

Criteria Description of the Measurement of the Circular Bioeconomy

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Abstract. With the implementation of the European Green Deal, the circular bioeconomy model is gaining in relevance as well as the concept of circular bioeconomy, which promotes a renewed economic approach to conducting economic activity. The transition of a socio-economic system from one qualitative state to another, causes the need to measure dynamic changes and establish progressive factors towards the formation of a circular business environment. The objective of the study is to monitor the measurement system of the circular bioeconomy and to outline criteria limitations and relevant indicators based on the defined characteristics. The methodological basis of the study consists of the methods of empirical and theoretical level, particularly the historical, abstract-logical, descriptive, comparative methods, method of observation and formalisation, theoretical generalisation, etc. In the process of scientific research, it was possible to carry out comprehensive monitoring of scientific developments of foreign and Ukrainian scientists and to establish existing methodological approaches to assessing the circular bioeconomy. A review of the literature provided an opportunity to identify key structural components that are within the sectoral space and targets that have a complementary relationship with the three-dimensional sustainable development. Sectoral segmentation and target gradation by circular orientation and bioeconomic manifestation allowed to form a system of indicators for measuring the circular bioeconomy according to the established criteria. The practical value of the study consists in the scientific substantiation of the criteria characteristics of the measurement of the circular bioeconomy and the establishment of a system of indicators with relevant limitations

Keywords: assessment system, circular measurement, bioeconomic manifestation, criteria limitations, sectoral space, targets, indicators, approach

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Introduction

In the context of the strengthening of European integration processes and the popularisation of the European Green Deal, alternative economic approaches to conducting economic activities are becoming relevant, which make it possible to minimise anthropogenic pressure on the environment and overcome the imbalance of the socio-economic system. Among these areas, special attention should be paid to the concept of circular bioeconomy, which promotes the implementation of a closed production cycle in order to reduce organic household waste and industrial residues. On the way to the development of a circular business environment, it becomes necessary to establish favourable progressive factors that cause dynamic changes. The ability to evaluate these changes will contribute to the adjustment of the national strategy and the formation of an effective state policy to support the closed production cycle. The implementation of this task requires the development of a comprehensive system for assessing the level of circular bioeconomy with the allocation of criterion constraints and relevant indicators, which determines the relevance of the chosen topic.

At the moment, the world scientific community is actively working on the development of a system for assessing the bioeconomic foundations of management and its active implementation in practical use. Scientists of European countries have managed to improve the procedure for assessing bioeconomy due to the effect of scaling indicators united by a flexible multi-level measurement system formed in accordance with the goals of EU bioeconomy [1]. T. Ronzon, S. Piotrowski, S. Tamosiunas et al. have tested the methodology for measuring the bioeconomy in European countries, comparing it with the results of other countries' assessments [2]. Lithuanian scientists focus on measuring the efficiency of bioeconomic activity in various sectors using the Cobb-Douglas production function [3]. A model of the geographical distribution of countries by indicators of bioeconomic activity was proposed T. Ronzon and R. M'Barek [4].

Unlike foreign experience in Ukraine, bioeconomic science research is at the initial stage, which encourages focusing on the issues of bioeconomy evaluation. Consequently, one of the leading Ukrainian scientists in the study of economic activity on a biological basis, V. Baidala in her own scientific works claims that monitoring of bioeconomy should be based on a classification of indicators that make it possible to assess the ecological and economic state of production [5]. At the same time, the author expresses the vision that in addition to the need to assess the level of development of bioeconomy, it is important to monitor the effectiveness of its growth [6, p. 34]. The corresponding assessment system makes it possible to identify the productivity of bioeconomic activity at the macro, meso and micro levels. For their part, Lithuanian scientists [3] propose to measure the effectiveness of the bioeconomic system using the modified Cobb-Douglas production function, which shows the relationship between changes in the resources involved in the production process and the volume of production on a biological basis, which also deserves special

attention. A. Ryabchenko focuses on the indicators of bio-product production, which are formed in accordance with parametric characteristics, namely: "1) sustainable biomass production; 2) increase in the added value of biomass while reducing energy costs; 3) optimisation of the cost of ecosystem services and economic efficiency of biomass-based production; 4) increase in the added value of biomass products" [7].

