

Formation of the Concept of a Circular Economy*

Formación del concepto de economía circular

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ABSTRACT

The article represents a historical survey describing appearing and development of circular economy as an independent concept and its interconnection to the phenomenon of new industrialization. The variety of definitions of the concept “circular economy” given by Russian and foreign scientists are provided in the article, basic approaches to the concept formation are determined. The comparative analysis of basic concepts related to environmentalism (sustainable development, ecologization, green economy, circular economy) was carried out. The evolutionary development of ecological imperatives that take part in the concept formation is studied; the characteristics of the concept, current state and general development prospects are described. The article is concluded by the clarified definition of “circular economy”. From the point of the author’s view, the circular economy concept is a general approach to promote green growth in countries’ development that allows to overcome global ecological problems and, as a result, to achieve sustainable state of the planet and to save lives on the Earth.

Keywords: industrialization, sustainable development, green economy, circular economy, social and economic development.

RESUMEN

El artículo representa una encuesta histórica que describe la aparición y el desarrollo de la economía circular como un concepto independiente y su interconexión con el fenómeno de la nueva industrialización. La variedad de definiciones del concepto «economía circular» dada por científicos rusos y extranjeros se proporciona en el artículo, se determinan enfoques básicos para la formación del concepto. Se realizó el análisis comparativo de conceptos básicos relacionados con el ambientalismo (desarrollo sostenible, ecologización, economía verde, economía circular). Se estudia el desarrollo evolutivo de los imperativos ecológicos que participan en la formación del concepto; Se describen las características del concepto, el estado actual y las perspectivas generales de desarrollo. El artículo se concluye con la definición aclarada de «economía circular». Desde el punto de vista del autor, el concepto de economía circular es un enfoque general para promover el crecimiento verde en el desarrollo de los países que permite superar los problemas ecológicos mundiales y, como resultado lograr un estado sostenible del planeta y salvar vidas en la Tierra

Palabras clave: industrialización, desarrollo sostenible, economía verde, economía circular, desarrollo social y económico.

* The research is made with the financial support of the Grant of the President of the Russian Federation to support young Russian scientists – candidates of Sciences – in terms of the research MK-587.2019.6 “Development of theoretical and methodical aspects of the circular economy concept as a new trend of sustainable social and economic development”.

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Recibido: 02/09/2019 Aceptado: 06/11/2019

1. Introduction

The research objective, which is based on the comparative studies methodology, is to conduct an acceleration in modern human development process demonstrates that the world is speeding up and there is much less time needed for new scientific and technical revolution. This phenomenon has dire consequences. Humanity appeared not to be able to transform its ideas about the interaction between human society and nature: change habits and everyday behavior, to confirm the statements above, the thought of O. N. Yanitsky that "...biological forms (including ecosystems) that have been formed during evolution have incompatible temporarities with socially constructed forms of modern life..." seems interesting (Shvab, 2017).

A man in the era of information accessibility with incredible opportunities for continued self-improvement, self-education and self-development has chosen the other way of life, simplifying his worldview and getting lost in the vast information field, putting incorrect accents on his priorities and interests. All these processes can be summarized by a well-known definition "consumer society". The paradox is that not only wasteful lifestyle of the population in developed countries, but also the increased resource intensity of the production of developing has caused the climate changes and ecosystems' decline (Melnik, Hens, 2007).

In reality a "super-consumer" model has rapidly changed to a "super-contaminator" model and caused a series of environmental disasters and catastrophes. Global environmental problems accumulated over the history of civilization's development has become clear by the beginning of XXI century and demanded an urgent solution. Due to the need of constantly appliance of primary resources, which, finally become wastes, the existing model of linear economics at the terms of industrialization development and the planet population growth appeared to be ineffective, unable to provide the necessary quality of life. Gradually, sometimes without realizing it, society itself created a trap in the form of scarcity of various types of resources, and the economies of most countries have a pronounced dependence on their volatility (Mashukova, 2016).

