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Bernadeta BARAN*

The Circular Economy in EU Policy as a Response to Contemporary Ecological Challenges

Abstract: This article discusses contemporary environmental challenges resulting from human economic activity and the idea of the circular economy (CE) as a response to these problems. The aim is to compare EU countries in terms of the efforts they are making to implement the CE model and to indicate EU strategic goals in this area. Furthermore, the article looks at arguments for an urgent change of the paradigm based on a linear model to achieve more equitable prosperity within planetary boundaries. The article was written on the basis of a secondary sources review, including relevant literature, legal regulations and reports. Statistical data come mainly from Eurostat and PlasticsEurope databases. The analysis leads to the clear conclusion that in today's resource-constrained world of rapid population growth, urbanisation and pollution, the linear model is no longer fit-for-purpose. The CE is also attractive economically. The transition will entail new investment (e.g. better design of production and recyclable materials, advanced sorting and chemical recycling) and contribute to cost reduction (saving of raw materials). For these reasons, the CE has become a strategic goal at the EU level as individual member countries have already acknowledged the need to modify their economies and grown aware of the benefits of the new model.

Keywords: circular economy, sustainable development, plastic, EU policy

JEL classification codes: O44, Q57, Q58

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* Department of Economic Policy and European Regional Studies, UE we Wrocławiu/Wrocław University of Economics and Business, e-mail: bernadeta.baran@ue.wroc.pl

Introduction

The modern economy is synonymous with industrial expansion, urban concentration and socio-cultural changes. The gross world product increased from EUR 2.6 trillion in 1900 to EUR 14.5 trillion in 1970 and EUR 60.4 trillion in 2017. Over the last four decades, the global use of materials has almost tripled, growing from 26.7 billion tonnes in 1970 to 92.1 billion tonnes in 2017. This is expected to double by 2050 [PACE, 2019]. The world's population increased from 1.6 billion in 1900 to 7.6 billion in 2018 and the urbanisation rate rose from 13% to 55% during this period [UN, 2018; 2019]. However, human economic activity has been based on a linear model in which an increase in production entails an increase in resources obtained from the environment and leaves behind waste with no regard to the sustainability of the process. This model has led to pollution growth, climate change and irreversible, significant transformation of all of the Earth's ecosystems. Under such circumstances, this model must be replaced by a new, circular approach that would provide the goods and services necessary for maintaining and improving the living standards of the growing population without increasing the consumption of raw materials and the quantity of waste. The purpose of this article is to discuss the arguments for an urgent change of the paradigm based on the linear model to achieve more equitable prosperity within planetary boundaries. Another aim is to compare the efforts of EU countries in implementing the closed economy model as well as to identify strategic EU goals in this area.

The article is structured as follows: its first part discusses the ecological results of human economic activity and the extent of contemporary environmental challenges. Particular attention is paid to plastic waste as the symbol of the economic changes of the last half-century and a cause for great concern about its negative impact on the environment. The next part examines the concept of the circular economy (CE). It provides the definitions adopted in the literature and indicates areas of its implementation, including in enterprises and cities. The two last parts aim at indicating the EU's strategic goals in the area of the circular economy and at illustrating the efforts of EU countries to close the loop, by analysing the most important circularity indicators. Examples of good practices are also presented as interest in the circular economy among various stakeholders, mainly local governments and businesses, has grown rapidly over the past decade.

Contemporary environmental challenges

All human activities affect the environment, its resources and the stability of ecosystems. The sustained focus on the growth of production and consumption as well as the growing demand for raw materials and energy have become a matter of concern in the context of nature and its resources. The global interest in environmental externalities dates back to the late 1960s

and early 1970s. A great stir was caused in particular by a report entitled *The Limits to Growth*. That publication undermined the assumption of unlimited possibilities of further economic expansion and pointed to the danger of natural barriers [Meadows et al., 1972]. In the 1980s, attention focused on the environmental problems of Third World countries. Scientists have begun to undermine growth concepts based on continuous growth in production, consumption and the unlimited exploitation of resources. Numerous signals also came from the economy, mainly because of growing costs of resource extraction and environmental protection as well as waste management. Moreover, environmentally aware citizens and non-governmental organisations highlighted the impact of economic activities on the health and well-being of the public [see: Meadows et al., 1972; Rockström et al., 2009; MA, 2005]. It was argued that growth must be sustainable and do not disturb the ecosystems. The concept of sustainable development has over the years taken an important place in the scientific discourse and is now the foundation of key socio-economic, political and environmental activities [see: Adams, 2009]. It seems, however, that the implementation of its objectives, particularly in the area of ecology, is far from what was expected. Neither the development of theory nor the growth of ecological awareness or even practical eco-innovations have significantly improved the state of the natural environment during the last few decades. Problems highlighted by Brown [1982], the pioneer of the concept of sustainable development, are not only up-to-date but have even been multiplied due to growing consumption and use of natural resources both in highly developed countries and in emerging economies such as China, India, Brazil, Indonesia and Mexico.

Reports by organisations monitoring the state of the environment and civilisation threats (e.g. UN Environment and the WWF) show that human economic activity has led to serious, irreversible ecological transformations and their effects can only be mitigated. One of the indicators that shows the scale of these transformations is the Living Planet Index (LPI). The LPI is a global biodiversity indicator, built from aggregated abundance trends of vertebrate species populations, and is used to communicate biodiversity trends. The LPI shows a 60% decline between 1970 and 2014, which means that, on average, animal populations are well over half the size they were in 1970. Habitat loss and degradation and overexploitation remain the biggest drivers of the biodiversity decline in the LPI. Together they account for at least two-thirds of all threats to populations. Beyond this, invasive species and disease, pollution and climate change are additional sources of pressure [WWF, 2018].

All the environmental reports show that critical levels have been exceeded on both the global and regional scales[1]. Crutzen and Stoermer [2000] claim that humanity's impact on the Earth is now so profound that a new geological

[1] The United Nations' Food and Agriculture Organisation (FAO) estimates that the species extinction rates are between 100 and 1,000 times faster than under natural conditions: 60% of the world's ecosystems are either degraded or misused; 75% of the fish stocks are over-exploited or

epoch, the Anthropocene, needs to be declared. Also many other scientists, including those from the Working Group on the Anthropocene, which started work in 2009, support this proposal. They argue that, since the Industrial Revolution, in particular the second half of the 20th century, human activity has led to [Vaughan, 2016]:

– extinction rates of flora and fauna far above the long-term average (the Earth is now on course for a sixth mass extinction that would see 75% of species extinct in the next few centuries if current trends continue),
– increase in the concentration of CO2 in the atmosphere affecting global climate change,
– plastic deposits in the waterways and oceans, where microplastic particles are now virtually ubiquitous (plastics will leave identifiable fossil records for future generations to discover),
– doubling the nitrogen and phosphorous in our soils in the past century with our fertiliser use,
– permanent marker in sediment and glacial ice with airborne particulates such as black carbon from fossil fuel burning.

