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RESOURCE MANAGEMENT AND PERFORMANCE MEASUREMENT INDICATORS IN THE CIRCULAR ECONOMY

Abstract

The concept of circular economy involves the use of indicators that help measure performance by looking at the key elements of this concept. Efficient use of resources and responsible behavior towards waste through reuse of materials and recycling of raw materials are one of the basic activities and tasks of the circular economy. It is important to prevent and reduce the production of waste materials and to ensure that resources are used in several production cycles. The aim of this paper is to point out the basic aspects of efficient use of resources, to get acquainted with the basic operational principles of circularity, but also to get acquainted with the indicators that can be used for reporting. The main goal is, therefore, to understand how organizations can choose a group of indicators that will help them measure the performance of the circular economy and its activities, but also to point out the principles that are important for the application of this concept.

Keywords: *circular economy, principles of circular economy, performance indicators, waste management, efficient use of resources*

JEL classification: *Q56, Q57, M21*

УПРАВЉАЊЕ РЕСУРСИМА И ИНДИКАТОРИ МЕРЕЊА ПЕРФОРМАНСИ У ЦИРКУЛАРНОЈ ЕКОНОМИЈИ

Апстракт

Концепт циркуларне економије подразумева употребу индикатора који помажу мерењу перформанси кроз сагледавање кључних елемената овог концепта. Ефикасна употреба ресурса и одговорно понашање према отпаду кроз поновну употребу материјала и рециклирање сировина једни су од

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основних активности и задатака циркуларне економије. Важно је остварити превенцију и смањење производње отпадних материја и обезбедити да се ресурси користе у више производних циклуса. Циљ рада је указивање на основне аспекте ефикасне употребе ресурса, упознавање са основним оперативним принципима циркуларности, али и упознавање са индикаторима који ће им бити од помоћи при мерењу перформанси циркуларне економије и њених активности, али и указивање на принципе који су од значаја за примену овог концепта.

Кључне речи: *циркуларна економија, принципи циркуларне економије, индикатори перформанси, управљање отпадом, ефикасна употреба ресурса*

Introduction

The circular economy is a recent concept that has emerged in response to the growing environmental and economic problems in the world. The economy uses resources from nature, consumes energy and returns waste materials, whether they are toxic or non-degradable. It is an unsustainable system, which can burst at any moment, because the hoops in the form of climate change, pollution and the effects of the greenhouse are increasingly gathering and tightening the economy, but also nature itself, which can no longer accumulate all these negative phenomena. Therefore, the importance of applying the concept of circular economy, which implies the circulation of matter and raw materials through the system, is increasingly emphasized. All resources and materials used must be from renewable sources and strive to achieve zero waste at the end of the reproduction cycle. It is important to ensure good waste prevention, use recyclable materials and components from the beginning, then strive to reuse the product after the end of its service life, with servicing, replacement of parts and redesign. Waste is managed responsibly and, in addition to recycling, the part that represents waste material is disposed of in a way that does not harm the environment.

The benefits of applying the concept of circular economy are visible at the micro and macro level. Companies have numerous savings from the use of used resources, money is now being invested in recycling, the use of new and advanced technology. At the level of the environment and the economy, the ecosystem, nature, non-renewable energy sources and resources are protected. All this contributes to increasing the competitiveness of the company, but also of the entire business environment. Efficient resource and waste management are underlined as two basic, equally important, goals of the circular economy. It can be concluded that resources are the basis of this concept because attention is focused on their protection, rational exploitation and maximum utilization - renewable and recyclable sources of raw materials. It is important to note that the circular economy is a closed system that connects procurement with the waste management phase. This achieves a compact business unit that operates effectively and efficiently based on the principles of circular economy. The value of resources is retained within that system by applying the principle of maintaining the value of materials through product reuse or recycling of raw materials.

The way in which the circular economy and its system function is explained by operational principles. According to one of the classifications, they are divided into basic, target and transversal. Principles are the basis of the existence and understanding of the concept, the basis that serves to share knowledge about the circularity in society and economic organizations.