Wrong perception and construction of a consumption model that developed during the industrial revolution in the XIX-XX centuries that became the basis of the linear economic model, based on the principles of the inexhaustibility of natural resources without waste management concern. Nowadays resources are considered limited, and most ecosystems, having lost the ability to assimilate, have become unstable (The Ellen MacArthur Foundation, n.d.). Without changes in developmental trajectory and review of key approaches to production and consumption a production crisis and further deterioration in the life quality are inevitable (Gureva, 2019).

The digital revolution at the beginning of the XXI century including a number of attempts to create and develop robotization process, the Internet of things and artificial intelligence has marked the transition to a new stage in the technological development of industrial production, called "Industry 4.0", the main driving force of which is the Internet of things. At the same time, the organization of the production process is characterized by a sharp reduction of energy and material consumption, the design of materials and organisms with predetermined properties. According to E. G. Calabina, consumer demand serves as the main driver of Industry 4.0, and the general concept is based on the perception of sustainable development as a process of maximizing the consumption of goods and services (Ivanova, Dyachenko, Gilyarova, 2018).

The transition to Industry 4.0 will create a world of virtual and physical unity of production with erased industry boundaries, significantly reducing the technological impact on the environment (Socheeva, 2017).

When considering digitalization as a transformational technology, on the one hand, an increase in public awareness is observed, and on the other, the effect of a certain "transparency" of society appears. There is a shift in consumer preferences from the path "I want to own" towards "I want to use"; the boundaries of understanding in the field of individual professional and everyday skills, personal concepts of work, leisure and education as a whole are changing. The new industrial era has a distinctive feature in the perception of labor from the point of social efficiency, when the workplace is considered as a tool for self-realization (the development of E. Toffler's concept of prosumerism) (Nechaeva, 2018).

2. Methods

In the middle of 20th century world scientific community, based on the analysis of the downward course of the scientific and technical revolution, made a conclusion about limits for growth opportunities set by linear (industrial) model exploration at a global scale that led to the concept of circular economy as an alternative solution.

In 1972 the United Nations Conference on the Environment was held in Stockholm (Sweden), the United Nations Environment Programme (UNEP) was established as the main UN body in the field of environment. The United Nations Conference on Environment and Development (UNCED), also known as the Rio de Janeiro Earth Summit, was a major United Nations conference held in Rio de Janeiro in 1992. The primary result of the conference was the raise of public awareness of the need to integrate environment and development. In June, 2012 the conference "Rio+20" has approved the nonbinding document, "The Future We Want", a 49-page work paper, including Millennium Development Goals. In it, the heads of state of the 192 governments renewed their political commitment to sustainable development and declared their commitment to the promotion of a sustainable future. The document largely reaffirms previous action plans. The 17 Sustainable Development Goals and 169 targets were announced at the UN document "Transforming our world: the 2030 Agenda for Sustainable Development" in 2015 (The United Nations Environment Programme, n.d.).

Over the past decade, special attention has been paid to the new concept of an economic model development, called the "circular economy", which is considered as a new path for the development of society along the path of sustainability (Figure 1).

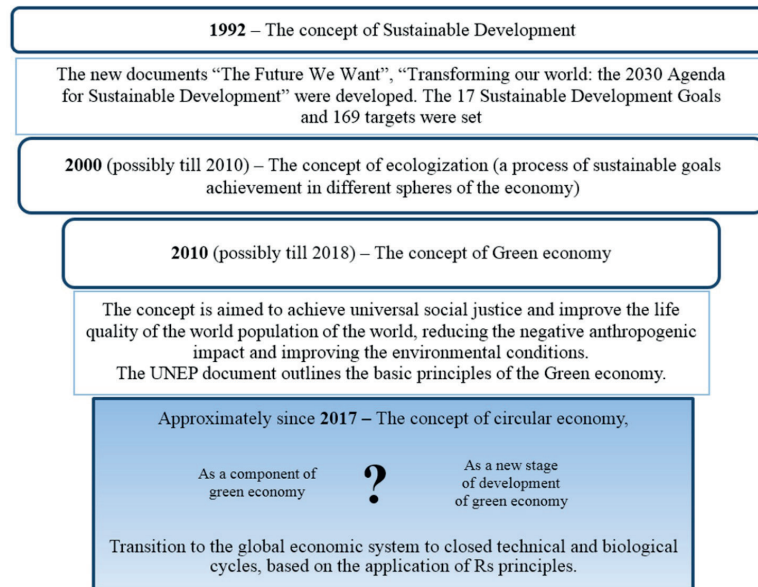


Figure 1. The path to the formation and popularization of the economics of environmentalism (prepared by the authors based on the works by Batova, Sachek, Tochitskaya (2018) and Gureva (2013)).