Urbanisation processes are one of the biggest environmental but also economic and social challenges. The UN [2018] reports that in 2018 an estimated 55.3% of the world's population lived in urban settlements. By 2050, urban areas are projected to house 66% of people globally, and one in three people will live in cities with at least half a million inhabitants[2]. Such concentrated economic activity has a direct effect on the environment: cities consume 75% of natural resources, produce 50% of global waste and emit over 70% of global CO2 emissions [Carter et al., 2015].

Europe is experiencing the growing consequences of human economic activity. Reports by the European Environment Agency [2018] indicate that progress in improving ecosystems is far from expected. Positive effects have been achieved in several priority areas, such as greenhouse gas emissions (which decreased by about 19% compared to 1990 despite an about 45% increase in economic production), the amount of energy produced from renewable sources and energy efficiency, water quality and waste management. However, other areas are dominated by negative or at least ambiguous trends (Table 1).

The report recognises that the greatest environmental problems in Europe include progressive loss of biodiversity, exceeding critical nutrient levels causing eutrophication, high levels of air and noise pollution, significant pressure on terrestrial ecosystems (mainly as a result of urbanisation), progressive loss of soil functions and land degradation. Achieving the objectives set in these areas is unrealistic not only by 2020, but also in subsequent years.

largely depleted; and 75% of the genetic diversity of agricultural crops has been lost worldwide since 1990 [COM/2011/244].

[2] UN, 2018, *The World's Cities in 2018*, https://www.un.org/en/events/citiesday/assets/pdf/the_worlds_cities_in_2018_data_booklet.pdf

Table 1. Indicator scoreboard by 7th Environment Action Programme thematic priority objective

Indicator	Past trend	Outlook for meeting the objective by 2020
Priority objective 1: to protect, conserve and enhance the Union's natural capital		
Euthrophication of terrestrial ecosystems due to air pollution	↑	↓
Gross nutrient balance in agricultural land: nitrogen	↑	↓
Urban land take	↑	↓
Forest utilisation	→	↓
Status of marine fish and shellfish in European seas	↑	↑
Abundance and distribution of selected species: birds and butterflies	↓	↓
EU protected species	↓	↓
EU protected habitats	↓	↓
Status of surface waters	→	↓
Priority objective 2: to turn the Union into a resource-efficient, green, and competitive low-carbon economy		
Resource efficiency	↑	↑
Waste generation	↓	→
Recycling of municipal waste	↑	→
Use of freshwater resources	↑	→
Greenhouse gas emissions	↑	↑
Renewable energy sources	↑	↑
Progress on energy efficiency in Europe	↑	→
Household energy consumption	↑	→
Transport greenhouse gas emissions	↓	↓
Food consumption — animal based protein	→	↓
Environmental and labour taxation	→	↓
Environmental goods and services sector	↑	→
Environmental protection expenditure	↑	↑
Priority objective 3: to safeguard the Union's citizens from environment-related pressures and risks to health		
Outdoor air quality in urban areas	↑	↓
Air pollutant emissions	↑	↑
Quality of bathing waters	↑	↑
Countries that have adopted a climate change adaptation strategy	n.a.	→
Environmental noise	→	↓
Consumption of hazardous chemicals	↑	→
Pesticide sales	→	→

↑ Improving trend/it is likely that the EU will meet the objective by 2020
→ Stable or unclear trend/it is uncertain whether or not the EU will meet the objective by 2020
↓ Deteriorating trend/it is unlikely that the objective will be met by 2020
Source: European Environment Agency [2018].

Plastic pollution

Plastic is a symbol of the economic changes of the last half-century and a cause for great concern about its negative impact on the environment. The first synthetic polymer was invented in 1869. Thirty eight years later an industrial method of production was developed, making it possible to manufacture plastics on a large scale. World War II created "favourable circumstances"

for the development of the industry. For example, parachutes were produced from nylon, the world's first fully synthetic fibre, and aircraft windows were made from plexiglass [Sciencehistory, 2018]. In 1950, the global production of plastics amounted to 1.5 billion tonnes. Between 1950 and 2017 the average annual production growth rate in the sector was 8.6%, with the highest dynamics in the last decade of the 20th century. By 2017, global plastic production had grown to 348 billion tonnes and is expected to double again over the next 20 years [PEMRG, 2018]. Europe[3] is the second-largest plastics producer (2017), with an 18.5% share of global production (29.4% comes from China and 17.7% from NAFTA member countries). The plastics industry[4] is the seventh-largest sector in the EU in terms of its contribution to industrial added value; its role is similar to that of the pharmaceutical and chemical industries [PEMRG, 2018; Eurostat, 2018].

The concept of plastics (polymers) is a broad one. The name refers to materials whose basic components are polymers, i.e. multimolecular chemical compounds obtained in industrial polymerisation processes (from so-called mers) and auxiliary components (additives). These additives make it possible to improve the mechanical and thermal properties of plastic products, increase their aesthetic value and at the same time reduce the price and give them special functional properties, e.g. durability, mechanical and chemical resistance (also for corrosion), low electrical and thermal conductivity, low specific gravity and recyclability [Ambrogi et al., 2017, pp. 87–108]. They make the use of plastics versatile in sectors such as household goods and packaging, electrical, electronic, automotive, medical, clothing, construction, aerospace, agriculture and sports, where demand for plastics is rapidly growing. However, it is estimated that from the 1950s, i.e. from the beginning of the plastics industry's development, until 2015, 70% of plastic waste has accumulated in landfills or in the environment [Geyer et al., 2017]. One of the biggest problems is that much of the plastic is designed to be thrown away after being used only once. Households generate 64% of the post-consumer plastic packaging waste, while trade and industry are responsible for the remaining 36%. As a result, single-use plastic packaging accounts for about 60% of the plastic waste, 41% of which is recycled, 39% is collected for energy recovery, and 20% is landfilled [EPRO, 2018; Eurostat 2018].