In a circular economy, performance indicators are used. Their number varies depending on the views of the authors, but what is suggested is certainly the use of not too many, but enough relevant indicators that will provide a good information basis for making a performance assessment. Most indicators are directly or indirectly related to measuring the performance of the use of resources, which are one of the main management topics of the circular economy. All of the above should be helpful in understanding the basic facts about resource use and waste management, as well as the ability to measure performance in a circular economy. The number of indicators in use depends on the characteristics of the business system, organization and characteristics of the production itself. The most important thing is that by choosing a set of indicators, management achieves the goals of adequate and accurate measurement of the performance of the circular economy.

Resource and waste management in the circular economy

The linear business model has become almost unsustainable for many economies around the world due to the numerous negative externalities that fast-growing industries and the activities they bring with them. The effects of the greenhouse, climate change, environmental pollution and the lack of an adequate solution for waste materials have prompted the world to think about potential solutions to the accumulated problems. There was a need for man to change his attitude towards nature and the material world because his existence was disturbed. In addition, the increasing use of energy and resources from nature with the increase in production contribute to the reduction of available raw materials or change their quality. These are just some of the reasons why the world economy is starting to pay attention to the concept of circular economy and to look for a solution in its principles and application.

The circular economy has its roots in the field of industrial ecology, and on the other hand, in the field of ecological economics, which emphasizes recycling and efficient use of waste, but also through specific areas such as industrial ecosystem, eco-efficiency, emission reduction (Sanchez-Ortiz et al., 2020). From the aspect of theory, circular economy is a concept that combines the principles of several schools of thought - the school of regenerative design, performance economy, green growth, industrial ecology (Pauliuk, 2018). It is an approach that promotes sustainable development and is one of the frameworks applied for the implementation of sustainable development strategies and the achievement of economic goals, while respecting environmental requirements and the need for rational and responsible use of natural resources.

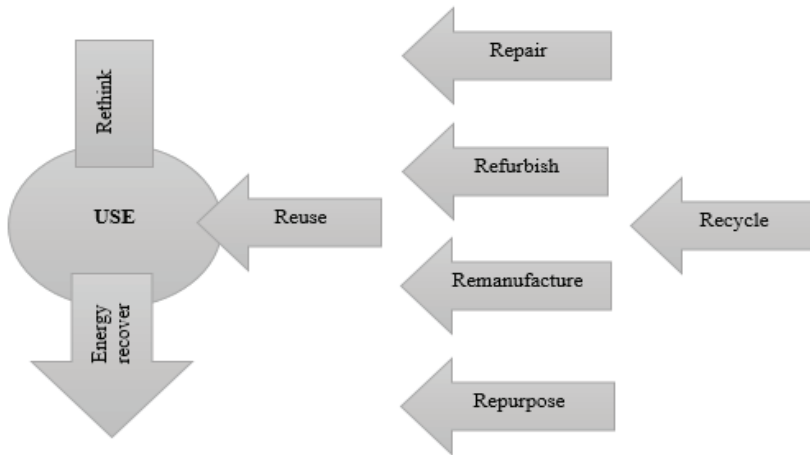
The concept of the circular economy, as an emerging framework for waste and resource management, aims to offer an alternative to linear production thinking through the use of reuse, recycling and remanufacturing strategies (Blomsma, 2017). Analyzing the circular economy as the so-called “an umbrella concept” that seeks to examine the

knowledge gap in the field of circular economy, with the aim of connecting the scientific and practical segment of the circular way of doing business, and until the appearance of the umbrella concept, they exist independently of each other (Hirsh & Levin, 1999). Numerous economies and companies, starting with Germany, which was among the first countries to support the concept of circularity, noticing the benefits of doing business according to the principles of circular economy, advocate abandoning the linear system and switching to a new model. Linear economy, with profit orientation as the main driver of all processes, uses natural resources from the environment, with insufficient respect for environmental principles and insufficient care for technical and technological waste that harms both humanity and nature itself. Although the linear model of the economy is dominant in the world, the world public, faced with increasingly difficult forms of environmental problems and poverty problems, notices that this model is becoming unsustainable in the long run (Čarapina & Mihajlov, 2015). That is why the world is turning to the application of the circular economy model and respect for the principles associated with it. On the other hand, the circular model of the economy strives to create a system with zero waste, maximum utilization of each substance and raw material that has already suffered the process of production and use. The benefits of doing business in the circular economy are reflected in the protection of resources and the environment through compliance with sustainable development guidelines, then in the increased use of renewable energy sources while reducing non-renewable, reducing losses that companies consciously or unconsciously make, increasing the competitiveness and reputation of companies in the eyes of consumers who recognize that someone cares about them and their environment and, therefore, choose recyclable and environmentally friendly products.

