parameters system will help to understand the ability of the national innovation system of Ukraine to switch to bioeconomy, while comparing with the corresponding parameters in European countries may reveal similar patterns that will stimulate the exchange of experiences, and the deviations will show a set of approaches to achieve the goal, depending on geographical, historical, structural, political and cultural conditions.

To strengthen the economic security of the European countries, it is necessary to organize a comprehensive monitoring of all necessary indicators (using the integrated index) and begin to form bioenergetic clusters. For this, it is necessary that National innovation system of Ukraine requires certain changes, namely: the shift to innovative advanced resource-saving technologies, production of high-tech goods; comprehensive support and promotion of creation of technology parks, technopolises, agri-biotechnology clusters; the introduction of resource and energy conservation policies at all levels, the transition to renewable energy sources, including biomass, support for biomass producers and processors, creation of the necessary infrastructure; implementation of the policy of encouraging large-scale research and development projects based on the creation of biotech products within the development of the bioeconomy; encouraging the use of information technology to learn; directing the country’s social policy to improve the quality of life, social standards that take into account environmental standards of food, water and air safety etc.; development of a system of maintenance of industries that are developing environmentally.

Promoting the formation of such interaction between business, the state and civil society - social partnership, which is aimed at developing of the bioeconomy.

The state long-term policy that aims to achieve the following main goals: independence from fossil resources, sustainable production, an efficient conversion of biological resources into valuable products and energy, as well as dissemination of knowledge that can significantly accelerate the development of the bioeconomy.

Thus, it can be argued that bioeconomic security on the European continent is possible only if all European innovation systems are integrated into one complex, which will ensure a high probability of energy independence. The calculated index index has a high level of measurement uncertainty, since the indicators included in it need to be significantly expanded.

But this index bioeconomic security clearly shows that four completely different countries that have individual advantages will be able to create a positive synergetic effect if they join into a single bioenergetic cluster.

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