There are serious environmental externalities related to plastic waste. The first one is degradation of natural systems as a result of leakage. In particular, the problem concerns the marine environment, where 80% of waste are plastics, mainly single-use ones. It is estimated that more than 150 million tonnes of plastic waste has accumulated in the world's oceans since 1980 [Jambeck

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3 Europe means the EU countries, Norway and Switzerland.

4 It includes plastics raw materials producers, plastics converters, plastics recyclers and plastics machinery manufacturers. The six larger European countries cover almost 70% of the demand: Germany (24.6%), Italy (14%), France (9.6%), Spain (7.7%), the United Kingdom (7.3%), and Poland (6.5%).

et al., 2015]. This leads to irreversible environmental changes. Fragments into which plastics are broken down, both larger and smaller (so-called microplastics), are found in all parts of the oceans. They have a significant impact on the whole ecosystem; entering the food chain, they get back to the human being, affecting health [Watkins, Brink, 2017]. Another cause for concern is chemical additives, which are the main component of plastics besides polymers. It has been proven that these stabilisers, plasticisers or pigments (for example bisphenol A and certain phthalates) have a negative impact on human health and the environment. Ludovic et al. [2017] carried out a review of studies analysing the occurrence of plastic additives in the marine environment, as well as their effects on and transfers to marine organisms. The studies show that plastic additives could represent an increasing ecotoxicological risk for marine organisms as a consequence of plastic accumulation and fragmentation in oceans. There are also uncertainties about the potential consequences of their long-term exposure to other substances, their combined effects and the consequences of leakage into the biosphere. It should also be emphasised that increasing production of plastics entails growing carbon dioxide emissions, from both plastic waste incineration and production processes (conversion of crude oil into plastics).

The concept of the circular economy

One of the great contemporary challenges and factors that determine the objectives of sustainable development are the limits of the linear model, in which an increase in production entails an increase in resources obtained from the environment and leaves behind waste with disregard of the sustainability of the process. Undoubtedly, this system was highly successful in generating material wealth but in recent decades it has demonstrated weaknesses due to resource depletion and a destructive impact on the environment. Projections of further effects of the linear economy in the face of the growing population (in particular middle-class, being future consumers) leave no illusions: the world's natural tolerance to human activity appears to be exhausted [Steffen et al., 2015]. On top of this, there is also a solid economic argument: in the face of today's technological possibilities, current production systems are becoming uneconomical due to non-utilisation of valuable waste. The Circularity Gap Report [PACE, 2019] finds that the global economy is only 9% circular – just 9% of the 92.8 billion tonnes of minerals, fossil fuels, metals and biomass that enter the economy are reused annually.

Scientists argue that the linear model should be replaced by a new, circular one, which would provide the necessary goods and services for maintaining and improving the living standards of the growing population without ever increasing the consumption of raw materials and the quantity of waste. While the concept of the circular economy has emerged as a political aim in the last decade, its origins have a longer story. It goes back to concerns

about the limits of growth and resource scarcity raised by Boulding [1966]. The following years brought further conceptual development of the idea of circularity. Nowadays, it has attracted an expanding body of research and literature from different fields and geographical areas [Ghisellini et al., 2016].

One of the most popular definitions holds that the circular economy is a system that is restorative and regenerative by design. It is based on three basic principles: preserving and enhancing natural capital (through the regulated usage of available resources, and the balance of renewable resource flows); optimising resource yields (which means that re-manufacturing, refurbishing and maintenance are well planned, in order to make materials a part of economic processes for as long as possible); and fostering system effectiveness (to minimise negative externalities and eliminate toxic substances, by either replacing or reducing them, for example choosing appropriate materials, thus leading to waste reduction or replacing fossilised energy resources by renewable ones). The transition towards a circular economy is not limited to certain materials or sectors. It is a systemic change that affects the entire economy and involves all products and services [EMAF, 2013].

There are many other definitions of the circular economy. Korhonen et al. [2017] identify, discuss and develop the various definitions provided by the emerging literature. Kirchherr et al. [2017] have gathered 114 circular economy definitions, which were coded on 17 dimensions. Their findings indicate that the circular economy is most frequently depicted as a combination of reduce-reuse-and-recycle activities. However, it should be noted that if the circular economy is approached from a waste management perspective, the risk exists that an end-of-the pipe position prevails in the finding of solutions, possibly leading to an optimised linear economic system with less waste, but not to innovations—technological and business models that are considered to be a key tool in the transition to a circular economy [Chesbrough and Rosenbloom, 2002]. Combining the challenges of putting the CE into reality and the practice-oriented approach of business model innovation led to the concept of circular business models (CBM). The concept is used to describe business models that are suited for the CE by incorporating elements that slow, narrow and close resource loops, so that the resource input into the organisation and its value network is decreased and waste and emission leakage out of the system is minimised [Geissdoerfer et al., 2018].

The above shows that the CE objective should be regarded as a paradigmatic change towards a new economic system with (nearly) zero waste in value chains in all sectors of the economy. This can only be achieved by a change of focus from "waste" to "resources" and a better understanding of their flow throughout the economic value chains in different sectors. This approach was adopted in the European Strategy for Plastics in a Circular Economy [European Commission, 2019]. The strategy emphasises that a circular economy framework requires fundamentally new approaches to the underlying business model and product designs. It recognises innovation as a key enabler for the transformation of the system, with innovation areas spanning the entire

value chain: renewable energy and feedstock, product design, business models and reverse logistics, collection and sorting mechanisms, mechanical and chemical recycling technologies, compostability and biodegradability.

As the circular economy should be approached from a wider economic development perspective, the concept is attractive not only because of its environmental benefits, but also from the economic side. The transition will entail new investment (e.g. better design of production and later recyclable materials, advanced sorting or chemical recycling), which remains an important factor in the face of declining growth rates in developed countries and will contribute to cost reduction (saving of raw materials). Multiple research efforts and the identification of best-practice examples (among others from global companies such as Renault, Philips and I:CO) have shown that a transition towards the circular economy can bring about the lasting benefits of a more innovative, resilient and productive economy [see: EMAF, 2015; Vuță et al., 2018]. Researchers even emphasise [see: Kirchherr et al., 2017], that the most common definitions recognise economic prosperity as the main goal of the circular economy, followed by environmental quality.

