

## Upravljanje cirkularnom ekonomijom u poslovnim organizacijama primenom digitalnih tehnologija

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**Apstrakt:** Upravljanje cirkularnim ekonomskim modelom u poslovnim organizacijama širom sveta zavisi od pojave inovacija u tehnologiji, organizacionim formama i poslovnim modelima. Stepem cirkularnosti jedne poslovne organizacije u značajnoj meri zavisi od razvoja digitalnih tehnologija u istoj. U stvarnom dinamičnom poslovnom okruženju, digitalne tehnologije omogućavaju iskorišćenje potencijala cirkularnih strategija za poboljšanje efikasnosti resursa i produktivnosti. Primenom digitalne tehnologije u poslovnim organizacijama moguće je izvršiti monitoring procesa tranzicije linearnog ekonomskog modela na cirkularni ekonomski model. Stoga, cilj ovoga rada jeste da se izvrši pregled razvijenih digitalnih alata, koje je moguće koristiti za praćenje cirkularne ekonomije na nivou jedne poslovne organizacije, a u svrhu poboljšanja procesa donošenja odluka u analiziranoj oblasti.

**Ključne reči:** cirkularna ekonomija, poslovna organizacija, monitoring, digitalne tehnologije.

## Circular economy management in business organizations using digital technologies

**Abstract:** The circular economic model management in business organizations around the world depends on the emergence of innovations in technology, organizational forms and business models. The level of circularity of a business organization largely depends on the development of digital technologies. In a real dynamic business environment, digital technologies can be applied to capture the full potential of circular strategies for improving resource efficiency and productivity. By applying digital technology in business organizations, it is possible to monitor the process of transition of a linear economic model to a circular economic model. Therefore, this paper aims to review developed digital tools, which can be used to monitor the circular economy at the level of a business organization, in order to improve the decision-making process in the analyzed area.

**Keywords:** circular economy, business organizations, monitoring, digital technologies.

### 1. Introduction

In recent years, there has been an increase in the world population, which has resulted in increased consumption of resources in order to meet various human needs. The current model of production and consumption of products intended for widespread use is not considered sustainable. The reason for this is that today, resources from nature are excessively consumed, especially those whose capacity is limited to create final products, which, after the phase of use, are mostly disposed in an unsatisfactory way. Such a model of production and consumption is called a linear economic model, which can be most simply defined as a one-way flow of energy and materials. This model is based on a "take-make-dispose" philosophy (Pagoropoulos et al., 2017). The linear flow of energy and materials contributes to the emergence of negative pressure on the Earth's ecosystems. In order to avoid current environmental problems that endanger the environment, it is necessary to change the current model of production and consumption of goods.

Furthermore, it can be concluded that the main reasons for the increase in ecological footprint are increased extraction of raw materials from nature and the increased amount of generated waste. Thus,

measures that will transform these two phases of the product life cycle must be defined at the global level. The concept of the circular economy (abbr. CE) is defined as an appropriate measure for changing the current model of production and consumption of goods. Namely, there is no evidence of the launch of term CE, but according to the literature review, it can be concluded that CE is the first time mentioned in 1990 by scientists Pearce and Turner (Pearce et al., 1990). At that time, the CE was not recognized as a concept that can influence the achievement of sustainable development. Over the last decade, this concept has gained attention because people have set themselves up aware of the fact that transformations of the present economic model are necessary. The expression of CE can be implemented in the entire economy, and it includes all products and services in different sectors, so it is challenging to find its single definition.

The concept of CE is defined as an alternative to the linear economy model. The CE promotes the urgency of closing materials loops, i.e., it promotes the transformations of resources' function. The generated waste becomes a valuable material that can be used in a completely different manufacturing process of a new products. That leads to the conclusion that the CE represents a way to integrate the economy and the waste management system.

The principles of the CE are based on the 4Rs concept (reduce, reuse, recycle, recover) and the 6Rs concept (reuse, recycle, redesign, remanufacture, reduce, recover) (Winans et al., 2017). The CE's ideology is that the products during their life cycle needs to be repaired, reused, improved, but not permanently disposed, because, in that way, a potential resource would be lost, i.e., secondary raw material would be lost.

In this research it is recognized that the concept of the CE can be implemented on a different level: macro (countries), micro (business organizations), and nano (products). On the macro level, implementation of the CE implies the adoption of legislation to regulate activities in this area at the national level. Then, implementation of the CE on the micro-level requires changes in business models from the business organizations. Thus, the global transformation of the linear economic model requires business organizations to develop, implement, and integrate a system that supports the CE. On the nano level, the CE considers activities concerning with design of products and the first measure from waste hierarchy, that is, activities covered by waste prevention as the most preferred option in the whole waste management system.