The actualisation of the topic in the educational space by the importance of promoting bio-based production with the predominance of the circular economy for the sake of a balanced development of society has contributed to a scientific study *whose main objective* is to form its own system of measuring the circular bioeconomy according to the established criterion limits. This can be realised through the study of foreign sources and Ukrainian scientific literature, its systematisation and generalisation of existing methodological approaches; identification of key structural components of measuring circular bioeconomy and substantiation of criterion restrictions, which will make it possible to form a system of indicators according to the established criterion characteristics.

Materials and Methods

Achieving results in the process of scientific knowledge makes it necessary to provide a methodological explication of sequential actions, which will become a guide in the study of the problems of evaluating circular bioeconomy. A methodological analysis is a basis for building the author's measuring trajectory for the development of circular bioeconomy with an emphasis on the formation of criterion constraints and their significance in the evaluation process. Therefore, it is proposed to consider a step-by-step algorithm of the conducted research on the system approach in Figure 1. The primary basis of scientific research is the study of foreign and Ukrainian experience for the objective characterisation of existing methodological approaches to measuring circular bioeconomy, which will make it possible to systematise the criteria features of the evaluation process within separate structured components and model the position on the formation of a system of indicators based on criteria characteristics. To implement the tasks of scientific research, a systematic approach was used, which is aimed at a comprehensive substantiation of many complementary ideas of leading scientists on measuring circular bioeconomy and forming a holistic vision of the issue. The research of the circular bioeconomy assessment system was carried out using methods of theoretical, empirical and general scientific (theoretical-empirical) levels in their complementary relationship. For example, the historical method considers the fundamental basis of the evaluation process, while the abstract-logical method allows establishing relationships between existing methods and makes it possible to try to structure their key components. The observation method helps to identify criterion features and target the purpose of indicators within the criteria characteristics, the

comparative method helps to identify similarities and differences in the practice of generating a comprehensive assessment system, the descriptive method makes it possible to substantiate the parameters of the production of methodological approaches, and so on. As a result, the theoretical generalisations of the best practices of foreign and Ukrainian scientists, a comprehensive analysis and systematisation of the results of scientific research, became the impetus for modelling the author's system for monitoring the

level of development of circular bioeconomy, the criterion limitations of which were constructed using the logical formalisation method. A sample of indicators is identified according to certain criteria by means of a hypothetical method, etc. Consistent implementation of the tasks set made it possible to achieve the intended goals and conduct thorough scientific research, as a result of which the vision of the issue of measuring the level of development of circular bioeconomy was formed.