To date, ecologists and economists have tended to dominate the circularity debate, focusing on closed-loop industrial systems (circular businesses and systems of provision). However, a transition towards a circular economy is not limited to certain materials or sectors. It can be effectively implemented at the level of enterprises, local government units and entire countries. Because of economic and demographic concentration in urban areas, cities should take the challenge of implementing the concept of the circular economy. They should turn themselves into sustainable circular systems to promote growth and mitigate negative impacts on the environment. City governments are uniquely positioned in this transition. They can enable, lead, and involve other key stakeholders from across the public and private sectors, using the wide range of policy levers and measures at their disposal. A circular approach to the way in which city governments manage the resources—materials, energy, water and land—could significantly reduce the consumption of finite resources globally and help to address urban problems including resource security, waste disposal, greenhouse gas emissions, pollution, heating, drought and flooding [OECD, 2019].

Circular economy as a strategic goal of the EU

A circular economy has become a strategic goal at the EU level both in the context of environmental restrictions and because of the bloc's economic potential. On 2 December 2015, the Commission adopted a Circular Economy Package (CEP) consisting of a Communication and an Action Plan [COM/2015/614], in addition to proposals for revised legislation on waste. The Action Plan (AP) identifies five priority sectors to speed up the transition along their value chain: plastics; food waste; critical raw materials; construction

and demolition; and biomass and bio-based materials. The Plan consists of 54 measures to "close the loop" of product lifecycles, which are intended to help stimulate Europe's transition towards a circular economy and thus boost global competitiveness, foster sustainable economic growth and generate new jobs. In the AP, a circular economy is explained as an economy *"where the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimised"*. The most important objectives are reducing the amount of waste generated, maximising recycling and reuse, limiting incineration to non-recyclable materials, and phasing out landfilling to non-recyclable and non-recoverable waste.

To track progress towards the circular economy, the European Commission committed itself to develop indicators on resource efficiency. This obligation was fulfilled in 2018 with the presentation of a monitoring framework composed of 10 indicators [COM/2018/029]. They have been grouped into four stages and aspects of the circular economy:

(1) production and consumption: EU self-sufficiency for raw materials (to address the supply risks for raw materials, in particular critical raw materials), green public procurement (to boost the circular economy), waste generation (to reduce the amount of waste generated), and food waste (to minimise the negative environmental, climate and economic impacts),
(2) waste management: overall recycling rates, recycling rates for specific waste streams (to turn waste into resources),
(3) secondary raw materials: contribution of recycled materials to raw materials demand, trade in recyclable raw materials (to boost the use of secondary raw materials, to maximise recycling and reuse, and to limit incineration to non-recyclable materials and phase out landfilling to non-recyclable and non-recoverable waste),
(4) competitiveness and innovation: private investment, jobs and gross value added, patents (to minimise resource use and foster material reuse, recovery and recyclability down the road, to boost the EU's global competitiveness and to create jobs and growth).

In 2019, all 54 actions proposed in the AP have been delivered or are being implemented [European Commission, 2019a]:

(1) a revised waste legislative framework entered into force, aiming to modernise waste management systems. It includes new ambitious recycling rates, clarified legal status of recycled materials, strengthened waste prevention and waste management measures, including for marine litter, food waste, and products containing critical raw materials, (2) the EU Strategy for Plastics was adopted, which is the first EU-wide policy framework based on a material-specific lifecycle-approach to integrate circular design, use, reuse and recycling activities into plastics value chains,
(3) Eco-design and Energy Labelling measures for a group of products have been adopted, including rules on material efficiency requirements such as the availability of spare parts, ease of repair, and facilitating end-of-life treatment measures,

(4) action has been taken to engage citizens in changing consumption patterns (The Product Environmental Footprint and Organisation Environmental Footprint methods can enable companies to make environmental claims that are trustworthy and comparable, while enabling consumers to make informed choices),
(5) funds have been earmarked for the implementation of the transition process. To stimulate further investment, the Circular Economy Finance Support Platform has produced recommendations to improve the bankability of circular economy projects, coordinate funding activities and share best practices.

Undoubtedly, an essential part of the CEP is a Strategy for Plastic adopted in 2018 [COM/2018/028]. The strategy aims to reduce the amount of plastic waste by creating conditions under which production of plastic products will be adapted to reuse needs while recycling will become a cost-effective solution for businesses. It was decided that by 2030 all plastic packaging placed on the EU market should be either reusable or recyclable. Recycling targets have been set for plastic waste (50% by 2025 and 55% by 2030) and for other types of waste: municipal waste (65%), wood (30%), ferrous metals (80%), aluminium (60%), glass (75%), and paper and cardboard (85%)[5]. The proposed targets not only specifically target waste plastics but also refer to a certain waste stream that can contain mixed materials. There are or there will be set recycling targets for all packaging, waste electrical and electronic equipment (WEEE), end-of-life vehicles (ELV), and building & construction. The aim is to reduce or even eliminate the consumption of certain disposable products (a ban is being considered on plastic straws, disposable cutlery, plates and mugs) and to limit the deliberate use of microbin plastics[6].

The EU wants to take responsibility to deal with the global problem of plastic waste through a range of measures, while capturing the opportunities created by a move towards a circular economy for plastics. A European Strategy for Plastics in a Circular Economy [European Commission, 2019] provides a list of measures that aim to improve the economics and quality of plastics recycling, to curb plastic waste and littering, to drive innovation and investment towards circular solutions, and to harness global action:

- facilitate collaboration across the plastics value chains towards a common vision to trigger actions at the regional, national, European and global levels,

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5 It is estimated that the achievement of the plastic recycling targets will produce positive results in saving considerable amounts of greenhouse gas emissions and in creating new jobs. It is expected that by 2025, more than 75,000 jobs will be created directly in the recycling value chain of plastics and over 120,000 jobs supporting the sector and its operations. In Poland, this could be 4,600 new direct jobs by 2025. Moreover, the cost of achieving these results appears to be moderate and feasible: around EUR 1.45 billion by 2025, which could be reasonably tackled by EU, national and market investments in the sector, e.g. with public-private partnerships [Hestin *et al.*, 2015].

6 EU countries are currently adapting to the Plastic Bags Directive, which obliges them to reduce the consumption of plastic bags by 80% by 2019 compared to 2010 levels.