A study of the considered areas of the economy of environmentalism showed their interdependence and interdetermination, the similarity of the formation approach, confirming that their final global goals are the same - the stable state of the planet and global survival, with difference only in ways of goals achievement and main approaches (Batova, Sachek, Tochitskaya, 2018; Circular Economy Australia, 2000; Reike, Vermeulen, Witjes, 2018).

The comparative analysis of the economics of environmentalism concepts based on main criteria is shown in Table 1.

Table 1

Comparative analysis of the economics of environmentalism concepts^a

Comparison criterion	Sustainable development	Ecologization	Green economy	Circular economy
Peak of popularization	1992	2000	2010	2017
Main agent	A person passes from the category of “object” to the category of “subject”	An ecologically aware person	An innovative person	A man is integral with nature and society
Main concept	Achieving the needs of the current generation during development does not negatively affect the ability of the future generation to satisfy their own	Economic development that meets environmental requirements	An economic model in which a high level of planet’s population wellbeing is achieved simultaneously with minimizing environmental risks	An economic model based on closed loops with multiply usage of resources and high-scale waste recycling
Goal	17 Sustainable Development Goals	Maximum profitability with minimal environmental damage	Achieving social justice, improving wellbeing simultaneously with reducing environmental risks	Achieving ecological balance with a steady economic and social growth in the well-being of the world’s population while maximizing the life cycle efficiency of various resources, goods and services
Mainstream	The trinity of social, economic and environmental systems	Much attention is paid to the problem of the distribution of various goods among the population, decoupling	A qualitatively new economic growth (green growth), provided by innovative aspects of balanced and safe development	Waste minimization (complete reduction in the future); minimization of resources extraction

Comparison criterion	Sustainable development	Ecologization	Green economy	Circular economy
Fundamental principles	16 basic principles declared at a UN conference in Rio de Janeiro, 1992 and the United Nations General Assembly Special Session (UNGASS) in New York, 1997	Precautionary, continuity, ubiquity, interrelatedness, integration	Generation equality, compliance with sustainable development principles reasonable natural and social capital accounting, sustainable and efficient use of resources, creation of “green” jobs, poverty eradication, improvement of competitiveness and increasing growth in the main sectors of the economy (European Environment Agency)	Developing imperatives of sustainable development R, earlier developed 3Rs were improved to 9Rs
Area of research	Improvement in the life quality for the diverse population of the planet	Maintenance of life support systems, assessment of natural capital, development of innovative assessment tools and variable environmental management models	Sustainable development, green investments, tourism, business, education, biomass, carbon pollution, development of land resources	Sustainable development and industrialization, extension of product life-cycle, industrial symbiosis, recycling, closed-loop supply chains
Time span of implementing	Open time frames	Unlimited	Time limit	Time limit
Final global goal	Stable state of the planet and global survival			

^a Prepared by the authors based on the references (Batova, Sachek, Tochitskaya, 2018; Belik et al., 2018; The Ellen MacArthur Foundation, n.d.; The United Nations Environment Programme, n.d.; Circular Economy Australia, 2000; Reike, Vermeulen, Witjes, 2018).

3. Result

The key difference between the initially accepted concept of sustainable development and the later concept of the circular economy is expansion of its sphere of concepts, because in the interconnection of environmental and economic spheres, a greater merger occurs through the necessary interaction (Figure 2).