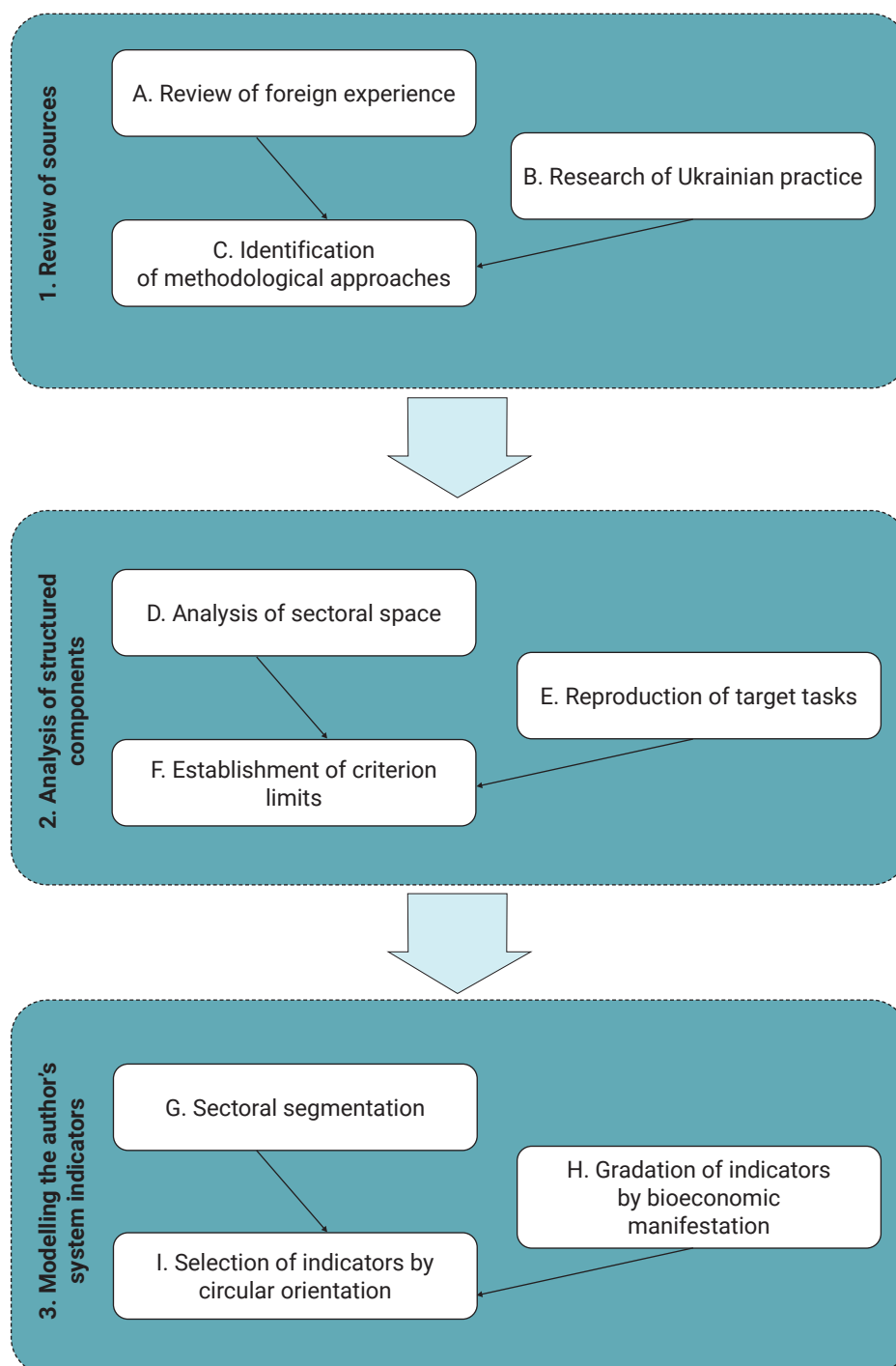


Figure 1. Step-by-step algorithm for forming a circular bioeconomy assessment system

Source: compiled by the author

Results and Discussion

The European system of monitoring the bioeconomic principles of management, launched in November 2020, covers a three-dimensional direction of achieving the goals of sustainable development, which allows assessing the economic, environmental and social progress of bioeconomic activities [1]. A feature of the European dimension is: 1) coverage of the primary sector, that is, agriculture, forestry and fisheries (percentage of deforestation in forests, used area of agricultural land and level of fish exploitation); 2) accounting for economic activities related to the production of goods and services based on renewable biological resources, creating a value chain from the supply of biomass by primary sectors to the transformation of products and their final consumption or reuse; 3) assessment of economic, social and environmental parameters [1]. Sources of data for monitoring the European bioeconomy are the national accounts of Eurostat [8; 9], statistics of industrial enterprises [10], production of goods and electricity [11; 12], which allow calculating value added by type of bioeconomic activity, the share of employed in the bioeconomic sector and the level of their labour productivity, features of biomass use and indicators related to the activities of the primary sector [13].

