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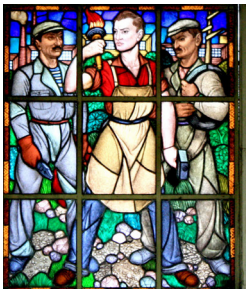
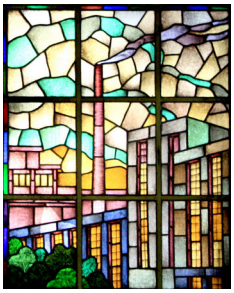

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Belgrade, 2021

The Third International Scientific Conference

CIRCULAR AND BIOECONOMY

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BOOK OF PROCEEDINGS

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FOREWORD

School of Engineering Management in Belgrade and Engineering Management Society of Serbia organised the third International Scientific and Practical Conference on Circular and Bioeconomy - CIBEK 21.

The Conference deals with more current topics, such as improving efficiency and reducing the use of resources; identifying and creating new opportunities for economic growth and promoting the innovation and competitiveness of cities and their surroundings as well as their companies; guaranteeing the security of supply of essential resources; fighting against climate change and limiting the environmental impact of the use of resources.

This conference brought in some different format, online, together scientists, professionals and students from Austria, Jordan, United Kingdom, Portugal, Spain, Italy, Luxembourg, Norway, United Arab Emirates, Romania, Slovenia, Croatia, Bosnia and Herzegovina, Montenegro, Macedonia and Serbia due to exchange ideas and concepts of great importance for the future sustainable economic development.

The Book of Proceedings, as a result of the Conference, is published and will be available to a wider audience, scientifically and practically focused on circular and bioeconomy multidisciplinary issues.

Belgrade, Editor

July, 2021 Brankica Pažun, PhD

CONTENT

MONITORING CIRCULAR ECONOMY AT THE MICRO-LEVEL

Angelina Pavlović, Snežana Nestić, Goran Bošković

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Abstract: There has been an increased interest in the circular economy (abbr. CE) at the global level in recent years, which is an adequate alternative to the existing linear economic model which follows „take-make-dispose“ step-by-step plan. The CE's primary goal is to reduce the extraction of natural resources and the generated amount of waste by achieving the economic, environmental and social components of sustainable development. However, the problem arises when it is necessary to monitor the progress towards the CE since there are no commonly accepted methods for measuring the CE. To ensure the successful replacement of the current linear economic model with a CE model, it is required to develop the ability to monitor and report on the CE, which implies the development of indicators at macro, meso and micro-levels. These circularity indicators are an obstacle in monitoring the circular economy since there are no accurately developed uniform indicators which can be used in every country or business organization. Therefore, this paper reviews the indicators that can be used to monitor the CE at micro-level in the Republic of Serbia because business organization are identified as key actors in transitioning to CE.

Keywords: monitoring, CE, indicators, business organization, micro-level.

1. INTRODUCTION

Current global economic model is mostly based on the linear flows of materials and energy [1]. This economic model implies the consumption of available natural resources in order to meet the existential needs of individual. The linear economic model leads to generation of waste and different types of emissions, depletion of natural resources and

transformation of natural landscapes which results in a complex environmental, social, and economic problems [2, 3].

In order to minimize mentioned problems, an opposite model is established called circular economic model. The circular economic model represents an alternative to a traditional linear economic model and in which it is necessary to keep resources in use for as long as possible. The CE aims to create new resources without reducing the consumption of human needs. The concept of CE is based on the economic, but also on the social and natural principle, which includes: design of waste in order to reduce pollution, longer life of materials and products in use and renewable natural resources. Sustainability of the CE concept is reflected in its regenerativeness and innovation [4]. Both determinants eliminate the current concept of linearity and replace the end-of-life product phase because circular economic model is based on sharing, leasing, reuse, repair, refurbishment and recycling of products in an almost closed loop [5]. Implementation of CE is recommended as an approach to economic growth that is in line with sustainable environmental and economic development [6].

The need to move from a linear economic model to a circular one is also reflected in the growing interest by researchers in area of CE which is proven by numerous research in this area in the last decade (Figure 1).