Business organizations represent the key to the countries economy, so it is considered they have a substantial role in the implementation of the CE.

This review provides an initial exploration of the intersection of two trends: circular economy and digital technologies. The motivation for this research lies in the fact that it is necessary to measure and monitor the circularity level of business organization. It is considered that monitoring of circularity can be carried out through monitoring and evaluation of various indicators that are still at an early stage of development. Circularity indicators accompanied by digital technologies can measure the circularity level in the business organizations. That is the reason why software tools and internet applications that can be used for that purpose are reviewed in the following chapters.

## **2. Monitoring of circular economy**

Implementation of CE is not limited to certain materials, products or sectors so its monitoring is a challenging task. The main reason for that can be explained by the fact that circularity indicators are in at the initial stage of development.

Monitoring of the CE is performed by indicators, which should primarily include trends in the protection of the economic value of products, materials, and resources but also trends in the reduction of waste generation. In this review paper, monitoring is identified as systematic measurement, testing and evaluation of circularity indicators of one business organization.

Based on data published by the European Commission, during monitoring of the CE, the following activities are considered (European Commission, 2018):

- reducing the need for extraction of new resources through simultaneous minimization of negative impact on the environment,

- social behavior of people described by the awareness of citizens and their engagement in the CE's adaption,
- business operations, so-called eco-innovation operations, which stimulate changes and adaptations of a business model in accordance with the principles of CE.

Implementation of the CE model in a business organization is not an easy process. If the management of an organization wants to apply the CE into its business, it is necessary to change business models completely, adapt strategies, and develop workforce skills through the simultaneous adoption of national legislation that enables and supports the application of the CE.

The management of one business organization needs to understand its circularity level, so it is necessary to develop and implement circularity indicators. The business organizations need metrics in which the application can facilitate the adoption of a circularity strategy. First of all, systematic changes are needed at the global level. Those changes will enable the management in the business organizations, to determine the level of circularity uniformly. Namely, it is necessary to develop a methodology on the global level by which business organizations will have a common approach for measuring and monitoring circularity performance. In addition to solving differences in circular metrics' scope and level, a common framework for measuring circularity at the organization level should solve differences caused by position in the value chain or product life cycle (Kristensen et al., 2020).

The product life cycle is an essential segment of the economy because it describes all the stages of a product. The concept of this cycle occurs when products are developed, introduced to the market, then grow actively, reach maturity and, finally – decline. All mentioned is described by the following phases of the life cycle (Komninos, 2002):

- extraction phase of resources required for the production process,
- design phase,
- production phase,
- the phase of distribution of finished products,
- the phase of product use by consumers,
- product disposal phase, in a waste form.

To make it easier to monitor circularity indicators in all phases mentioned above, it is necessary to apply digital technologies. Thus, it is increasingly recognized that the monitoring framework of the CE must include different software tools and internet applications. With the help of digital technologies, it is possible to perform systematic monitoring of CE. Namely, to determine the exact level of circularity of the business organization in which the assessment is performed.

### **3. The possibility of using digital technologies to support circular economy in business organizations**

The basic concept of CE is based on the assumption of the efficient use of resources in the production process. The fundamental principles of CE are established on the increase of the product or service value, while reducing the amount of waste generated or at least bringing that amount to a minimum. The product should be designed in a way that generated waste material can be reused or recycled at all stages of the product life cycle.

As the twenty-first century is the century of information technologies, it is logical that innovations in communications technology and materials use technologies and production processes that contribute to the development of the CE concept. Namely, it is considered that the concept of CE would not be applicable since technology could not support its ideas (Radivojević, 2018).

The possibility of CE implementation leads to increased investment in research and development, and consequently, in the development of technologies that enable the application of the CE's concept. The global industry is mostly entering the era of digitalization and artificial intelligence, and the impact of smart manufacturing on market competitiveness is growing. Computer Integrated Manufacturing (abbr. CIM) is a system that integrates and manages all activities in the production process using information technology such as computers, networks, and communications. CIM represents the process of production automation and the integrated flows of information and materials (Regodić & Cvetković,

2011). Implementation of the CIM system would significantly improve the circular economic model's application because its progress would be monitored more easily.

Also, in the coming period, significant support in the development of indicators for measuring the organization's circularity can be models developed using advanced computational methods, such as artificial intelligence (abbr. AI).

AI can enable innovation in a circular economy in three primary ways (Ellen MacArthur Foundation, 2019):

- design circular products, components, and materials,
- operate circular business models,
- optimise circular infrastructure.

It is possible to develop a universal methodology for determining a business organization's circularity using smart and AI technologies. In that way, it is possible to create an opportunity to support circularity indicators globally. As already mentioned, if the management of an organization wants to apply CE in its business, it is necessary to change the business model completely, and that includes the application of digital technology that supports CE.