The guiding principles of the EU bioeconomy evaluation process are the regulatory criteria of the monitoring system, which at the initial stage were limited to the promotion of the Sustainable Development Goals, which later transformed into a vision, in addition to promoting the achievement of a sustainable goal, to take into account the need for climate neutrality, encouraging the transition to a circular economy and the development of sectors on a biological basis [14]. Currently, the criteria limitations of the European bioeconomy monitoring system cover targets at all stages of creating value chains within the implementation of environmental, economic and social directions.

A key position of the European bioeconomy assessment is the coordination of statistics by sector of bioeconomic activity, which is covered in the classification of economic activities of the European Community (NACE) [15]. According to this document, bioeconomy includes: agriculture (NACE code A01), forestry (A02), fishing (A03), manufacture of food products (C10), manufacture of beverages (C11), manufacture of tobacco products (C12) and manufacture of paper and paper products (C17). According to European standards, other sectors are considered hybrid, for which dual statistical information is recorded, in particular, products manufactured on a biological and non-biological basis (for example, textile production, in which both biomass (cotton, wool, silk) and synthetic fibres can be used as raw materials). For hybrid sectors, the identification of the share of bio-based goods is determined by experts by multiplying the volume of bio-based production (minimum range) by the proportion of bio-based products (minimum range). At the same time, it is proposed to calculate the average fractions of a biologically

based product from the minimum range. As for the share of the industry on a biological basis, calculations are made by dividing the production cost of products on a biological basis by the total cost of production of the corresponding sector. The share of the volume of electricity production on a biological basis (solid biofuels, charcoal, biogas, biodiesel, biofuels and renewable waste) is obtained by distributing all energy products on a biological basis to the total gross energy production, expressed in energy value [2].

The published work of the Food and Agriculture Organization of the United Nations (FAO) [14] on the definition of indicators for the assessment of sustainable bioeconomy, highlights a similar to the European, balanced approach in the economic, environmental and social dimensions. At the same time, there are noticeable differences in the limitation of a certain set of indicators, which are divided into two groups, namely: 1) indicators of the territorial level within the Sustainable Development Goals; 2) indicators of products (value chains), at the same time including those that cover the processes of standardisation, certification and labelling. Consequently, the criterion limitations of the proposed methodology, which reflects the participatory nature of its formation, are territorial localisation (global, national, regional level) and industry limitation according to the International Standard Industrial Classification of All Economic Activities (ISIC) [16].

The special feature of measuring the bioeconomy of individual countries, in particular Argentina, Australia, Germany, Malaysia, the Netherlands, and South Africa, comes down to economic criteria, which exclude environmental and social impacts. For example, the Malaysian bioeconomy index is represented by such economic parameters as value added from bioeconomic activities, exports of bioeconomic products, attracting investment in the bioeconomy, employment in the bioeconomic sector and productivity [17, p. 11]. The Finnish valuation system covers such indicators as biological output, value added, exports of goods, investment resources and employment. Germany is actively committed to improving the bioeconomy monitoring process and is developing an integrated approach, taking into account biomass flows, key economic performance indicators and bioeconomy modelling capabilities. Instead, the United States is limited to calculating industry-specific indicators of value added and employment in sectors related to the production of biological products [17].

Effective attempts by Ukrainian scientists to consider the features of national bioeconomic activity and develop a system for assessing its progress, made it possible to identify bioeconomic indicators according to the following principles: 1) the most effective need; 2) the objectivity of reflecting the processes of bioeconomy; 3) measurability and efficiency; 4) the unity of information from different sources; 5) the formation of initial information and its limitations; 6) the possibility of developing programmes for processing bioeconomic Information [5]. The basis for

forming a system of indicators for measuring bioeconomic activity is the gradation of biotechnology applications by colour sectors. Proponents of the sectoral approach highlight indicators of the annual volume of production of bio-products for certain branches of bio-economic activity, namely: agriculture, forestry and fisheries, food and forest industry, bioenergy; sub-sectors (chemical and textile industry, pharmaceutical industry, water supply, waste processing, construction, tourism, research and innovation); interrelated industries (supporting services (software) and technology sector, providing the activities of the main and sub-sectors); potential sectors of the national economy, the development of which it is aimed for the future [7].

