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# **INDUSTRY 4.0 AND KAIZEN COSTING 4.0 – OPPORTUNITIES FOR DEVELOPMENT OF COST MANAGEMENT SYSTEMS TOWARDS CIRCULAR ECONOMY**

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**Abstract:** The importance of management accounting and cost management systems for industrial enterprises is constantly growing. In the conditions of the fourth industrial revolution, management systems of economic agents need to adapt to the new economic environment. This article is an attempt to present the influence of Industry 4.0 on a specific cost management system - Kaizen costing. Additionally, it presents the possibilities for the application of Industry 4.0 and Kaizen costing in the circular economy, which has become the main economic perspective for the EU countries.

**Keywords:** management accounting, Industry 4.0, Kaizen 4.0, circular economy, cost management systems, costs.

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## **Introduction**

**S**hortages of basic production resources worldwide are caused by a number of factors. Costing and cost reporting systems for goods and services rendered, which aim to optimize production resources are directly affected by the economic situation. Industrial entities produce goods that are

consumed by everyone in society. Modern systems such as Kaizen costing are the "drive" behind the economic development of countries such as Japan, where the system itself originated. Economic development and the fourth industrial revolution are the grounds for a new stage in the development of cost management systems. A research on the influence of the Kaizen costing system, Industry 4.0 and the circular economy on the development of industrial production is important both for theory and practice. The development of Industry 4.0 after 2020 had a direct effect on Kaizen and initiated a new stage of its development, designated as Kaizen 4.0. The article is an attempt to investigate the use of Industry 4.0 and Kaizen 4.0 in the new economic reality (circular economy).

#### **Research methods, objective, subject and constraints of the study**

Industry 4.0 and its impact on Kaizen costing and cost reporting system in the context of the circular economy are identified as the **subject** of this scientific research. Its **objective** is to investigate the possibilities and applicability of the system in the current economic conditions (Industry 4.0) and circular economy.

The methods used to conduct the scientific research are: critical analysis of the literature related to the costing and cost accounting system Kaizen costing, Industry 4.0 and the circular economy; synthesis of research opinions; descriptive method and SWOT analysis to define the main opportunities and weaknesses of Industry 4.0 and Kaizen costing 4.0 in order to determine the possibilities for their application in a circular economy. The main constraint of the research is that these systems were evaluated only in industrial enterprises.

#### **Executive summary**

At the end of 2019, the restrictions related to the COVID-19 pandemic resulted in reduced production capacities, disrupted supply chains and border regimes imposed in various countries both in the EU and worldwide, and thus caused shortage of production resources. The subsequent military operation on the territory of Ukraine which resulted in economic sanctions on a country that is a major source of raw materials and resources further deepened the food crisis. The importance of all these factors requires a study on the way Industry 4.0 affects the use of costing and cost accounting systems in terms of optimization of production resources in the current economic conditions. One of these systems is Kaizen costing and its development in recent years. The system covers both the production aspects in an enterprise and the psychological aspects in the work of personnel in industrial enterprises. It is a basis for developing production systems to reach the goals set by the circular economy.