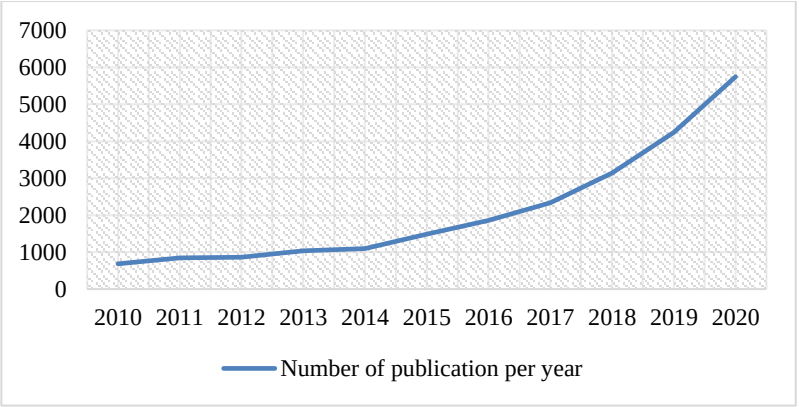

Figure 1. Annual evolution of publications by research area: CE
(Research database: Science Direct)

The replacement of the linear economic model with a circular model brings with it numerous changes at the global, national and local level. Also, this transition requires development, implementation, and integration of a support system for the CE. In order to achieve that, it is

necessary to measure and monitor the circularity using macro, meso and micro level indicators. This statement, at the same time, represents main problem of further development of CE concept because indicators for monitoring transition toward a CE are insufficiently developed.

Aim of this paper is to analyze the indicators, which have been developed and which can be considered adequate for determining the level of circularity of a business organization. Professional literature in the field of managing indicators of performance and economic success of the organization is very diversified and provided in several different directions, and that is why paper analyzes only the indicators that can be integrated into the field of CE at the micro-level.

2. MONITORING OF CE

Monitoring of CE aims to record its current state, as well as to identify changes in the quality and improvement of the same over time [7]. Also, monitoring of CE is important for achieving the following goals:

- defining measures for improving circularity level,
- identification of weaknesses, threats, strengths and opportunities of the current state of circularity,
- making adequate and timely decisions in CE area,
- public reporting about CE.

According to the reports published by European Commission (abbr. EC), during the determination of circularity levels, activities such as reducing the need for extraction of new resources and minimizing negative pressures on the environment, social behavior of people, which describes the awareness of citizens, as well as their engagement and participation in the CE and business operations which stimulate the change and adaptation of business models in accordance with the basics of the CE should be considered [8].

To measure, manage, and compare level of circularity, it is necessary to establish circularity indicators.

Indicators provide us with such cognitive facts about a phenomenon or process on the basis of which that phenomenon can be further and deeper researched, described and explained [9,10]. The indicator consists of data, which are collected and sorted according to predefined criteria, so they can be used in different areas. Based on the indicators, various assessments, classifications, estimates, and predictions

can be done. They are very important tools in economic assessments. Combining indicators gives even more complex indicators called indices.

Circularity indicators are in their early stage of developement and the main goal is to monitor circularity on different levels which are explained by the Table 1 [11,12].

Table 1. Levels of CE monitoring

LEVEL	DESCRIPTION
Macro	The highest level of circularity determination in cities, provinces, regions or states.
Meso	Determining the circularity of socially networked connections between individuals or social organizations (for example: eco-industrial parks).
Micro	Determining the circularity of a business organization through the determination of circularity levels of products and its components, services, consumers, etc.

As already mentioned, indicators are the most effective form for monitoring changes and achieving goals of sectoral policies and strategies, which also applies to the area of CE. CE indicators help to better understand complex problems and provide quantitative information in a simple and clear way. Like the others, circularity indicators should be representative, relevant, convincing, transparent and accurate.

It is important to note that the biggest barrier to the implementation and later, for monitoring of the circular economy is the lack of legal regulations in this area, as well as the lack of guidelines on how to implement and monitor the concept. There is only one internationally recognized standardization in terms of circularity performance of used materials "BS 8001: 2017 Framework for implementing the principles of the CE in organizations" developed by the British Standards Institution. BS 8001 provides a practical framework and guidance to the management of organizations for the application of the CE principle [13].

This paper will analyze in detail the indicators that can be characterized as circularity indicators and which can be used for monitoring and determining the degree of circularity at the micro-level, which implies to the circularity level of business organization in the Republic of Serbia.