A generalisation of foreign experience and a review of the evaluation practice of Ukrainian scientists gives grounds to assert that a unique international standardised system for monitoring circular bioeconomy is currently absent. The

available methods are mainly identified according to such criteria as: 1) the share of GDP accounted for by industries involved in the bioeconomic sector (sectoral approach); 2) are within the targets of sustainable development and the European course of "green" growth (target approach). At the same time, the criterion characteristics are often combined, since limiting the monitoring system to only a share of GDP is quite controversial, since excluding the environmental and social impact of circular bioeconomy is impossible due to the constant orientation.

The basic approach among scientists is defined as the sectoral approach, which causes the most controversy due to differences in the allocation of economic activities related to bioeconomy. Typing of relevant areas according to the classification of economic activities of the European Community (NACE) and national codification (KVED) is proposed to be considered in Table 1 [4; 18].

Table 1. Typification of industries in the circular bioeconomy monitoring system

KVED code/ NACE	Industries and activities	Fumagalli and Trenti	Efken et al.	Ronzon et al.	Piotrowski et al.	Own vision
A01	Agriculture	+	+	+	+	+
A02	Forestry	+	+	+	+	+
A03	Fishing	+	+	+	+	+
C10	Manufacture of food products	+	+	+	+	+
C11	Manufacture of beverages	+	+	+	+	+
C12	Manufacture of tobacco products	+	+	+	+	+
C13	Manufacture of textiles	+	+	+	+	+
C14	Manufacture of wearing apparel	+	+	+	+	+
C15	Manufacture of leather and related products	+	+	+	+	+
C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	+	+	+	+	+
C17	Manufacture of paper and paper products	+	+	+	+	+
C20	Manufacture of chemicals and chemical products	+	+	+	+	+
C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations		+	+	+	+
C22	Manufacture of rubber and plastic products			+	+	+
C31	Manufacture of furniture			+	+	+
D35	Electricity, gas, steam and air conditioning supply			+	+	+
E38	Waste collection, treatment and disposal activities; materials recovery					+
G46	Wholesale trade, except of motor vehicles and motorcycles		+			+
G47	Retail trade, except of motor vehicles and motorcycles		+			+
I55	Accommodation		+			+
I56	Food and beverage service activities		+			+
M	Professional, scientific, and technical activities					+
J	Information and telecommunications					+

Source: developed on the basis of [19-22]

The locomotive industry among the outlined ones, which is entirely related to bioeconomic activities, is the primary sector (A in KVED), since it plays a key role in ensuring a high level of food security in the country and produces raw materials in the form of biomass for the industrial and energy sectors. In addition to the agricultural sector, the secondary industrial sector (C and E in KVED) is significant for circular bioeconomy, since it is a raw material consumer that produces goods on both a biological and

non-biological basis (hybrid sectors) and provides a solution to the issue of industrial organic waste management. The tertiary sector covers economic activities related to the production of services, which include research work, the educational process, the information industry, the transportation system, and so on. At the same time, the service sector provides favourable scientific and technical conditions for the implementation of bioeconomic activities and plays an important auxiliary role in its reproduction (Fig. 2).