## **1. Historical review of the development of Kaizen costing and its importance for the global economic processes**

The costing and cost accounting and management system Kaizen costing originated in Japan as a means of enhancing production units by improving production quality and at the same time optimizing costs. A specific feature of Kaizen costing is that it was first used in the management accounting of Toyota corporation in the 1950s. It was presented to the scientific community by Masaaki Imai in her scientific publication *KAIZEN – The Key to Japan's Competitive Success* (1986). The system can be described as “Kaizen is a Japanese term used to describe a blitz like approach to study processes and install efficiency within an organization. This approach relies on frontline employee input for “quick fix” suggestions relating to business processes. Essentially, focus sessions are conducted in search of the obvious areas of operational improvement.” (Skouses, Christopher; Walther, Larry, 2009, p. 93). The system is considered progressive and focused on cost management. Before we move to Kaizen costing, we have to present the development of the Kaizen budgeting system, which is "an approach to budgeting that implies constant improvement and reduction of certain categories of costs" (Павлова, 2010, p. 184). It is these characteristics of the costing and budgeting system that define Kaizen as a complete system for managing and optimizing costs. A number of cost management systems (Activity-based costing, Target costing, Direct costing, Just-in-Time, Activity-based Management, etc.) are directly aimed at meeting the information needs of enterprises during the Third Industrial Revolution. This is precisely what determines the association of Industry 4.0 with Kaizen 4.0. Information security "is based on the inherent qualities of accounting itself as a separate information activity, which, at least so far, are neither possessed nor can be taken over by another information activity of the enterprise". (Димитров, М., Душанов, И., 2015, стр. 19). The system goes through various stages of development related to economic development, the main ones being:

- Kaizen 1.0 (1950-1980) – this stage is associated with a general quality increase;
- Kaizen 2.0 (1980-2010) - this stage is marked by simplifying the processes in the economic entities;
- Kaizen 3.0 (2010-2020) – the third stage focuses on unit restructuring;
- Kaizen 4.0 (2020 – present) – the last stage is still in progress and is aimed at an exponential growth of economic activities.

The concept of exponential growth was borrowed from mathematics as an alternative to linear growth. A clear distinction needs to be made between

the exponential growth of the economy, where "it is due to the egregious consumption by the super-affluent in a socioeconomic system founded on growth without limits" (Dhara, Chirag; Singh, Vanadana, 2021) and growth aimed at continuous emergence of new technologies enabling the production of new and/or better-quality products with a low carbon footprint. It is to the latter option for development of the economy that Industry 4.0 and Kaizen 4.0 are aimed. The implementation of key features from the ideas of the fourth industrial revolution leads to the improvement of Kaizen, which in turn leads to improvements of the overall organization in the industrial enterprise.

This article discusses the latest stage of system development, which is directly related to the fourth industrial revolution or Industry 4.0. Economic development and the requirements it imposes inevitably require adaptation of the systems related to cost management. This is typical of all management accounting systems and more specifically cost management systems. The adaptation of the system is related to the "principle of responding to changes in the external environment - the management accounting system should be flexible in relation to changes in the external environment in order to provide management with information in conditions of uncertainty and risk" (Павлова, 2010, стр. 26). This is necessary due to the information needs and the provision of management teams for decision-making at different hierarchical levels in the enterprise. The environment of uncertainty and risk in the last few years is characteristic of the economic development of the EU countries. Kaizen costing is among the systems which evolve and aim to help economic entities, most of which are industrial enterprises. At the current stage, Kaizen 4.0 focuses on exponential growth of economic activities.

"The focus of the system is on eliminating redundant human labour efforts and additional production processes. Improvements that can result from the Kaizen approach include:

- eliminating overproduction;
- reducing the number of defective products due to process changes;
- synchronising the production processes and eliminating bottlenecks;
- identifying and eliminating redundant inventories;
- reducing lead times through more intensive communication with suppliers;
- improving the processes of storing and processing." (Atrill, P., McLaney, E., 2021, p. 172).

The main role of Kaizen 4.0 in an Industry 4.0 environment is to control risks and utilize the full potential in the activity of industrial enterprises. This role can also be presented in four main aspects: determining the strategic goals for the specific enterprise; analysing value chains; transforming the vision for future periods and determining the investment and its return for the activity.

Thus, the cost management system sets tasks to monitor the effectiveness of using Industry 4.0 in the activity of industrial enterprises. The impossibility of fulfilling any guideline suggests that a check be made on the applicability of Kaizen 4.0 and Industry 4.0 together.