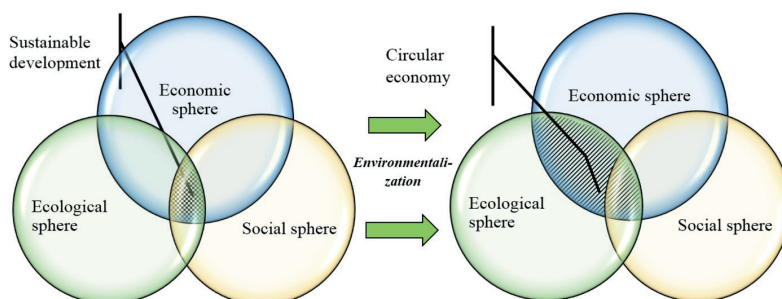


Figure 2. The relationship between the concepts of sustainable development and the circular economy (prepared by the authors based on the work by Murray, Skene, Haynes, 2017).

The transition from industrial to post-industrial society in the 60s of XX century based on the technological and further innovative progress caused the appearance of the concept of circular economy in the scientific literature. The circular economy concept was introduced in 1966 by Kenneth Ewart Boulding (an American economist). The concept was mainly rooted in ecological and environmental issues: “a man should find his own place in circular environmental system”. Later the concept has gained more economic character (Homrich, 2018).

There are several opinions on the origin of the term “circular economy”, a number of scientists believe that the circular economy is a new stage in the development of the concept of sustainable development and the green economy; on the other hand, much less often, it is considered as an independent direction of economic theory, appeared in the 1970s of the XX century (Gureva, 2013; 2019).

The literature search has been performed in Scopus, Elsevier, Elibrary, WOS databases and Google Scholar using “circular economy” as a keyword in the title, keywords or abstract of the document. The term is widely spread in foreign scientific literature while in Russian academic literature it is much less common. Nevertheless, a number of scientists emphasize that the circular economy is not an analogue of the “green” economy, but acts as an integral part of it, a way to achieve sustainable development (Mashukova, 2016).

The earliest reference to the circular economy belongs to Walter Stahel. In his 1976 research report, he offered the idea of transition from the linear model of resource-dependent economy to an economy in loops (or circular economy) (Gureva, 2019; D'Amato et al., 2017; Reike, Vermeulen, Witjes, 2018).

The main definitions of the term “circular economy” given by different researches are represented in Table 2.

Table 2

Main definitions of the term “circular economy”^a

Year	Author	Definition
2004	The Waste and Resources Action Programme	an alternative to a traditional linear economy
2004	Sergienko . and Rona .	a global economic model that separates economic growth and development from consumption of non-renewable resources
2007	Wen C. F. et al.	a way to solve the problem of sustainable development
2007	Melnik L. G. and Hens L.	an activity for the production, distribution and consumption of goods, based on the principles of conservation of various resources and materials, “non-waste economy”
2008	Geng Y. and Doberstein B.	a realisation of a closed loop of material flows in the economic system
2008	Yuan Z. et al.	a political strategy aimed to reduce resource scarcity and pollution
2009	Zhang H. et al.	a way to a sustainable development
2011	Zhu Q. et al.	a way of continued economic development without creating significant environmental and resource problems
2012	The Ellen MacArthur Foundation	a new way to design, make, and use things within planetary boundaries. A circular economy is based on the principles of designing out waste and pollution, keeping products and materials in use, and regenerating natural systems
2013	Su B. et al.	It is a strategy of sustainable development that aims to increase the material and energy efficiency
2013	Sazonova T. Yu	a new trend, a basis for The fourth industrial revolution
2014	United Nations	a system that keeps the added value in products for as long as possible and eliminate waste. It keeps resources within the economy when a product has reached the end of its life, so that it can be productively used again and again and hence creates further value
2014	Jiao W. and Boons F.	a holistic concept covering the activities of ‘reduce, reuse, and recycle’ in the process of production, circulation, and consumption”
2014	Wei F. et al.	a model of economic development with maximum resource utilization and environmental protection
2015	Birat	“a contemporary and popular concept that describes how materials and resources should be handled in the future”
2015	Murray A.	“an economic model wherein planning, resourcing, procurement, production and reprocessing are designed and managed, as both process and output, to maximize ecosystem functioning and human well-being”
2015	Haas W. et al.	“a simple, but convincing, strategy, which aims at reducing both input of virgin materials and output of wastes by closing economic and ecological loops of resource flows”
2015	Tukker A.	a mutually-beneficial philosophy that confirms that a thriving economy and a healthy environment can coexist
2016	Ghisellini et al.	a space for solving aggravating resource problems, a concept that allows us to separate the direct use of resources from economic growth
2016	Circular Economy in Australia	“an alternative model that anticipates and designs for resources to be either safely returned to nature or back into systems where they can be reused or renewed”
2016	Sauve S., Bernard S., and Sloan P.	“a model of production and consumption of goods through closed loop material flow that internalize environmental externalities linked to virgin resource extraction and the generation of waste (including pollution)”
2016	Lieder M. and Rashid A.	“a solution to series of challenges such as waste generation, resource scarcity and sustaining economic benefits”
2016	Serbulova N. M., Sivolapenko E. V., and Panosyan S. A.	a recovery or regenerative production system; is an integrated waste management process.
2016	Pilyugina M. A.	an economy that improves people’s well-being and ensures social justice, significantly reducing environmental risks
2017	Geissdoerfer M. et al.	“a regenerative system in which resource input and waste, emission, and energy leakage are minimised by slowing, closing, and narrowing material and energy loops”
2017	Alexandrova V. D. and Esipova O. V.	an economic activity aimed at energy conservation, regenerative environmentally friendly production, circulation and consumption. The circular model is the most successful way of saving resources and materials and continuous economic growth