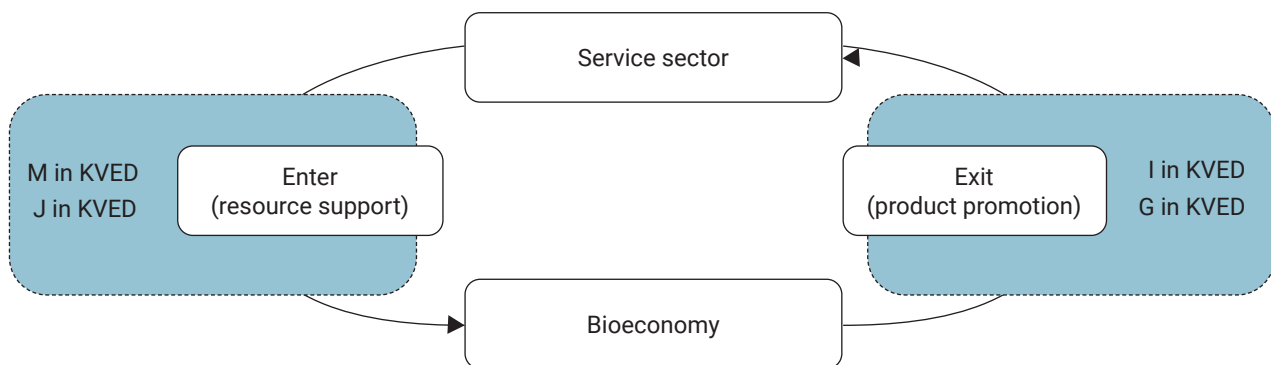


Figure 2. Complementarity of bioeconomic activities with the service sector

Source: compiled by the author

Within the existing sectoral space of circular bioeconomy, it is worth highlighting the bioenergy sector, given the powerful potential for transforming biomass

into a final product and a significant share of biofuels in the total amount of energy consumed (Fig. 3).

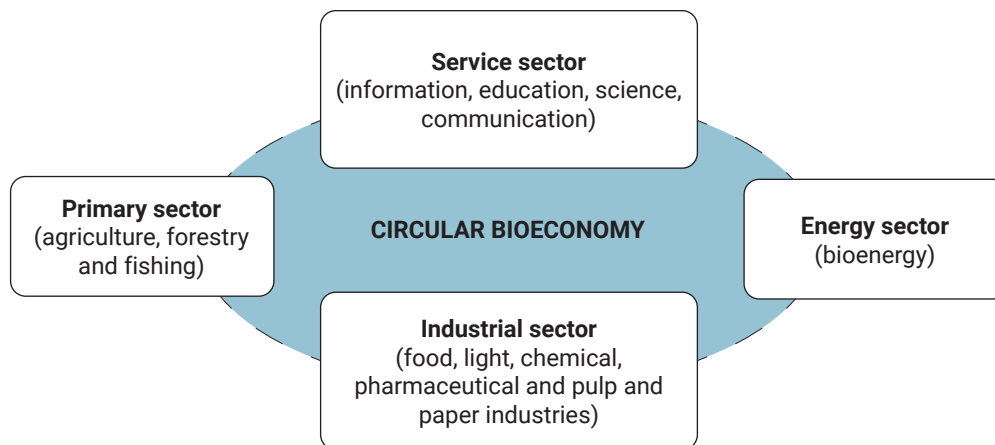


Figure 3. Sectoral space of circular bioeconomy

Source: compiled by the author

Activities within the aggregate sector space are aimed at implementing the basic goals of circular bioeconomy, in particular, 1) reducing the volume of organic production waste by organising business processes with maximum processing of the remaining consumed products, and 2) motivating business entities to step up production on renewable biological resources as a fundamental condition for the sustainable development of circular bioeconomy,

which makes it possible to overcome the imbalance of the ecological and economic system. Consequently, the basic criteria characteristics of the author's circular bioeconomy monitoring system define the target tasks, sectoral division and constant orientation of society's development. A graphical visualisation of the circular bioeconomy monitoring system based on criteria is shown in Figure 4.