## **2. The effect of Industry 4.0 on the development of the circular economy**

These main characteristics of a system can be combined with the main concepts of circular economy, which is "sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products as long as possible" (Европейски парламент, 2023). It aims to stop the aggressive and continuous extraction of resources and promote the use of recycled materials in production of new products. The circular economy should not be seen as an isolated solution or a new direction for the European and global economy. It is the result of a long process of implementation of the document related to climate change, and more specifically, the Kyoto Protocol, which is considered its foundation. The EU supported the concept with Decision 2002/358/EC of the European Council and, on a national level, the Environmental Protection Act (SG, No. 91 of 2002), followed by the Climate Change Limitation Act (SG, No. 22 from 2014). This study focuses on the implementation of the circular economy in the EU and Bulgaria through uniform steps adopted in the integration of this new economic perspective. The aforementioned documents show that the idea of a circular economy arose "as a conceptual idea and was developed into a strategy to create a clean environment, in the modern understanding, these ideas go beyond the need for recycling mechanisms, but encompass new business models, which generate added value through optimization of input resources". (Иванова, 2022, стр. 45).

This opinion supports the thesis that the circular economy is more than recycling as an idea for recovery of part of the already invested resources but also for creation of new economic sectors. This would add value in any economy and replace lost jobs and tax revenues in government budgets. Moreover, it is defined as an "industrial system that addresses these challenges by decoupling growth from resource consumption an industrial system that tries to break the link between economic growth and increasing consumption of resources" (Eisenreich, A., J. Fuller, M. Stuchtey, 2021, стр. 23) of linear economy. The economic processes caused by the unprecedented situation with the energy crisis in the EU and Bulgaria are an opportunity for rapid implementation of the circular economy in various industrial sectors. By sector, the EU has set the following targets for the most resource-intensive industries:

“**electronics and ICT** — circular electronics initiative to achieve a longer product life cycle; **batteries and vehicles** — a new regulatory framework on batteries to increase sustainability and promote the circular potential of batteries; **packaging** — new mandatory requirements on what is allowed on the EU market; **plastics** — new mandatory requirements for the content of recycled materials and a special focus on plastic micro-particles, **textiles** — a new EU strategy for textiles to boost competitiveness and innovation in the sector; **construction and buildings** — a comprehensive strategy for a sustainable architectural environment promoting circular economy principles; **food** — a new legislative initiative on reuse to replace packaging”. (Европейска комисия, Справяне с нарастващите цени на енергията: набор от мерки за действие и подкрепа, 2021 г.)

With the above sectors and goals set by the EU, it is also necessary to indicate the importance of Industry 4.0. They can be achieved through the fourth industrial revolution and the development of production technologies that it offers. At the core of Industry 4.0 is a “new business model. For their management, businesses need innovative solutions based on the capabilities of new digital technologies. Some of these solutions are associated with improvements of accounting” (Петрова, 2018, стр. 242) and “Industry 4.0 is the result of the development of technology and human ingenuity. Innovations and modernization of organizations give rise to the need for evolution at all levels through retraining of the human factor or automation of a great number of the activities”. (Василев, 2018, стр. 338) The main difference from all other industrial revolutions (the first one from 1750 to 1850, the second – in the second half of the XIX century and the beginning of the XX century and the third – in the 70s and 80s of the XX century) and Industry 4.0 is that it will use the individual human talent to a greater extent than capital as the main production factor (Несторов, 2022, стр. 499). Based on innovation and scientific achievements, Industry 4.0 is part of the opportunities for a faster transition to low-carbon production, which helps to implement the circular economy sector by sector.