- develop, harmonise and enforce regulatory and legal frameworks guided by systems thinking to connect the different actors of the plastics value chain(s),
- set up, connect and fund mechanisms to coordinate strategically the transition towards a circular economy and to invest in upstream and downstream capacity across Europe,
- provide funding for research and a range of financial incentives for systemic innovation in business models, products and materials fit for a circular economy for plastics,
- educate and support citizens, companies and investors on the transition towards a circular economy for plastics.

Circular economy in EU countries – implementation and good practices

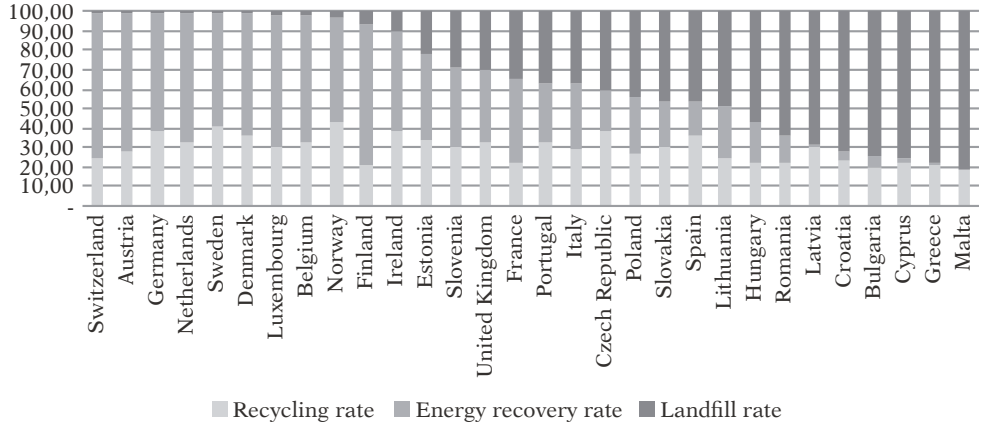
The circular economy is a new economic model that the EU is determined to fully implement in the near future. Some EU countries have previously recognised the need and benefits of creating their own national CE strategies. Finland, Italy and the Netherlands have integrative roadmaps in a bid to achieve a full CE model by a specific date. Germany's Closed Substance Cycle and Waste Management Act promotes multi-use, low-waste, long-life and repair-friendly products. Sweden, Portugal as well as Germany aim their programmes at specific industries, notably green and bioeconomic sectors, while Spain, Slovakia, France, Belgium and Romania are bringing CE aspects to their national strategies through waste management, which is considered as an essential part of CE. The United Kingdom is also advanced on the way to economic transformation although different approaches have emerged (e.g. in England and Northern Ireland there is no formal strategy and circularity is supported by extensive and voluntary measures, while in Scotland and Wales comprehensive strategies have been adopted).

In 2016, Finland became the first country to draw up a national road map to a CE. The Finnish Innovation Fund, or Sitra, was the coordinator and driving force behind the effort. The first version of the Finnish roadmap was a combination of a concrete action programme and strategy, outlining concrete actions for growth, investment and exports. In 2018, after opinions were collected from citizens and public and private entities on the need for change and necessary action, Sitra prepared an updated version of the roadmap [Sitra, 2019] together with hundreds of representatives from organisations, interest groups and various ministries. The document, which was unveiled in 2019, raises the level of ambition in Finland's efforts to switch to a CE and to update the objectives and actions of the first roadmap. It elevates CE solutions to the centre of the growth strategy of economic competitiveness, while extending the strategic objectives across society. It depicts in even more detail the CE visions of society's different segments and lists a group of new concrete actions to whose advancement Finnish agents have already committed themselves.

The roadmap also highlights best practices and pilot programmes that can be easily replicated to provide added value on a national scale, starting from the food system to transport and logistics, and forest-based and technical loops. The roadmap recognises the importance of coordinated action.

To gauge the efforts of EU countries to close the loop, one should look at some indicators illustrating this process. One of the most popular methods and a significant step towards tackling this challenge is to use waste as a resource and increase its recycling rate, especially for plastics [Ghisellini et al., 2016]. As already mentioned, plastics are valuable materials covering a wide range of applications in everyday life and have the potential to be recycled many times while retaining their value and functional properties. The efficiency of EU countries in this area is improving (Figure 1): between 2006 and 2016, the amount of plastic waste collected for recycling increased by 79%, energy recovery grew by 61%, and the amount of landfilled waste decreased by 43%. However, the problem of plastic waste is visible: the energy recovery rate (41.6%) is still higher than the recycling rate (31.1%), and the recycling rate only slightly exceeds the landfill rate (27.3%). In nine countries, plastic waste is mainly landfilled. The highest landfill rate for plastic waste was observed in Malta (82%), Greece (78%) and Cyprus (75%), while the lowest was in Austria, Germany, the Netherlands and Sweden (less than 2%). In Poland, 43% of plastic waste is landfilled [PEMRG, 2018].

Figure 1. Plastic waste recovery and landfill rates in European countries (%), 2016



Source: own calculations based on [PEMRG, 2018].

Generally, the depicted levels of plastic recycling in EU countries mean that the potential associated with the recycling of plastic waste remains largely unexploited. It is estimated that economic losses resulting from single-use plastic packaging alone amount to 95% of their material value, which is between EUR 70 billion and EUR 105 billion a year [EPRO, 2018; Eurostat 2018]. Therefore, improving the indicators would mean huge economic benefits as

well as reduced dependence of plastic production on fossil fuel extraction [EMAF, 2017].

Other main circularity indicators show a great diversity in the implementation of the CE model among EU member states (Table 2).