With the growing environmental and climate problems in the world, more and more attention is being paid to sustainable development and the circular economy. The circular economy is seen as an instrument for achieving sustainable development goals through the pursuit of efficient and rational use of resources and respect for environmental and zero waste principles, all through a system that allows product reuse or recycling of components after the end of product life. It is necessary to use circular economy strategies that require as little use of natural resources as possible and offer maximum utilization of waste materials and raw materials that have already gone through the production process.

Figure 1 shows the strategies applied in the circular economy system - strategies further away from the center requiring less investment and less use of natural resources. At the same time, the materials and raw materials in use are made from recycled raw materials and components of products that were in use, reducing the overload of the natural environment from which less resources and energy are now extracted, and reducing or completely neutralizing waste that pollutes nature.

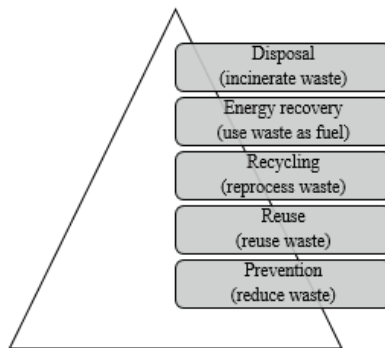
Figure 1: Strategies for the use of resources and materials in the circular economy



Source: Adapted to Potting & Hanemaaijer (2018)

Doing business in a circular economy, along with improving the management of waste and materials, helps to address issues related to their impact on the environment. The return of materials from waste streams to the process of recycling or reuse contributes to longer use of goods and increasing the intensity of use, which is the aspiration of the circular economy - maximizing the value of materials circulating within the economy, minimizing material consumption and paying special attention to primary materials and waste streams. All this maintains the value of resources within the system for a longer period of time (OECDiLibrary, 2021).

Figure 2: Waste management hierarchy



Source: Adapted to OECDiLibrary (2021)

The main goal of efficient management of resources and waste is waste prevention, general reduction of waste, especially hazardous substances. In addition, the reuse of products at the end of their useful life or the preparation and treatment of waste components for reuse is something that is also considered a priority. Looking at Figure 2,

recycling, energy recovery through the use of waste as fuel and waste disposal through landfilling and incineration of what cannot be used as fuel for energy production, are direct waste management. Essentially, to use absolutely everything from raw materials - to return nothing to nature, can set it back and damage it because it needs time to regenerate and recover.

Operational principles of circular economy

The term “operating principle in the circular economy” describes and explains how the circular system works, how the parts of the system and the strategy are interconnected. One of the classifications divides the operational principles according to the main goal of each implementation strategy (Suarez Eiroa et al., 2019). In that sense, we are talking about target principles, basic and transversal operational principles.