When we analyse the above information, we have to take into account that industrial production is a specific economic activity that is possible only when certain relations of supply and demand of the industrial product are present. A fast and effective implementation of innovative production methods is not always possible and largely depends on the available technologies and the specifics of the manufactured product. A number of resources are also required for a transition to ecologically clean production, the main ones being supplied by the Russian Federation. Management accounting facilitates the process by comparing the opportunity cost of certain activities. This type of cost is “a quantitative measure of resource consumption. If we measure the costs based

on forfeited opportunities, i.e. resources to be used for other purposes, we will determine the opportunity costs" (Йонкова, 2016, стр. 42). This is how many enterprises explore the possibilities to offer different technologies, because each country in the EU and/or around the world has a specific structure of its economy. Such an example is the economy of Poland. The country has large deposits of coal and therefore operate many thermal power plants, which is the reason for its slow and smooth process of implementation of the Kyoto agreement and the EU regulations. A research on Bulgaria's production of electricity from various sources can determine to what extent the country has implemented low-carbon methods of production according to the goal set by the EU and what regulations were adopted and enforced in Bulgarian legislation. The information presented below does not summarize the industrial production in Bulgaria but supports the opinion that a quick and reliable transition to green production is not always possible. The data are presented as a percentage of total production for each individual factor.

The information presented in the table reveals two distinctive periods - from 2017 to 2020 and after 2021. This division is also necessary because of the change in the economic environment worldwide due to the Covid-19 pandemic. During the first period, a decrease of 13.8 percent compared to other resources, or a 28.57 percent reduction was reported in the group of coal while the use of renewable sources and nuclear power increased. In this mechanical substitution the positive feature is the increase of renewable sources by 7.3 percent compared to other energy sources, and 44.24 percent in the group itself from the beginning of the studied period. Nuclear energy is increasing due to the unprofitable production of electricity from thermal power plants (the rising prices of the greenhouse gas emission quotas) and the regulated electricity market in Bulgaria. This shows that in Bulgaria there is no comprehensive solution for the integration of production facilities to replace coal as a resource that negatively affects the environment. This conclusion is also corroborated by the data for 2021, when the shortage of electricity led to an increase in the consumption of coal, a slowdown of the rate of increase of the use of renewable sources (from 9.2% growth in 2020 to 2.7% in 2021), and significantly reduced the consumption of nuclear electricity. This proves that the circular economy is not a single solution and integration of specific capacities, but a comprehensive concept for development of the sector with sustainable solutions. In a number of EU countries, the same trend is observed in the energy sector. The chosen industrial sector is not accidental, as its carbon footprint in Bulgaria is the largest and it pollutes the most the environment and water.

Table 1.

**Structure of the energy sources used in production of electricity in Bulgaria from 2016 to 2021<sup>1</sup>**

Source/Year	2017	2018	2019	2020	2021
Total	100	100	100	100	100
Coal and derivative solid fuels	48.3	42.3	40.0	34.5	38.74
Oil shale and oil sands	0.0	0.0	0.1	0.1	0.07
Oil and petroleum products	0.2	0.2	...	...	...
Natural gas	0.6	0.2	0.3	0.4	0.22
Renewable and biofuels	16.5	21.6	21.8	23.8	24.45
Non-renewable waste	0.3	0.4	0.6	0.6	0.61
Nuclear heat	33.6	34.9	36.8	40.0	35.41
Heat	0.4	0.4	0.5	0.6	0.5

### 3. SWOT analysis of Industry 4.0 and Kaizen 4.0 in the context of circular economy

The SWOT analysis is the main tool for studying the relationships between Industry 4.0, Kaizen 4.0 and the circular economy. It was chosen because the main task of the analysis is "to develop a business strategy for the development of an enterprise or site ensuring that all the main factors and driving forces for successful growth are taken into account. Opportunities within the company and external factors are also considered". (EBPOKAYHT KOHCYJIT, 2020). These factors are strengths, weaknesses, opportunities and threats. By examining and presenting each of them, we can formulate a strategy for each specific enterprise or sector in each EU member state. The analysis is specific to marketing research, but it is possible to apply it to other sectors of the economy.

First of all, the opportunities and risks of implementation of Industry 4.0 and the circular economy for the industry in Bulgaria and the EU are presented as a brief SWOT analysis, which highlights certain dependencies for specific products, strategies, policies, etc.