Table 2. Selected circular economy indicators for EU countries, 2016 (Municipal waste and municipal recycling rate – 2017 data)

	Municipal waste (per year, per person, kg)	Food waste (kg)	Municipal recycling rate (%)	Recycling rate of all waste (excluding major mineral waste, %)	Material reuse rate (% of total material use)	Patents related to circular economy (in period: 2000–2014)	Private investment in circular economy sector (EUR mln)
Austria	570	209	57.7	66	10.6	139	292
Belgium	410	345	53.7	78	18.9	118	632
Bulgaria	435	105	34.6	27	4.3	10	87
Croatia	416	91	23.6	52	4.4	4	51
Cyprus	637	327	16.1	31	2.3	4	11
Czech Rep.	344	81	34.1	60	7.6	81	-
Denmark	781	146	46.3	61	8.2	65	250
Estonia	390	265	28.4	10	11.8	6	33
Finland	510	189	40.5	41	5.3	111	119
France	514	136	42.9	54	19.5	671	2490
Germany	633	149	67.6	54	11.4	1260	2809
Greece	504	80	18.9	-	1.3	5	66
Hungary	385	175	35	63	6.4	36	195
Ireland	580	216	40.7	41	1.7	40	-
Italy	489	179	47.7	68	17.1	315	2201
Latvia	438	110	23.3	-	3.9	11	68
Lithuania	455	119	48.1	68	4.5	19	53
Luxembourg	607	175	48.3	64	6.5	26	-
Malta	604	76	6.4	63	5.2	1	-
Netherlands	513	541	54.2	72	29	186	858
Poland	315	247	33.8	56	10.2	294	717
Portugal	487	132	28.4	52	2.1	22	223
Romania	272	76	13.9	30	1.5	34	333
Slovakia	378	111	29.8	44	4.9	9	134
Slovenia	471	72	57.9	80	8.5	8	-
Spain	462	135	33.5	46	8.2	232	978
Sweden	452	212	46.8	49	7.1	47	656
UK	468	236	43.8	58	17.2	313	3974

Source: own, based on Eurostat [2019].

Belgium, Germany, Britain, France and Italy lead the way in the process of economic transformation among EU members. These countries have extensive and efficient recycling systems (high material reuse rates) and high levels of innovation in circular economy sectors. A further five EU15 countries, the Netherlands, Austria, Sweden, Denmark, and Finland, are also performing well in terms of investment levels and recycling rates for all waste. All these countries are characterised by a high level of environmental awareness, adequate government policies and large-scale private investment, resulting mainly from the size of the economies. The forerunners in municipal waste recycling are Germany and Austria, while Denmark is the most advanced in industrial symbiosis and green public procurement. At the same time, EU15 countries produce a lot of waste and move a large part of their waste to energy production. Energy recovery is a common practice especially in Nordic countries. Such a policy minimises landfilling but does not help boost the recycling and reuse rates. Meanwhile, most new EU member states have low waste production rates compared to Western European countries. Their recycling rates have improved significantly, but they do not invest so much in circular economy sectors. The only exception is Poland, which ranks third in the EU, after Germany and France, in terms of the number of patents since 2000 and seventh in terms of the amount of investment. Among the new EU countries, the highest circularity rates are reported by the Czech Republic.

Enterprises and municipalities contribute to an improvement in national circularity indicators. Numerous examples from industry and various service sectors, both business-to-business and business-to-consumer markets, illustrate the varied approaches businesses have taken when creating their circular business models. In some of the best practice examples, resource loops are tightly closed because economic incentives are in place to return goods and/or because solid partnerships have been developed between the supplier/wholesaler/dealer and the production company. In other cases, the resource loops are left more open due to initiatives being voluntary, experimental, small-scale or covering only part of the market [Guldmann, 2016]. Among the global companies that are the leaders in applying circular business models are Renault, Philips and I:CO. The French automobile manufacturer is now engaged in service models for battery leasing, redesign of components for dismantling, remanufacturing of parts, recycling of parts and materials and development of service model agreements with suppliers. It has a network of 300 vehicle dismantlers and a joint subsidiary vehicle recycler that support its remanufacturing business model[7] [Renault Communications 2014]. Philips has incorporated circular business models in its three business divisions: lighting, healthcare,

[7] Forty-three percent of the parts supplied to the plant by Renault's European network are recuperated in the remanufacturing process; 48% are unserviceable and are thus recycled in the company's foundries into new parts; while the remaining 9% is valorised in treatment centres. In total, 30,000 engines, 20,000 gearboxes and 16,000 fuel injection systems are remanufactured at the plant each year, providing jobs for 345 people [Renault Communications, 2014].

and consumer lifestyle. In the lighting division, the Dutch technology company became a pioneer of circularity-as-a-service by shifting from selling light bulbs to offering lighting-as-a-service. In this model, customers pay a service fee for the light while ditching the hassle of burnt-out bulb replacement and disposal. Philips installs, maintains and upgrades the systems. By retaining control of its products, the company finds it easier to reclaim valuable materials while maintaining an ongoing customer relationship. One of the customers is Amsterdam's Schiphol Airport. In the healthcare division, Philips has implemented its Refurbished Systems, which offer a choice of pre-owned systems that have been thoroughly refurbished, upgraded and quality tested. Finally, in the consumer lifestyle division, the company has started to adjust design practices so that products can be increasingly modular. This results in better ease of repair, longer lifetimes and, ultimately, improved environmental footprints [Philips, 2014].

A third example of a company in which all activities are based on closed circulation assumptions is I:CO (I:Collect). This Swiss company works in the textile industry and is a respected global provider of solutions and innovator for collection, reuse and recycling of used clothing and shoes. All items are sorted manually and categorised by I:CO's partner facilities, based on up to 350 factors. The scale of I:CO's worldwide take-back system and logistics network is unique in the textile industry. It collects clothing and shoes in more than 60 countries and collaborates with a number of companies internationally, such as Walmart, Esprit, American Eagle Outfitters, H&M, Jack&Jones and NameIt. At present, only a small percentage of all textile waste worldwide is collected. I:CO has therefore developed an alternative collection system that rewards consumers and conveniently takes place directly at a retailer's point of sale. This allows fashion companies to take on responsibility for their product. At the same time, end consumers are motivated to prevent textile waste [I:CO, 2019].

Also city units are encouraged to apply innovative strategies for approaching circularity at the urban level. More people living in condensed areas (half of the world's population lives in cities) means higher amounts of waste, greater resource consumption and more energy used. Designing a truly circular city means building infrastructure that minimises the negative effects on human health and the environment and solves numerous problems, including stormwater management, heat stress and pollution. While no city is fully circular yet, many of them are already known under names such as "smart cities", "green cities" or "eco-cities" [Caragliu et al., 2011; Joss, 2011]. These include Amsterdam, Helsinki, Brussels, Glasgow, London, Manchester, Berlin, Groningen, Hamburg, and Gothenburg. To understand how cities can become more circular, recent studies identify the main CE initiatives promoted in emerging case studies around the world [Lindner et al., 2017]. Petit-Boix and Leipold [2018] identified and developed a typology of CE strategies promoted in cities, based on urban initiatives. These strategies were grouped according to four target urban systems: infrastructure (local food production, energy production, recovery and efficiency, efficient waste management infrastructure, green

construction and materials, water conservation and reuse, smart IT, green mobility), social consumption (product repair and reuse, food waste management, sharing initiatives, disposable products reduction), industries and businesses (industrial symbiosis, use of recycled materials, remanufacturing, product eco-design, upgraded technologies, waste/product reuse and cascading, green procurement) and urban planning (land occupation and zoning, sustainable planning). Petit-Boix and Leipold identified around 300 initiatives in the 83 cities included in the sample. Forty-seven percent of their strategies have focused on urban infrastructure, followed by social consumption (24%), and industries and businesses (22%). However, a number of initiatives have been focused on waste management, energy supply, green construction and materials, and repair and reuse options, showing that the implementation of CE is diverse and expands across different topics and urban targets.