### 3.1. Software tools and internet applications to support, promote and develop CE

CE is a regenerative economic system in which production resources, waste, waste emissions, and energy outflow are significantly reduced by slowing down, rounding, and extending energy and material cycle in the production. As this economic system is innovative, it must follow innovations from other areas, such as smart technologies.

There is no universal methodology for determining the circularity of a business organization, but developing software tools to support, promote, and develop CE has begun. For that reason, this chapter provides an overview of currently developed software tools/internet applications, which can be used to monitor CE. This overview is shown in table 1.

Table 1. Overview of analyzed software tools/internet applications for CE monitoring

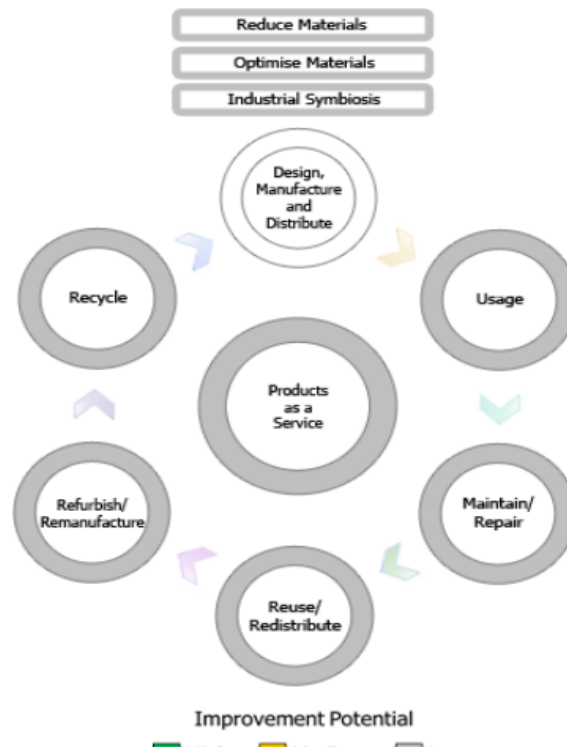
Acronym	Name	Author	Year of tool development
CET	Circular Economy Toolkit	Evans & Bocken	2014
CC	Circular Calculator	IDEAL&CO Explore	2016
CTI	Circular Transition Index	WBCSD	2020
/	Circulytics	Ellen MacArthur	2020

Based on a systematic review of the literature and research of relevant articles, studies, and reports on the CE, four software tools/internet applications which can be used for business organizations have been identified, in order to monitor the CE systematically.

#### 3.1.1. Circular Economy Toolkit

Circular Economy Toolkit or so-called CET was developed at the University of Cambridge. CET is an online tool for assessing activities that have the potential to improve the circularity of a business organization (Evans and Bocken, 2014). By using this tool, organizations can determine each phase of a product life cycle, with low, medium, or high chance for improving of circularity. The analysis is conducted online using a questionnaire containing thirty-three questions about specific activities in the organization. The analyzed phases are shown in Figure 1.

Figure 1. Overview of activities analyzed using CET



(Source: Circular Economy Toolkit, 2020)

### 5.1.2 Circular Calculator

Circularity calculator (abbr. CC) is a tool that helps a business organization to understand how strategic decisions are made, when developing and designing products affect the degree of circularity of the material flow and its potential retention of material value. CC shows the degree of circularity of a different material flows, which depends on whether the materials are reused, remanufactured or recycled.

The analyzed calculator is available at [www.circularitycalculator.com](http://www.circularitycalculator.com). It allows modeling of different conceptual solutions and business models in order to explore and compare different scenarios and their impact on overall circularity, recycling rate, and retent potential (Janik and Ryszko, 2019 12; Moraga, 2019).

### 5.1.3 Circular Transition Index

The Circular Transition Index (abbr. CTI) can determine the degree of transition to the CE in business organization and it has been developed by the World Business Council for Sustainable Development. The CTI offers business organizations insights into their CE performance. With this tool, the business organization's management can identify circular opportunities and linear risks to improve company longevity and resilience (WBCSD, 2020). Therefore, CTI can serve to set a baseline and monitor progress on circular transition in business organizations.

World Business Council for Sustainable Development has launched the methodology for determining the transition indicators to the CE on the market in the form of internet applications that can be accessed via the internet address: [www.ctitool.com](http://www.ctitool.com)

With the CTI methodology, it is possible to determine the company's circularity by defining indicators, classified into three groups (WBCSD, 2020):

- close the loop (% circular inflow, % circular outflow, % water circularity, % renewable energy)
- optimize the loop (% critical materials, % recovery type), and

- value the loop (circular material productivity).