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<sup>1</sup> Based on HCI statistics for the period 2016 – 2020 in NSI's Yearbook 2022 and the data for 2021 is from NSI's publication Energy Balance 2021.



Table 2.

*SWOT analysis of Industry 4.0 in the context of circular economy*

Factors	Positive effects of Industry 4.0	Negative effects of Industry 4.0
Internal environment	Cost optimization, implementation of new technologies	Restructuring of the industrial enterprise
External environment	Expanding the market positions by launching competitive products	Dependence on resources for implementation of new technologies

Table 2<sup>2</sup> presents the positive and negative aspects of the implementation of Industry 4.0 for the external and internal environment in an industrial enterprise in the context of the circular economy:

- **The positive aspects** for the internal environment are cost optimization and implementation of new technologies. Industrial revolutions may combine both aspects because the main goal of implementation of new technologies is to optimize costs, improve quality, etc.;

- The main **opportunities** for the external environment is the increased competitiveness of the manufactured product(s) and rendered services, which creates an opportunity to increase the market share;

- **The negative aspect** for the internal environment is the need to reorganize the structures in the industrial enterprise. Depending on the production, there are economic entities for which the implementation of new production technologies may lead to a complete restructuring of units that are directly or indirectly dependent on production. This slows down operations and creates difficulties during the period of transition from the old to the new technology;

- **The risks** created by the use of Industry 4.0 in the external environment, are summarized as resource dependence for the implementation of production technologies. Regardless of the steps taken to enforce the circular economy, there are productions that have no analogues and the main raw materials for them cannot be recycled. This creates the need to procure scarce

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<sup>2</sup> The information in the table is based on an analysis of scientific literature and publications focused on the opportunities and shortcomings of Industry 4.0 - Industry 4.0 Digitization for Productivity and Growth, European Parliament; Industry 4.0 - Ministry of Innovation and Growth; Towards Industry 4.0: an overview of European strategic roadmaps, C. Santosa, A. Mehrsaia, A. C. Barrosa, M. Araújo, E. Aresc, "Strategic guidance towards Industry 4.0 – a three-stage process model", S. Erol, A. Schumacher, W. Sihn; "Industry 4.0-how to navigate digitization of the manufacturing sector", D. Wee, R. Kelly, J. Cattell, M. Breunig; Industry 4.0 and accounting challenges and opportunities, Petrova, P. et al.

resources, for which the enterprise may have to wait for several reporting periods, which slows down the process of implementing new technologies, etc.

This analysis aims to identify future problems identified as negative aspects to be addressed and thus improve the implementation of Industry 4.0 and the implementation of the circular economy concept in EU member states.

First of all, the circular economy is a new way of thinking and Kaizen costing is based on the change in thinking about production, marketing, etc. of the products of a given enterprise. After the SWOT analysis of Industry 4.0 we did the same analysis for the Kaizen 4.0 cost management system and its implementation in a circular economy. The order of the analyses follows the logic to analyse first the characteristics of Kaizen costing and then the circular economy and Industry 4.0.

*Table 3.*

***SWOT analysis of Kaizen costing 4.0 in the context of circular economy***

Factors	Positive effects of Kaizen costing 4.0	Negative effects of Kaizen costing 4.0
Internal environment	Improving employees' skills and cost optimization	Time for integration of the system
External environment	Improving competitiveness by raising staff qualification	Slower investments in new production technologies

Table 3<sup>3</sup> presents the positive (opportunities) and negative (disadvantages) aspects for the external and internal environment in an industrial enterprise of implementing Kaizen costing 4.0 in the context of the circular economy:

- **The positive aspects** for the internal environment are improving staff skills and cost optimization. A distinctive feature of the cost management system itself is the increase of the qualification of the staff only in accordance