Conclusions

- Since the boom of the Industrial Revolution, the linear economy has delivered high standards of living and tremendous wealth in some parts of the world. However, this has been achieved at a high cost to the planet and many people. A particularly visible and extremely dangerous process for ecosystems is plastic pollution and climate change. In today's resource--constrained world of rapid population growth and urbanisation that linear model is no longer fit-for-purpose. A paradigm shift is therefore urgently needed to achieve more equitable prosperity within planetary boundaries.
- The circular economy represents an alternative to the currently predominant linear "take-make-waste" system. In a closed-loop economy, products, components and resources are maintained at their highest level of value and utility and kept within closed loops for as long as possible while waste generation is minimised. As a result, the CE is attractive not only because of the environmental benefits, but also economically. The transition to a CE entails new investment (e.g. better design of production and recyclable materials, advanced sorting and chemical recycling) and contributes to cost reduction (saving of raw materials).
- Interest in the CE has been growing rapidly over the past decade among various stakeholders (policy makers at different levels and businesses). Circular business models have been successfully implemented in various industries. Also interest in the role of cities in implementing the CE model has increased substantially. This is because cities account for much of the resources used in an economy and hold critical concentrations of business activity, human capital and regulatory/administrative capacity needed in crafting the transition to a CE.
- A circular economy has become a strategic goal at the EU level both in the context of environmental restrictions and because of its economic potential. Some EU countries have previously recognised the need and benefits

of creating their own national CE strategies. As a result, circularity indicators show a great diversity in the implementation of the circular economy model among EU members. Pioneers in the process of economic transformation include Belgium, Germany, Britain, France and Italy, Netherlands, Austria, Sweden, Denmark, and Finland.

References

Adams W.M. [2009], *Green Development: Environment and Sustainability in a Developing World*, Routledge London.

Ambrogi V., Carfagna C., Cerruti P., Marturano V. [2017], Additives in Polymers, in: C.F. Jasso-Gastinel, J.M. Kenny [eds.], *Modification of Polymer Properties*, Elsevier.

Boulding K. [1966], The Economics of the Coming Spaceship Earth, in: H. Jarrett [ed.], *Environmental Quality in a Growing Economy, Resources for the Future*, Johns Hopkins University Press, Baltimore.

Brown L.R. [1982], *Jutro może być za późno*, PWE, Warszawa.

Caragliu A., del Bo C., Nijkamp P. [2011], Smart cities in Europe, *Journal of Urban Technology*, 18.

Carter J.G., Cavan G., Connelly A., Guy S., Handley J., Kazmierczak A. [2015], Climate change and the city: Building capacity for urban adaptation, *Progress in Planning*, 95.

Chesbrough H., Rosenbloom R.S. [2002], *The Role of the Business Model in Capturing Value from Innovation: Evidence from Xerox Corporation's Technology Spinoff Companies*, Harvard Business School, Boston.

COM/2011/244, European Commission, Communication from the Commission to the European Parliament, The Council, The Economic and Social Committee and the Committee of the Regions: Our Life Insurance, Our Natural Capital: An EU Biodiversity Strategy to 2020, Brussels.

COM/2015/614, European Commission, Communication from the Commission to the European Parliament, The Council, The Economic and Social Committee and the Committee of the Regions: Closing the Loop – An EU Action Plan for the Circular Economy, Brussels.

COM/2018/028, European Commission, Communication from the Commission to the European Parliament, The Council, The Economic and Social Committee and the Committee of the Regions: A European Strategy for Plastics in a Circular Economy, Brussels.

COM/2018/029, European Commission, Communication from the Commission to the European Parliament, The Council, The Economic and Social Committee and the Committee of the Regions: On a Monitoring Framework for the Circular Economy, Strasbourg.

Crutzen P.J., Stoermer E.F. [2000], The Anthropocene, *Global Change Newsletter*, May.

Ellen Mac Arthur Foundation EMAF [2013], *Towards the circular economy*, https://www.ellenmacarthurfoundation.org/assets/downloads/publications/Ellen-MacArthur-Foundation-Towards-the-Circular-Economy-vol.1.pdf

Ellen MacArthur Foundation, SUN and McKinsey Center for Business and Environment EMAF [2015], *Growth Within: A Circular Economy Vision for a Competitive Europe*, https://www.ellenmacarthurfoundation.org/assets/downloads/publications/EllenMacArthurFoundation_Growth-Within_July15.pdf

Ellen Mac Arthur Foundation EMAF [2017], *The new plastics economy – rethinking the future of plastics & catalysing action*, https://www.ellenmacarthurfoundation.org/assets/downloads/publications/NPEC-Hybrid_English_22-11-17_Digital.pdf

European association of plastics recycling and recovery organizations EPRO [2019], www.epro-plasticsrecycling.org

European Commission [2019], *A circular economy for plastics, Insights from research and innovation to inform policy and funding decisions*, Brussels.

European Commission [2019a], *Report from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on the implementation of the Circular Economy Action Plan*, Brussels.

European Environment Agency [2018], *Environmental Indicator Report. In Support to the Monitoring of the Seventh Environment Action Programme*.

Geissdoerfer M., Morioka S.N., Monteiro de Carvalho M., Evans S. [2018], Business models and supply chains for the Circular Economy, *Journal of Cleaner Production*, 190.

Geyer R., Jambeck J.R., Lavender Law K. [2017], Production, use, and fate of all plastics ever made, *Science Advances*, 3(7).

Ghisellini P., Cialani C., Ulgiati S. [2016], A review on circular economy: The expected transition to a balanced interplay of environmental and economic systems, *Journal of Cleaner Production*, 114.