Year	Author	Definition
2017	Pakhomova N. V., Rikhter K. K., and Vetrova M. A.	one of the tools for solving environmental problems to accomplish sustainable environmental future
2017	Kirchherr J., Reike D. and Hekkert M.	“an economic system that is based on business models which replace the ‘end-of-life’ concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes, thus operating at the micro level (products, companies, consumers), meso level (eco-industrial parks) and macro level (city, region, nation and beyond), with the aim to accomplish sustainable development, which implies creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations”
2018	Mashukova B. S.	a philosophy of recycling and profit from what was previously considered unnecessary and sent to the utility waste as part of the traditional linear economy
2018	Nechayeva E. O.	an economy based on renewable resources, the transition to renewable energy sources and the processing of secondary raw materials
2018	Antropov V. A., Bochko V. S., and Kniss M. Yu.	- an integral part of the broader concept of a “green” economy; - the next stage of a “green” economy development
2018	Korhonen J. et al.	a sustainable development initiative with the objective of reducing the societal production-consumption systems’ linear material and energy throughput flows by applying materials cycles, renewable and cascade-type energy flows to the linear system

^a Prepared by the authors based on the published works (Alexandrova, 2017; Antropov, Bochko, Kniss, 2018; Margaryan, 2018; Mashukova, 2016; Mishenin, Koblianska, 2017; Nikulychev, 2017; Sergienko, Rohn, 2004; United Nations, n.d.; Pakhomova, Rikhter, Vetrova, 2017; Rudneva, Gureva, 2015; Sazonova, 2013; Sivolapenko, Proskurina, Panosyan, 2017; Yanitskiy, 2018; Suárez-Eiroa et al., 2019; Reike, Vermeulen, Witjes, 2018; Geissdoerfer et al., 2017; Geng, Doberstein, 2008; Ghisellini, Cialani, Ulgiati, 2016; Haas et al., 2015; Jiao, Boons, 2014; Kirchherr et al., 2018a; Korhonen et al., 2018b; Maier, 1999; Prieto-Sandoval, Jaca, Ormazabal, 2018; Sauvé, Bernard, Sloan, 2015; Burger et al., 2019; Tukker, 2015; Zhang et al., 2009).

In general approaches for “circular economy” definition for the 15-years long period of its development (from 2004 to 2019) may be grouped as follows: a certain model, activity, system, strategy, process, tool, economy, philosophy. The most commonly used and generally accepted, found in the reviewed papers and the media, is the term by The Ellen MacArthur Foundation proposed in 2012. It is worth noting that at the moment there is no officially approved definition for the term (Figure 3).