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<sup>3</sup> The information presented in the table is based on an analysis of scientific literature, the Kaizen Institute and publications focused on the opportunities and shortcomings of Kaizen - *Management accounting for decision makers 9th edition*, Atrill, P., McLaney, . E; Management accounting, Colin Drury; Improving Kaizen with Industry 4.0, <https://visualdecisions.com/webinar-recordings/improving-kaizen-with-industry-4-0.html>; How do you adapt kaizen costing market conditions and customer demants, <https://www.linkedin.com/advice/0/how-do-you-adapt-kaizen-costing-changing-market>; Impact of Kaizen implementation on performance of manufacturing companies staff, Rahmanian, F.; Rahmatinejad, Z; Kaizen as a global business philosophy for continuous improvement of business performance, Janjić, V.; Bogićević, J.; Krstić, B.; Kaizen Costing: Interorganizational Cost Management., Cooper, R.; Slagmulder, R., etc.

with the specifics of the economic sector. The development of the skills to constantly look for alternative use of resources and reduction of the cost of goods produced and/or services rendered are of great importance for the entire industry, sector, etc.;

- The **opportunities** related to the external environment are: improving competitiveness by increasing the qualification of personnel as an opportunity for making quick strategic, operational and tactical decisions for the surrounding economic environment;

- The **negative aspects** for the internal environment is the time required to integrate the system. Depending on the overall structure of the economic entity in which Kaizen costing 4.0 is implemented, its implementation may take a very long time and thus the effect may be negative rather than positive. This creates difficulties and therefore we have to be aware of the concepts of the system and its main objectives;

- The **risks** in the external environment are as risks for delayed investments in new production technologies. Investments in retraining and/or additional qualification of personnel require funds that may lead to a slower return on investment for the industrial enterprise.

The results of the SWOT analysis for the application of Kaizen costing 4.0 in a circular economy reveal, in addition to specific data, certain issues regarding its implementation. The implementation of this system is undoubtedly useful and significant, but how and when to should be implemented are also important questions.

The SWOT analyses reveal the opportunities and shortcomings of the implementation of Industry 4.0 and Kaizen costing 4.0, for which similar positive and negative aspects are observed. Cost management systems, and Kaizen in particular, are sensitive to all external changes and are integrated with the main goal of creating quality reporting information for management decision-making. Industry 4.0 is undoubtedly changing the economic foundations of the European and global economy, which would make the transition to a circular economy easier and more effective. The positive aspects are opportunities to optimize production costs and develop the enterprise, the economy, etc., while the negative aspects show when the use of these systems would not be effective.

The information analysed in this scientific research reveals the following possibilities for the development of the Kaizen costing 4.0 cost management system combined with Industry 4.0:

- Rapid identification of problems in industrial enterprises - the high level of digitalization of production processes helps to accurately identify problem areas and the possibilities to solve them;

- Creation and testing of solutions - the development of technologies and the opportunities provided by Industry 4.0 reveal problem solving options.

Kaizen costing 4.0 examines the significance and effectiveness of each decision, aiming at optimal organizational level in industrial enterprises;

- Development of medium-term and long-term strategies - the exponential growth in technology development creates opportunities for predictability of the production process and creation of work process standards. This is how strategies and predictability are achieved in the medium and long term.

## Conclusion

The present scientific work does not pretend to be a comprehensive study on the topic but an attempt was made to present and prove theses that are significant for the economic development. The critical analyses of opinions on the circular economy, Kaizen costing 4.0 and Industry 4.0 aim to clarify the concepts and their significance for the policies implemented by the EU. By presenting the implementation of ideas from Industry 4.0 in Kaizen costing 4.0, the author aimed to analyse the importance of accountability in the current economic conditions. The SWOT analyses highlight the positive and negative aspects of the fourth industrial revolution and the cost management system in the context of circular economy. The shortage of basic production resources both globally and on the European markets requires quick and effective solutions for the transition to a circular economy.

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# ***ECONOMIC ARCHIVE***

**YEAR LXXVI, BOOK 2 – 2023**

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