3. MONITORING OF CE AT THE MICRO LEVEL

In the era of intensified globalization and internationalization, large business organizations represent the main drivers of the economic growth [14]. As the modern business environment is dynamic, that is exposed to constant internal and external changes, it is necessary for each business organization to define purposeful principles, procedures, methods and methodologies for improving both quality and performance of CE, which will be applied in all business activities of the organization [15]. In order to adequately manage an organization, performance needs to be quantified appropriately to assess the degree of circlarity goal achievement [16]. Performance refers to the degree of achievement of defined goals or potentially possible achievement in terms of important characteristics of the organization for relevant stakeholders. Therefore, performance is generally determined through a multidimensional set of criteria [17]. The performance must be measurable, but that it must not be equated with the set goals.

In order for the goals of a business organization to be able to represent its mission and vision in the area of CE, it is necessary for them to be precisely defined and measurable, and at the same time to make the result visible to the stakeholders. Namely, what should be a priority when setting circularity goals is that the goals are defined in accordance to the so-called SMART principle. SMART is an acronym for Specific, Measurable, Achievable, Relevant and Time-bound goals [18].

In order for a business organization to achieve its circularity goals in a certain period of time, it is necessary to use performance management systems. Simply put, performance management is done by the management of organizations to determine if their business is going in the right direction. To measure, manage, and compare performance, organizations are required to define performance indicators.

Implementing the CE model in business organizations is one complex process because it requires a change of the complete business model so there is no single indicator which can determine the degree of circularity the entire organization, but it is determined on the basis of numerous indicators, which directly or indirectly contribute to the development of CE.

Based on research conducted by the World Business Council for Sustainable Development [19], it has been proven that 48 % of the identified circularity metrics refer to the organization's internal operations or production processes. Examples of such metrics are energy efficiency or energy consumption per unit of product or renewable energy

consumption. Then, 22 % and 20 % of the analyzed circularity metrics qualify according to the raw material extraction phase and the waste disposal phase, respectively. Indicators such as material consumption, content of recycled materials or hazardous substances in products are common indicators of the extraction phase of raw materials, while the amount of waste is directed to the permanent disposal in landfills as well as the amount of recycled waste are typical examples of indicators used in the product's disposal phase. Circularity indicators in the phases of product design, distribution and product use are rarely used, namely 6 %, 1 % and 4%, respectively [19].

This paper focuses on an overview of some indicators, which can be considered relevant for monitoring progress towards the adoption of the CE models in organizations. Based on the literature review, this analysis will cover a total of nine indicators which can be used at the micro-level in the Republic of Serbia. Micro-level circularity indicators provide detailed information for specific CE decision-making processes in an organization.

All indicators defined in this paper are measurable and their focus is on the environmental segment of CE. A review of indicators is shown in Table 2.

Table 2. Review of CE indicators at micro-level

ACRONYM	INDICATOR	REFERENCE	YEAR
DEI	*Disassembly Effort Index*	*Das et al.*	2000
CEENE	*Cumulative Exergy Extracted from the Natural Environment*	*Dewulf et al.*	2007
MCI	*Material Circularity Indicator*	*Ellen MacArthur*	2015
CEI	*CE Indicator*	*Di Maio & Rem*	2015
RI	*Recycling Indicies*	*Van Schaik & Reuter*	2016
EVR	*Eco-Efficient Value Ratio*	*Scheepens et al.*	2016
PLMC	*Product Level Circularity Metric*	*Linder & Williander*	2017
CTI	Circular Transition Index	*WBCSD*	2020
PEF	*Product Environmental Footprint*	*European Commission*	2020

In addition to the indicators shown by Table 2, two more general indicators can be used at micro-level for CE monitoring such as amount of generated waste as well as the amount of waste that is recycled.

Based on systematic review of the literature and research of relevant articles, studies and reports on the CE, nine indicators, which can be used at the micro level and which description is provided in Table 3, have been identified.

Table 3. Brief description of CE indicators at micro-level can be used in Republic of Serbia