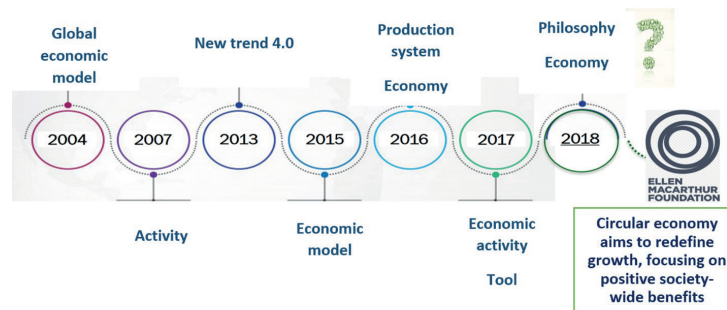


Figure 3. Approaches for the definitions of “circular economy” (prepared by the authors).

There are three stages distinguished in the evolution of the circular economy (Table 3).

Table 3. Stages of the evolution of circular economy^a

Time period	Title	Description
1970 – 1990	Reuse activities and waste management	In the European countries and the USA a number of environmental legislative measures have been adopted. The 3R (reduce, reuse and recycle) concept has become more popular at governmental level. State measures were restrictive, taking into account producers’ preferences The Polluter-Pays-Principle was stated. The focus was shifted at the waste management issue, but due to the lack of development in environmental culture and concern the territories of poor countries were used for waste storages and recycle. Rapidly developing television and the media were paying attention to the ongoing environmental changes. Scientific literature on recycling, collection, waste management appeared

Time period	Title	Description
1990 – 2010	Eco-efficiency strategies	<p>The idea of environmental payments (pollution charges) (the Brundtland report. 1987) had a certain influence on the evolution of the circular economy. Environmental problems were perceived by society as a kind of economic opportunity. In the early 2000s with development and growth of the Internet and the increased speed of information exchange, a number of environmental problems were announced as global (ozone layer depletion, global warming, etc).</p> <p>The academic community is actively developing possible ways of zero-waste production, but only in the industrial sphere.</p> <p>The first references to the circular economy appeared in a number of scientific literature databases, for example, in Scopus in 2004. The idea of a closed-loop economy is gradually becoming popular</p>
2010 till present	Maximum saving at the age of resource depletion	Nearly 2010, the concept of a circular economy, summarizing the most viable ideas of theoretical researches, has gained its final form. The central stated problem is the survival of mankind in terms of the reduction and a natural resources crisis, the growth of the world population and the amount of waste. In particular, ideas and investigations devoted to the circular economy created by the team of The Ellen MacArthur Foundation are widespread. It is planned that further economic growth will be independent from natural resources and thus the energy dependence will be overcome. That'll make it possible to save the ecosphere. Experts offer companies to plan the development based on three principles: green innovation, alternative sources, a shift of the industrial paradigm. Currently, about 500 companies in the world are using a circular economy strategy.

^a Prepared by the authors based on the work by D'Amato et al. (2017).

The name Ellen MacArthur is closely connected with the concept of a circular economy. She finished her single-handed circumnavigation of the globe in world record time in 2005. Following her retirement from professional sailing in 2010, Ellen MacArthur announced the launch of the Foundation named after her that aims at the acceleration of the transition to a circular economy. The Ellen MacArthur Foundation works in Education & Training, Business & Government, Insight & Analysis, Systemic Initiatives and Communications

The Foundation now is a global leader in applying systems theory and complexity theory to tackling the greatest challenges of our time that works with business, government and academia to build a framework for an economy that is restorative and regenerative by design. The Fund is an active participant in the world's leading economic forums and attracts an increasing number of founding partners (Sergienko, Rohn, 2004).

Based on the academic papers analysis the authors made the conclusion that most scientist use the prefix "re" while describing the principles of the circular economy. The prefix "re", occurring originally in loanwords from Latin, used with the meaning "again" or "again and again" to indicate repetition, reflects the meaning of the circular economy (D'Amato et al., 2017).

Initially there were three guiding principles of the circular economy – "3R" principles (reduce, reuse, recycle) that have been transformed to "9R" principles. It should be noted that their further development is still possible (Figure 4).

A detailed characteristic of the 9R-s principles of circular economy is presented in Figure 5.