Guldmann E. [2016], *Best Practice Examples of Circular Business Models, Ministry of Environment and Food of Denmark*, Environmental Protection Agency, Copenhagen.

Hestin M., Faninge T., Milios L. [2015], *Increased EU Plastics Recycling Targets: Environmental, Economic and Social Impact Assessment*, Bio by Deloitte.

I:CO [2019], *Building textile circularity*, www.ico-spirit.com

Jambeck J., Geyer R., Wilcox C., Siegler T.R., Perryman M., Andrady A., Narayan R., Law K.L. [2015], Plastic waste inputs from land into the ocean, *Science* 437(6223).

Joss S. [2011], Eco-cities: the mainstreaming of urban sustainability – key characteristics and driving factors, *International Journal of Sustainable Development and Planning*, 6.

Kirchherr J., Reike D., Hekkert M. [2017a], Conceptualizing the circular economy: An analysis of 114 definitions, *Resources, Conservation & Recycling*, 127.

Korhonen J., Nuur C., Feldmann A., Birkie S.E. [2017], Circular economy as an essentially contested concept, *Journal of Cleaner Production*, 175.

Lindner P., Mooij C., Rogers H. [2017], *Circular Economy in cities around the world. A selection of case studies*, https://www.circulareconomyclub.com/wp-content/uploads/2017/07/Report_CollectionCaseStudies2017_FinalV2–1.pdf

Ludovic H., Alexandre D., Ika P., Camille L., Ronan J., Philippe S., Guillaume D. [2017], Occurrence and effects of plastic additives on marine environments and organisms: A review, *Chemosphere*, 182.

McDowall W., Geng Y., Huang B., Barteková E., Bleischwitz R., Türkeli S., Kemp R., Doménech T. [2018], Circular Economy Policies in China and Europe, *Journal of Industrial Ecology, A special issue on the circular economy*, 21(3).

Meadows D.H., Meadows D.L., Randers J. [1972], W.W. Behrens III, *The Limits to Growth*, Universe Books, New York.

Millennium Ecosystem Assessment MA [2005], *Ecosystems and Human Well-Being: Synthesis*, Island Press, Washington D.C.

Petit-Boix A., Leipold S. [2018], Circular economy in cities: Reviewing how environmental research aligns with local practices, *Journal of Cleaner Production*, 195.

Philips [2014], *Rethinking the future – our transition towards a circular economy*, Amsterdam, www.philips.com

Platform for Accelerating the Circular Economy PACE [2019], *The Circularity Gap Report – Closing the circularity gap in a 9% World 2019*.

PlasticsEurope Market Research Group PEMRG [2018], *Plastics – the Facts 2018, An analysis of European plastics production, demand and waste data*.

Renault Communications [2014], *Competitive circular economy*, www.group.renault.com

Rockström J.S., Noone W., Persson K. et al. [2009], A safe operating space for humanity, *Nature*, 461(24).

Sciencehistory [2018], *The History and Future of Plastics*, https://www.sciencehistory.org/the-history-and-future-of-plastics

Sitra [2019], *The critical move – Finland's roadmap to the circular economy 2.0*, Helsinki.

Steffen W., Richardson W., Rockström K., Cornell J. et al. [2015], Planetary boundaries: Guiding human development on a changing planet, *In Science*, 347(6223).

The OECD Centre for Entrepreneurship, SMEs, Regions and Cities [2019], *The Circular Economy in Cities and Regions*.

United Nations UN [2018], *World Urbanization Prospects 2018*.

United Nations UN [2018a], *The World's Cities in 2018*, https://www.un.org/en/events/citiesday/assets/pdf/the_worlds_cities_in_2018_data_booklet.pdf

United Nations UN [2019], *World Population Prospects 2019*.

Vaughan A. [2016], Human impact has pushed Earth into the Anthropocene, scientists say, *The Guardian*, 7 January 2016.

Vuță M., Vuță M., Enciu A., Cioacă S.-I. [2018], Assessment of the Circular Economy's Impact in the EU Economic Growth, *Amfiteatru Economic*, 20(48).

Watkins E., Brink P. [2017], *Marine Litter: Socio-Economic Study*, A report by IEEP for UNEP, Brussels.

WWF International [2018], *Living Planet, Report 2018: Aiming Higher.*

Zhu J., Fan C., Shi H., Shi L. [2018], Efforts for a Circular Economy in China: A Comprehensive Review of Policies, *Journal of Industrial Ecology, A special issue on the circular economy*, 21(3).

Gospodarka cyrkularna w UE jako odpowiedź na współczesne wyzwania ekologiczne

Streszczenie: W artykule podjęto zagadnienie współczesnych wyzwań środowiskowych wynikających z działalności gospodarczej człowieka oraz gospodarki o obiegu zamkniętym jako odpowiedzi na te problemy. Celem artykułu jest porównanie wysiłków krajów UE we wdrażaniu modelu gospodarki zamkniętej, a także wskazanie strategicznych celów UE w tym obszarze. Ponadto, artykuł wskazuje argumenty za pilną zmianą paradygmatu opartego na modelu liniowym w celu osiągnięcia bardziej sprawiedliwego podziału dóbr w granicach możliwości Ziemi. Artykuł oparto na analizie źródeł wtórnych – literatury przedmiotu, aktów prawnych i licznych raportów. Dane statystyczne wykorzystane w pracy pochodzą głównie z baz danych Eurostatu i PlasticsEurope. Analiza prowadzi do jednoznacznych wniosków, że w dzisiejszym świecie zanieczyszczonym do granic możliwości, z ograniczonymi zasobami, z szybko rosnącymi liczbą ludności i wskaźnikiem urbanizacji, dalsze wykorzystanie modelu liniowego nie jest już możliwe. Model gospodarki zamkniętej dostarcza też ekonomicznych argumentów – przejście na CE pociąga za sobą nowe inwestycje (np. innowacyjne modele produkcji i wykorzystania surowców wtórnych, zaawansowane sortowanie lub recykling chemiczny) i przyczynia się do redukcji kosztów (oszczędność surowców). Gospodarka o obiegu zamkniętym stała się strategicznym celem na poziomie UE, podobnie jak w poszczególnych krajach UE, które już wcześniej dostrzegły potrzebę zmiany modelu swoich gospodarek i korzyści z tego wynikających.

Słowa kluczowe: gospodarka cyrkularna, rozwój zrównoważony, plastik, polityka UE

Kody klasyfikacji JEL: O44, Q57, Q58

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