INDICATOR	DESCRIPTION
DEI	Disassembly is the process of physically separating parts of a products in order to recover valuable and reusable parts or components of the product, facilitate the process of material recovery (recycling), remove of hazardous or toxic materials, extended the life of product component, etc. As disassembly of products is a positive activity from the aspect of environment, because it reduces the amount of material that needs to be disposed of, it means that this parameter can be used in monitoring of CE. Disassembly Effort Index – DEI is an indicator that considers the work and processes required to disassemble a product into multiple components. The indicator is expressed as a percentage and can be used to calculate the cost of disassembly and return on investments [11, 20].
CEENE	CEENE is an indicator of cumulative exergy, which is extracted from the environment and used in business organization. Exergy is a measure of energy quality, so this indicator aims to assess the energy quality of resources. In order for CE to be raised to the top of the organization's development, a serious exergetic analysis of existing technologies and economic patterns is needed [21]. CEENE is an exergy-based method, even though it considers not only the resource quantity but also the extent to which consumption removes resource quality [22].
MCI	Material circularity indicator is defined as basic indicator that shows to what extent the linear flow of a product has decreased, ie to what extent the circular flow of a product has improved (or increased). This indicator is determined for each product, based on the materials from which it is made, so it is considered that already in the process of product design, the degree of circularity of the entire organization can be influenced [23]. The MCI of a business organizations can be determined as a weighted sum of MCIs values estimated for all products [11].
CEI	CEI is defined as the ratio of the value of material recycled from one product to the value of material needed to reproduce the same product. When developing this indicator, the market value of the material (for example €, $) was chosen as the unit of measurement

	[24]. CEI is an indicator that can help the organization's management to simplify the decision-making process in order to create new value and technological innovation in the production process.
RI	RI or recycling indicator assesses the readiness and ability of an organization to manage solid waste in a way that promotes circular material flows, ie shows the percentage of products that can be recycled. This indicator is considered relevant to the field of CE because it determines the rate of product recycling. The recycling index is determined at all stages of the product life cycle, and has been developed in accordance with the valid eco-labels of the European Union. Primarily, RI is a clear and transparent tool for visualization, communication and insight into product components or the entire product, which can be recycled [25].
EVR	Ecological efficiency coefficient is an indicator that calculates the ecological efficiency of a product and / or service as a ratio of eco-costs (environmental impact that the product creates during its life cycle expressed in monetary terms) and product value (the price people are willing to pay for product on the market). The EVR calculation requires the expression of all consequences that the product can cause in the environment, all with the aim of reducing environmental pollution and human health [26].
PLMC	Circularity metric at the product level is a metric that focuses exclusively on the circularity of the product, taking into account the composition of waste, ie the percentage of primary and secondary raw materials in the production process. PLMC is calculated as the ratio between the economic value of recycled material (secondary raw material) and the economic value of all materials used in the production process [27].
CTI	CTI as one of the indicators, which can show the circularity of the business organization, can be used by any organization, regardless of size, sector or the country of origin. The CTI is based on material flows through the company and it provides a menu of specific indicators taht are divided into three groups: closing the loop, optimization of the loop and evaluation of the loop [28].
PEF	Ecological footprint of the product is an indicator developed by the European Commission, in order to find a common way to measure circular performance in European Union organizations, which want to distribute their product. The approach of determining the ecological footprint of a product is still in the testing phase. PEF represents in a way a standardized life cycle analysis (abbr. LCA), because it is necessary to determine the ecological footprint of a product during its life cycle (production, use, disposal, transport). It is formed on a number of existing standards and guidelines [29].

The indicators listed in Table 3 can be used at the micro level, but not all indicators are equally valid for the area of CE, so it is necessary to compare them.

3.1. COMPARISON OF ANALYZED CIRCULARITY INDICATORS

In the previous section, all relevant references related to the identified circularity indicators were analyzed, in order to investigate the characteristics, formulas, data requirements and possible implementations of these indicators in business organizations. In order to facilitate the comparison of the identified indicators, Table 4 has been created.

As it can be determined from Table 4, the criteria for further analysis were established during the comparison. The criteria are divided into four groups, referring to the implementation of a CE model in the organizations.

According to Kristensen and Mosgaard, the concept of resource-efficiency, which is extremely important for development of CE, is represented in the 3Rs dimension - reduce, reuse and recycle [30]. Regarding to the dimension 3Rs should include the indicators which are related to the possibility that the product will be reused [31]. In this paper, the dimension 4Rs is considered, which in addition to reducing, reusing and recycling includes recovering of products.

By reviewing the literature it is concluded that the CE indicators should be compared within the three dimensions of sustainability: environment; economy, and society [32]. More precisely, the second group of criteria refers to aspects of sustainable development, i.e. it is determined whether defined indicator has social, environmental or economic benefits.

When monitoring of CE is conducted at the micro-level using defined indicators, it is important for experts to know whether that indicator can be applied at the level of the product, its component or constituent materials because circularity of one organization is calculated in accordance to the circularity of its final products in total. So, the third group of criteria for comparation of indicators is a group that shows at what level the circularity is determined.