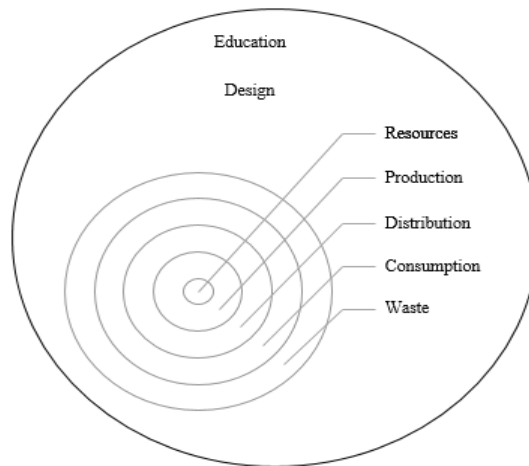
The target principles are a direct link between theoretical goals and practical strategies in the circular economy. The first operational principle of this category - adjustment of inputs (inputs to the system with regeneration rate) is the principle that first divides resources and inputs into renewable and non-renewable. The essential aspiration of this principle is to eliminate the use of non-renewable resources. This is one of the main goals of the circular economy because its postulate is precisely the promotion of renewable energy sources and the use of renewable resources, as well as the reuse of the same materials and raw materials after use. Renewable energy management must respect two rules of sustainable development: first, that the utilization rate is equal to the regeneration rate and, second, that the waste emission rate is equal to the natural assimilation capacity of the environment in which the waste is emitted (Daly, 1990). The second principle - adjusting inputs to the rate of absorption is a principle that considers strategies that eliminate technological waste, and adjust the emission of biological waste to acceptable limits for the ecosystem. All circular economy strategies have this ecological dimension and attitude towards the environment that is socially responsible and sustainable.

Basic operational principles are crucial to achieving theoretical goals and they are able to channel strategies that indirectly adjust the use of inputs with a regenerative rate and waste out of the system to the rate of absorption. One of such principles of circular economy is the principle of closing the system, which aims to connect the phase of waste management with the procurement of resources. It integrates the 3R philosophy of waste management prevention, preparation for reuse, recycling, where the reuse and recycling phase is especially important, which is the focus of this principle (Usapein & Chavalparit, 2014). Certain products or their components can be reused after the end of their useful life, or they can be decomposed into components that can be recycled and reused in the reproduction process. Such a system of work saves energy, resources and leads to increased efficiency in the use of resources and raw materials, which simultaneously protects the ecology and the environment. The principle of maintaining the value of resources within the system by improving the durability of the product or connecting the intermediate phases of the product life cycle through reuse, repair, renovation, overhaul, etc. The principle of reducing the size of the system means reducing the total resources circulating within the system, which is realized by strategies to reduce the total amount of products needed to meet the needs and through the production of sustainable and environmentally friendly products (Heshmati, 2015).

Transversal principles participate in promoting other principles in any circular economy strategy. Within this group, the principle of designing is identified. The importance of this principle is reflected in the fact that a well-designed product can be easily repaired or recycled, and only the promotion of eco-design contributes to the overall success of the company. Another principle from the group of transversals is the principle of education in the field of circular economy, which is necessary for people to understand the importance of economical and rational use of resources, as well as the importance of circular behavior from the consumer's point of view.

The circular economy model, in a rounded way, looks at nine important business elements based on its principles: inputs, outputs, resources, production, distribution and services, consumption, waste management, design and education. In addition, this conceptual solution for presenting the essence of the circular economy is based on two models - 1) the circular economy model, proposed by the European Commission, and 2) the Ellen Mac Arthur Foundation model, which introduces the concepts of technical and biological output. The use of non-renewable resources and the existence of technical waste must be reduced to a minimum (Suarez Eiroa et al., 2019).

Figure 3: Conceptual framework of circular economy



Source: Adapted to Suárez-Eiroa et al. (2019)

The operational principles that support a sustainable and circular economy are derived in a way that enables the adjustment of the flows of the social and economic system to the values that promote sustainable development (Suarez Eiroa et al., 2021). For the construction of a sustainable and resilient socio-ecological system, it is important to apply the principles of sustainability, elasticity and circularity, because all of them lead to the achievement of the desired goals through synergistic action. Sustainability refers to the analysis of production and consumption through the use of inputs and the analysis of the output of the reproduction process, while circularity is related to the retention of resources and materials within the production sustainable process over a long period of time. The resilience of a system is its ability to change and adapt to changes in the environment.

Performance measurement indicators in the circular economy

The subject of expert debate is the question of what should be measured in the circular economy, because different indicators can lead to different conclusions (Moraga et al., 2019). The methodologies and indicators used and considered independently are not able to track all aspects of the circular economy. There is a need for a comprehensive and holistic approach that encompasses the environmental, economic and social dimensions (Jovanović, 2017).