Through the assessment via CTI, value chains that are essential to accelerating the transition to the circular economy can be identified.

### 5.1.4 Circulytics

Circulytics, like other tools, supports the transition of a business organization to the CE model regardless of industry, complexity, and size. Through the assessment of material flows, Circulytics helps to measure the circularity of business organization. Tool Circulytics reveal the extent to which a business organization has achieved the circularity of its services or products. That assessment can be achieved by using a wide range of currently available indicators, promoted by the English Ellen MacArthur Foundation. One of these indicators is a well-known Material Circularity Indicator (abbr. MCI).

This tool is the most innovative in this area because it (Ellen MacArthur Foundation, 2020):

- measures entire circularity of business organization,
- supports decision-making and adoption of strategies for the CE,
- displays advantages and highlights the areas for the improvement of CE,
- delivers information about circular economy performance.

### 5.2 Comparison of the analyzed software tools/internet applications

In the previous section, all relevant references related to the identified software tools and internet applications, which can be used to determine the circularity level in the business organizations, are analyzed.

In order to facilitate the comparison of the identified tools, table 2 has been created.

Table 2. Comparison of analyzed software tools/internet applications

Criterion	Software tools/Internet applications			
	CET	CC	CTI	Circulytics
Basic principles of the CE				
Waste reduction	X	X		X
Reuse	X	X		X
Recycling	X	X	X	X
Recovery	X	X		X
Aspects of sustainable development				
Economic aspect	X	X		X
Ecological aspect	X	X	X	X
Social aspect				X
The level of use of tools				
Material			X	X
Component				X
Product / Service	X	X		X
Method of using digital technologies				
Software tools			X	X
Internet applications	X	X	X	X

As can be seen from table 2, this analysis proposes several criteria that can be used to compare the quality of the considered tools and applications. When conducting the comparison, it was identified which criteria are taken into account during the evaluation of circularity in business organizations, using analyzed tools/applications.

The criteria related to the implementation of a circular economic model in the organization are classified into four groups.

The first group of criteria is focused on the application of the 4Rs concept as basic principles of the CE, which includes:

- reduction (prevention) of waste generation at the source,
- reuse of products,
- recycling of waste, and
- waste energy recovery or utilization.

The next group of criteria applies to aspects of sustainable development. According to these criteria, it is discovered which aspects (social, environmental, or economic) are considered when determining circularity.

The third group of criteria is a group that determines whether the software or internet application can be applied for evaluating the circularity at the product level, its component, or its constituent materials. Within the last group, the method of digital technologies usage was analyzed, more precisely whether the level of circularity in a business organization is determined using a software tool or an Internet application.

The analysis found that all tools, except the CTI tool, support the 4Rs concept as the CE's fundamental principle. Regarding the aspect of sustainability, all tools used during the determination of circularity include the environmental aspect, and the economic aspect is taken into account by all tools except CTI. In contrast, the social aspect of sustainable development in its work considers only the tool Circulytics. The analyzed tools can mainly be applied at the product level. The format for determining the circularity depends on the author, so the CET and CC tools are available online via an Internet application. In addition to the Internet application, CET and Circulytics are available to users through software, which is not free. Namely, the user has to pay to download them.

After reviewing all the criteria, it is concluded that the best is to use Circulytics in a business organizations because only with this tool all the criteria are met and with it, the management of the organization would have an insight into its current level of circularity.

#### **4. Conclusion and further research**

Defining and determining the performance of CE, i.e., determining the level of circularity in business organizations is one of the critical problems of achieving sustainability through the CE because there is no uniform way to monitor or carry out benchmarking of the CE. The main goal of this review was the analysis and comparison of developed digital tools for the support of CE at the business organization level.

Based on a systematic review of the literature, four software tools/internet applications have been identified that can be used to monitor CE: CET, CC, CTI, and Circulytics. During the comparative analysis of these tools, the criteria related to the implementation of the CE principles, aspects of sustainability, level of application, the format of determination, but also the criteria related to the organizational and operational aspects for the implementation of circularity tools have been taken into account.

After reviewing all the criteria, it is concluded that Circulytics stands out as a software tool/internet application because only with this tool, all the criteria are met. Circulytics is a digital measurement tool that gives a completely comprehensive picture of the organisation's circularity in all business operations (Ellen MacArthur Foundation, 2020). Circulytics was developed by the English Ellen MacArthur Foundation, which means that this foundation aims to compensate the lack of regulations in the field of the CE through the development of a methodology that assesses how well the organization is transforming from a linear to a circular business model.

Future research in this area will be focused on conducting a case study based on analyzed software tools/internet applications. It is important to find a way to determine the level of circularity of one business organization using the best-identified tool - Circulytics.

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