The last group of criterion includes the method of using indicators. As it has already been explained, all indicators must be measurable so criterion in the last group defines whether the value of the indicator can be obtained by the text forms, software tools and internet applications.

Table 4. Comparison of analyzed circularity indicators

CRITERION	*DEI*	*CEENE*	*MCI*	*CEI*	*RI*	*EVR*	*PLMC*	*CTI*	*PEF*
4Rs									
Reduce		●	●			●	●		●
Reuse			●	●		●	●		●
Recycling	●		●	●	●	●	●	●	●
Recover	●	●	●	●		●			●
Dimension of sustainable development									
Economic	●		●	●		●	●		
Environmental	●	●	●	●	●	●	●	●	●
Social									
Indicator usage level									
Material		●	●					●	
Component			●		●				
Product / Service	●		●	●	●	●	●		●
Indicator format									
Text forms	●	●	●	●	●	●	●	●	●
Software tool								●	
Internet application								●	

The analysis found that 34 % of the analyzed indicators promote the 4Rs concept (MCI, EVR, PEF), and that PLMC and CEI indicators do not only promote energy recovery from waste and waste prevention, respectively.

Regarding the dimension of sustainability, all indicators include the environmental dimension, the economic dimension consist out of five, from the total nine indicators, while the social dimension is not included by any indicator.

The analyzed indicators can mainly be applied at the product level, and through the determination of indicators at the product level, the circularity indicators of the entire organization can be obtained.

The format for determining the indicators depends on the authors who are shown in Table 2, but most of the identified indicators are determined manually by using text forms.

In addition to these criteria, the ones related to organizational and operational aspects of the implementation of circularity indicators were taken into account, such as: time required for implementation of indicators, data required for analysis, required special competencies of employees and whether the indicator supports decision-making process. However, a review of the literature found that all the mentioned criteria for almost all indicators are positive and they were not shown in Table 4.

A detailed analysis of Table 4, concludes that of all the indicators, MCI is the most suitable for application in business organizations. This indicator allows management in organizations to identify additional, circular values of their products and materials and to mitigate the risks of both the price volatility and the supply of materials in the market [23]. This indicator can be considered suitable even in the product design process, but it can also be used for internal reporting, when making procurement decisions or for assessing or evaluating the performance of an organization in the field of CE.

4. CONCLUSION

Due to increased pressure on the environment, society needs a new economic model such as the analysed CE model. The main advantage of the implementation of CE in the Republic of Serbia can be explained by the fact that it creates resource efficiency, promotes renewable energy, and enables cleaner production, which moves towards zero waste [33].

As the main actors in the implementation of CE are business organizations, since they are the drivers of the global economy, the possibility of monitoring the circular economy at the micro level is considered in this paper.

This review showed that in the Republic of Serbia, there is no common way of measuring micro level CE, which it is found to also be a barrier for the further uptake and implementation of CE, as it is difficult to measure progress towards complete CE acceptance of organizations.

Based on a systematic review of the literature, nine indicators have been identified that can be used to monitor CE: DEI, CEENE, MCI, CEI, RI, EVR, PLMC, CTI and PEF. The analyzed indicators serve the purpose of providing standardized metrics, in order to guide future

assessments on circularity. These nine indicators evaluate or describe level of circularity of product/material/component on the basis of which the circularity of the entire organization is determined.

During the comparative analysis of these indicators, the criteria related to the implementation of the CE principles through 4Rs concept, dimension of sustainability, level of evaluations, format of determination, but also the criteria related to organizational and operational aspects of the implementation of indicators were taken into account. After reviewing all the criteria, it is concluded that it is best to use MCI for the indicator that will be used to monitor CE in business organizations that operate in the Republic of Serbia. The MCI was developed by the English Ellen MacArthur Foundation, which means that this foundation aims to compensate the lack of regulations in the field of CE through the development of a methodology that assesses how well the organization is transforming from a linear to a circular business model.

Every business organization has the potential to increase their level of circularity, and by doing so, to increase their level of efficiency and effectiveness of business. Future research and analyzes in this area will be focused on conduct of a case study based on analyzed indicators. It is important to find a way to determine the level of circularity of one business organization, using the best-identified indicator – MCI and to find key points that can be perfected in order to improve circular business performance.

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