The lack of a clear conceptualization of the basic principles together with an increasing number of additionally emerging areas in the study of R-imperatives, can be explained by the following:

- many research papers by different authors are devoted to the circular economy concept, that's why a clear area of the knowledge can be hardly determinated.;
- the circular economy is not a strictly isolated field of study; it origin took place at the intersection of different sciences;
- globalization processes taking place in the scientific environment allow us to identify and present to the world scientific community previously unknown studies, which affects the dynamic perception of the circular economy;
- international organizations use in their terminology and official documents various R-principles, sometimes the principles and terminology of different companies bear no mutual responce (D'Amato et al., 2017; Jiao, Boons, 2014).

According to the researches of The Ellen MacArthur Foundation (the pioneer at the promoting of the circular economy ideas) distinguish its several features:

- maintaining a sustainable balance of natural resources and monitoring their condition and use in order to avoid the natural capital depletion;

- development, distribution and widespread implementation of optimized manufacturing processes achieve the maximum level of its reuse;
- increasing the efficiency of economic and environmental systems of industrial activity by excluding negative effects (Alexandrova, 2017; Sergienko, Rohn, 2004).

3 R General model of the circular economy	4 R Circular economy: priorities and mechanisms	5 R Principles of the circular economy	9 R Principles of useful application of materials and products
Reduce	Material choice and design	Reduce	Refuse (stop excessive usage of raw materials)
Reuse	Cascading	Reuse	Reduce (decline volume of raw materials used)
Recycle	Lifetime extension	Recycle	Reuse (use again)
	Change of consumption pattern	Recovery	Repair (maintenance and repair)
	Resource management	Reclamation	Refurbish (renovate and redecorate)
	Infrastructure development		Remanufacture (rebuilding of a product to specifications of the original manufactured product using a combination of reused, repaired and new parts)
	Resource restoration		Repurpose (to use something for a different purpose to the one for which it was originally intended)
	Safe disposal		Recycle (treat or process (used or waste materials) so as to make suitable for reuse)
			Recover (conversion of non-recyclable waste materials into usable heat, electricity)

Figure 4. Evolution of the circular economy guiding principles (prepared by the authors based on the published works (Batova, Sachek, Tochitskaya, 2018; Mashukova, 2016; Nikitina, Zvonovskiy, 2018 ; Sazonova, 2013; Serbulova, Sivolapenko, Panosyan, 2016).

Legend	Title	Description
0R	Refuse	Refusal of excessive use of raw materials. Consumers are supposed to buy and consume less. Waste volume reduction (such as packaging paper, disposable tableware etc.) is emphasized in some literature sources All stages of the product life cycle are affected, including design, production processes, etc.
1R	Rethink	New thinking of product life cycle and raw material usage in order to change and improve it.
2R	Reduce	Reduction of raw material usage with further total elimination of waste production both on individual and industry level
3R	Reuse	Practice of using discarded product of good condition again by another customer. Active development of reselling especially at Amazon and eBay and other top online shopping sites.
4R	Repair	Maintenance and repair of defective product so it can be used with its original function. There are several options for implementing this principle: a consumer repairs the product themselves or at a special repair company or manufactures of products provide repair and maintenance service
5R	Refurbish	Restore or renovate an old product and bring it up to date without changing most part of it (especially buildings, heavy equipment)

6R	e a r e c o n o m y	Remanufacturing	Use parts of a discarded product in a new product with the same function to prolong its lifecycle
7R		Repurpose	Use a discarded product for a different purpose to the one for which it was originally intended, otherwise "second life of thrown products. Looks like 1R, the difference is that it is used not in manufacture spher but at the sphere of design
8R		Recycle	Process materials to get new products, sorting of waste to "capture" and return of "clean" resources to the production cycle.
9R		Recover	Incineration of material with energy recovery and/ or biorefinery

Figure 5. Characteristic of the 9R-s principles of circular economy (prepared by the authors based on the works by other authors (D'Amato et al., 2017; Jiao, Boons, 2014; Kirchherr, Reike, Hekkert, 2017; Sauv , Bernard, Sloan, 2015).