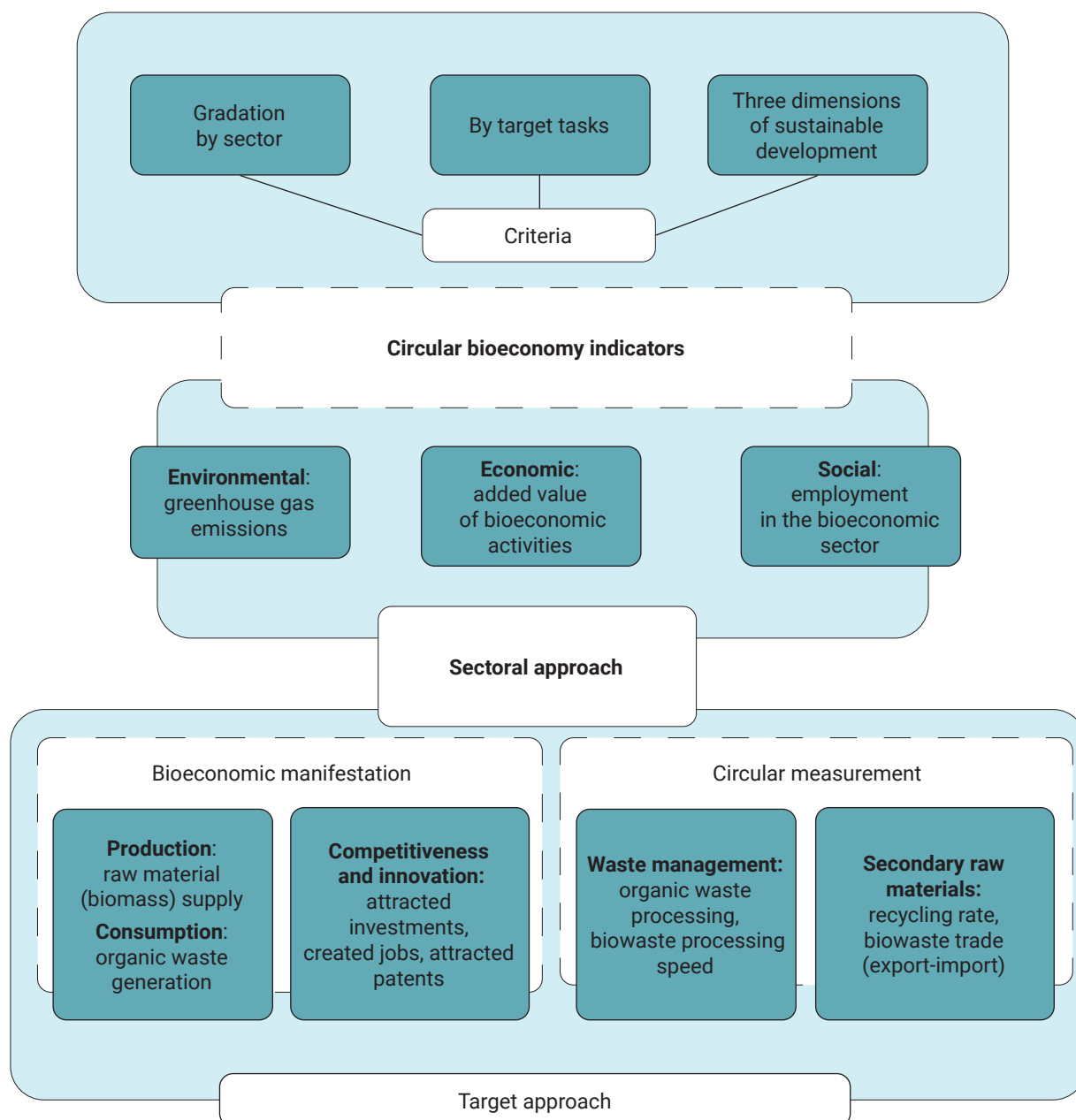


Figure 4. Criterion measurement of the author's circular bioeconomy monitoring system