Numerous studies show variation in the number of indicators proposed as relevant for analysis - from one indicator up to 189, while most studies advocate the use of a smaller number of indicators that should not exceed a dozen indicators, relevant to the analysis of performance efficiency in circular economy (Negri et al., 2021). The framework for measuring the performance of the circular economy must be clearly defined to support the business of the organization in all phases of its transition from linear to circular business, and in all phases of development of resources, competencies and levels of awareness and knowledge of the concept of circular economy. Therefore, it is necessary to determine the priority indicators and focus on their use, and over time, with the increase of knowledge and needs, to expand the list.

The performance monitoring framework should contain relevant indicators that can be grouped into four phases of the circular economy: production and consumption, waste management, secondary raw materials, and competitiveness and innovation (Sanchez Ortiz et al., 2020). In addition, the system of indicators is developed according to the level for which it is intended - micro and macro level. At the micro level, companies choose indicators in accordance with the characteristics of the company and the conditions in which it operates. These are usually indicators based on the 3R principle. The macro level involves the selection of indicators that help design and monitor policy at the state level.

According to Pauliuk (2018), the measurement of performance in the circular economy is based on the use of indicators within the control panel, with the help of the BS 8001: 2017 standard. It is a standard that is not certified, but is written in the form of recommendations for the implementation of circular economy (Niero & Rivera, 2018), and implies respect for six principles: 1) systemic thinking, 2) innovation, 3) management, 4) transparency, 5) value optimization and 6) cooperation. Pauliuk (2018) points out the existence of sets of circular economy performance indicators, but is also of the opinion that most indicators are actually a measure of resource efficiency. Based on the available information, the main performance measurement indicators or, in another case, their auxiliary indicators can be used (Sanchez Ortiz et al., 2020): direct use of materials or raw materials, the extent of material loss in key production cycles, share of secondary raw materials in material consumption, share of ecologically certified materials in the use of total materials, time required to dismantle the product, share of recycled materials in new products, total waste in the production process, quality of recycled material compared to the original material, environmental effects and analysis of total costs and benefits of waste management.

Indeed, most indicators relate to the efficiency of resource management because they and their use are the most important aspect of management in a circular economy. From exploitation, through reproduction to waste management, resources are the focus of all important processes because the circular economy has the basic mission of protecting natural resources and energy, in the processes of exploitation and production, while preserving ecosystems and sustainable development.

An important moment of the circular economy is the retention of resources within the system, when the products can no longer be used, but their components and materials are used for recycling and reuse as inputs. With knowledge of the market value of a resource, circularity can be viewed as part of the value of a resource in the form of a percentage that returns after the end of the life of the product. The methodology for measuring resource efficiency depends on the characteristics of resources, ie their use and the impact they have on the environment (Di Maio et al., 2017). The four key categories of resource use include: material use, energy use and climate change, water use, and land use. For these categories of resource use, there are indicators related to the use of resources and their impact on the environment, viewed at the level of domestic demand, but also globally. Economic value is a key parameter for measuring resource efficiency because it reflects both the quantity and quality of resources themselves, so value-based indicators are more efficient in decision-making and policy implementation. In this sense, the professional literature recognizes 16 relevant indicators shown in Table 1 (Behrens et al., 2016).

The indicators from the table with a clear focus on the use of resources look at the use of raw materials, land and water at the level of the domestic economy, but also on a global scale, in order to protect excessive exploitation and use. On the other hand, indicators attach equal importance to environmental protection and measuring the impact on its safety and sustainability during the process of using materials and energy. It is important to follow the data at the level of one economy, but also at the level of the world economy.