4. Discussion

The practical application of the circular economy can be observed at all levels of the global economic activity - from an individual action to the planetary level of interaction of countries representatives, which will make possible the transition from linear model of the economy (Table 5).

Table 5. Comparative analysis of the linear and circular economy models^a

Comparison criterion	Circular economy	Linear economy
1	2	3
Subject	A consumer acts like an integral part of society and nature	A consumer thinks only about his benefits
System integrity	Interrelatedness, triunity of economy, ecology and society	Market acts like an entire system
Main aim	To achieve ecological balance during sustainable economic and social growth and prosperity by increasing the effectiveness of product, service and resource life cycle	To maximize profit with lack of attention to the ecological issues. The process is characterized by unbalanced economic growth and prosperity and social stratification.
Production level	Closed cycle manufacturing directed to minimize the amount of products. The manufactured goods in general are of higher quality and reusable	Constant growth of the amount of manufactured goods and services (of low quality in general), increasing of production rate at all spheres. The process is characterized by overproduction crisis and market glut.
Consumption level	Developing of new goods and services consumption pattern depending on the its necessity and importance for a consumer	Satisfaction of excessive desire for goods, peculiar to behavior of super-consumer
Type of natural resource management	Creating of resources	Consuming of resources
Society-nature interrelation	Integration of ecologization in the system of manufacturing processes. The process is characterized by reduction of anthropogenic impact on the environment	Increasing anthropogenic impact on the environment causes planetwide environmental crisis
Resources used	Interaction of financial, informational, intellectual, labour and other resources in order to produce and use goods made of recyclable materials.	Natural resources extracted without considering environmental damage.
Amount of wastes	Gradual reduction targeted to total disappearance of wastes by applying new approaches available from the process of technological development. Appearing of new branches	Constant industrial and consumer waste growth. Waste accumulation causes global ecological problem.
Types of manufacturing prevailing in industry	Development of knowledge-based and innovative industries.	Labour-intensive manufacturing, characterized by low level of innovative activity and involving different types of intangible asset.
Social partnership	Active socio-economic position with high level of business responsibility	Environmental illiteracy, environmentally unfriendly companies conforming to environmental laws, regulations, standards and other requirements only under pressure
Product lifecycle	Prolonged product (service) lifecycle with a recycle and reuse opportunity	Short product (service) lifecycle, caused by its quick moral depreciation

^a Prepared by the authors based on the references (Belik et al., 2018; Esipova, Blazhov, Satsyuk, 2018; Lieder, Rashid, 2016).

There are several challenges faced during the implementation of circular economy concept:

- 1) cultural (companies' environmental decisions and actions, lack of interest and awareness of a consumer, following linear economy principles during operational process, interest in final value chains);
- 2) legislative (limited closed-loop procurement, lack of international consensus, prohibition of laws and regulations);
- 3) market barrier (poor quality materials, standardization, high investment value, limited financing of circular business models);
- 4) technological (the ability to deliver high-quality refurbished products, lack of presentation of project decisions, lack of environmental impact assessment) (Kirchherr, Reike, Hekkert, 2017).

A number of authors noted similar prerequisites necessary for an effective transition to a circular economy:

- necessity to establish a strong legal and policy framework for environmental protection;
- government support measures for organizations implementing the principles of circular economy;
- support and stimulation of research activities devoted to the circular economy;
- popularization and promotion of eco-friendly and environmentally conscious business-ideas among companies;
- increasing environmental awareness and education (Alexandrova, 2017; Larionov, 2018).

5. Conclusion

The circular economy has great potential for optimizing managerial, technological solutions to overcome environmental and economic problems in the resource sphere. The theoretical base of circular economy was influenced by economic theories of industrialization development of socio-economic systems.

Summarizing the above, it can be assumed that the circular economy is an economic model based on the principles of closed systems of technological and biological cycles, which can be considered as a tool of the green economy aimed to achieve sustainable development and fulfill the key SDGs.

The concept of circular economy is a universal way of green growth, which allows to take the place of the linear economy model, and thereby: minimize the resource dependence of production, overcome the global social and economic inequality, solve environmental problems caused by the global crisis and, finally, overcome the crisis of environmental sustainability and save life on earth.

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