Source: compiled by the author

The established criteria allow for outlining indicators for measuring circular bioeconomy within the framework of sectoral segmentation (sectoral approach), which provides for the determination of the economic (gross value added), environmental (greenhouse gas emissions), social (employment) component (three dimensions of sustainability) for the above-mentioned industries and types of bioeconomic activity. Criteria for target benchmarks are viewed through a target approach that combines the features of bioeconomic activity and takes into account the requirements of closed waste-free production (circular measurement). At the same time, the bioeconomic manifestation is determined by the indicators of production (availability of

biomass), consumption (volume of organic waste generated) and competitiveness (attracted investment in the bioeconomic sector, jobs created in the bioindustry, the number of registered patents related to bioeconomic activities). Within the framework of the circular measurement, secondary raw materials are evaluated by the coefficient of processing capability and the volume of exported or imported bio-waste, as well as indicators of processing organic waste are determined. The formed system of indicators for measuring circular bioeconomy is a scientific basis, which in the process of its practical implementation will make it possible to assess the state of bioeconomic activity at the moment and will make it possible to outline further strategic prospects.

Conclusions

Based on the study, it can be concluded that the vast majority of countries offer to measure the contribution of bioeconomy in terms of economic factors (for example, value added and employment). At the same time, environmental criteria for monitoring bioeconomic activity are often ignored. Given the importance of the ecological footprint in modern society and considering circular bioeconomy as a key trajectory of sustainable development, it is worth focusing on the use of a holistic approach that will emphasise the ecological significance of economic activity on a biological basis. Consequently, the author's circular bioeconomy monitoring system provides for the formation of methodological tools based on traditional sectoral segmentation (sectoral approach), taking as a basis three dimensions of sustainability, which, at the same time, is aimed at determining social well-being (employment), economic

growth (gross value added) and environmental equilibrium (greenhouse gas emissions). Taking into account the integrating concepts of circular bioeconomy, which are within the limits of ordinary goals and have a relevant character for their implementation, a target approach is proposed, the criterion characteristics of which are expressed through bioeconomic manifestation (production, consumption, competitiveness, activation of innovation) and circular measurement (processing of organic waste, the degree of use of secondary raw materials in the production process). The formed system of indicators based on criteria is a theoretical scientific asset, which in the process of testing will make it possible to carry out a comprehensive study of the development of circular bioeconomy and adjust national strategic guidelines for the implementation of an effective state policy to support the closed production cycle.

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Критеріальна характеристика вимірювання циркулярної біоекономіки

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Анотація. В умовах імплементації Європейського зеленого курсу, актуальності набуває модель замкненого циклу виробництва, разом і концепція циркулярної біоекономіки, яка пропагує оновлені альтернативні економічні підходи до ведення господарської діяльності. Перехід соціально-економічної системи з одного якісного стану в інший, викликає необхідність вимірювання динамічних змін і встановлення прогресуючих чинників на шляху до формування циркулярного бізнес-середовища. Тому метою наукового дослідження є моніторинг системи виміру циркулярної біоекономіки з виокремленням критеріальних обмежень та релевантних показників за встановленими характеристиками. Методологічною основою дослідження є методи емпіричного та теоретичного рівня, зокрема історичний, абстрактно-логічний, описовий, порівняльний, метод спостереження та формалізації, теоретичного узагальнення тощо. У процесі наукового дослідження було здійснено комплексний моніторинг наукових напрацювань зарубіжних і українських вчених та встановлено наявні методичні підходи до оцінювання циркулярної біоекономіки. Внаслідок огляду літературних джерел було виявлено ключові структурні компоненти, що знаходяться в межах секторального простору та цільових орієнтирів, які мають комплементарний зв'язок з тривиміром сталого розвитку. За допомогою секторальної сегментації та цільової градації за циркулярною спрямованістю та біоекономічним проявом було сформовано систему показників вимірювання циркулярної біоекономіки за встановленими критеріальними характеристиками. Практична цінність дослідження полягає у науковому обґрунтуванні критеріальних характеристик виміру циркулярної біоекономіки та встановленні системи показників за відповідними обмеженнями

Ключові слова: система оцінювання, циркулярний вимір, біоекономічний прояв, критеріальні обмеження, секторальний простір, цільові завдання, індикатори, підхід