Table 1: Indicators for measuring resource efficiency

	Orientation to the use of resources		Orientation to the impact on the environment	
	<i>Resources for domestic production and consumption</i>	<i>Domestic resources in the global context of use</i>	<i>Impacts on the environment by the use of resources in the domestic conditions</i>	<i>Impacts on the environment in the global context</i>
Use of materials	Domestic consumption of materials	Consumption of raw materials	Indicator of life cycle of resources in a certain territory - ecologically weighted consumption of materials	Indicator of life cycle of resources - ecologically weighted consumption of materials
Energy use and climate change	Gross domestic energy consumption	Energy footprint	GHG emissions in the domestic territory	Global GHG emissions
Water use	Water consumption	Water footprint	Water exploitation index	Global water exploitation index
Land use	Domestic land demand	Current land demand	Domestic primary production intensity	eHANPP, LEAX and other ecosystem quality indicators

Source: Behrens et al. (2015)

One of the indicators that can be used for this purpose is VRE (Value of Resource Efficiency) indicator. It is a resource efficiency indicator that is harmonized with environmental, social and economic policies. It indicates whether a particular branch or the entire economy is using resources efficiently (Di Maio et al., 2017). It is calculated as follows:

$$VRE = \frac{Y}{\sum_i W_i X_i}$$

where Y is the output value, X_i are the resources, and W_i is the environmental impact value. To measure resource efficiency, W_i represents the impact of resource use on the living environment as well as the social implications of resource use X_i. This indicator uses market prices as a known quantity that directly show the demand for resources, which indicates their scarcity or value for the economy. The focus is on non-renewable sources of resources, and the inputs that are in the analysis are energy, raw materials and labor.

Resource management efficiency indicators are of great importance to management as a creator of business strategies because they enable the identification of important parts of the strategy, assessment, monitoring and measurement of resource management. Of course, not all indicators can be used, for practical reasons, but also for the impossibility of perceiving the results of their measurements, as well as monitoring and creating a good information base for all of them.

Due to the existence of a wide range of resources, the difference between them and the fact that they are renewable, non-renewable, toxic or non-toxic to the environment, assessing the efficiency of their use and the use of indicators themselves is a complex task. It is important to identify a couple of indicators that can help assess the performance of the circular economy, especially in the initial stages of development and application of this concept.

Conclusion

The undoubted importance of the circular economy is reflected in the adoption of a new business framework, as well as in the adoption of new principles and rules of conduct that are acceptable to society and nature. The question arises: what would have happened to our society and the world economy if circularity had been known much earlier, if there had been a desire and intention to respect the principles of sustainable development and the principles of circularity? Life would probably be much better, we would breathe cleaner air, have adequate climatic conditions and clean rivers. But, it is good if the world still understands that only with a change in thinking and way of doing business can the existing living and business standard be maintained, albeit disturbed, but with radical changes sustainable in the long run. The most important thing is to understand that waste is actually a resource, a cheap resource that brings both profit for the company and society as a whole.

The circular economy implies responsible management of natural resources and energy sources, respect for the principles of sustainable development, good attitude towards the environment and maximum utilization of the resources that are in use. The benefits of applying this concept are clear - at the micro and macro level and, most

importantly, future generations will also benefit from it. The model successfully integrates all basic and important elements of business: inputs, outputs, resources, production, distribution and services, consumption, waste management, design and education. For the four key categories of resource use - material use, energy use and climate change, water use and land use, it is important to have a framework with indicators to measure the performance of these categories at the domestic economy level, but to know indicators showing the global picture of use. Retaining value within the system is a feature of the circular economy, the value passes from one form to another, through a closed system that connects procurement with waste management.

In order to manage something, a way must be found to measure the results of activities, which is why it is important to measure the performance of the circular economy, above all the efficient use of resources and adequate waste management. More efficient business and a positive outcome of measuring indicators that are adapted to the characteristics of the production process and the products themselves, but also the characteristics and types of resources used, allow to conclude whether the application of the circular business concept has positive effects and to what extent it affects society and environment. The indicators that will be in use depend on the activity of the company, the type of resources used, the products that are made from those resources. Therefore, the professional literature suggests the selection of adequate indicators in no more than a dozen, in order to properly respond to the need to report and control the results of performance measurements. Measuring the performance of the circular economy is important to know how society applies this concept, whether and how quickly it changes its old business habits and how socially responsible it is. Companies must start from the micro level of application of the principles and performance measurement, so that in the end, the macro level of analysis itself makes sense and positive changes.

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